Pilot 2006 Environmental Performance Index

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Yale University

Center for International Earth Science Information Network (CIESIN)
Columbia University

In collaboration with

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Geneva, Switzerland

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The Pilot 2006 Environmental Performance Index Report is available online at www.yale.edu/epi

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Disclaimers

This *Pilot 2006 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 in the coming year as the EPI project moves beyond its pilot phase. Comments, suggestions, feedback, and referrals to better data sources are welcome at www.yale.edu/epi.

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

Acknowledgements

The Pilot 2006 Environmental Performance Index (EPI) incorporates the results of extensive consultations and cooperation with subject-area specialists, statisticians, indicator experts, and policymakers across the world. Recognizing that environmental performance is intrinsically multi-dimensional and that its measurement requires an in-depth understanding of each dimension as well as the interrelationships between dimensions and the application of sophisticated statistical techniques to each, we have drawn on the wisdom and insights of a network of experts including: Neric Acosta, SoEun Ahn, Michelle Bell, Marianne Camerer, David Campbell, Ben Cashore, Aaron Cohen, Arthur Dahl, Winston Dang, Vinay Dharmadhikari, John Dixon, Simeon Djankov, Ellen Douglas, Darlene Dube, Jay Emerson, David Ervin, Majid Ezzati, Rafael Flor, Bakhodir Ganiev, Stanley Jay Glidden, Andres Gomez, Luis Gomez-Echeverri, Lloyd Irland, Claes Johansson, Daniel Kammen, Bruno Kestemont, R. Andreas Kraemer, Christian Layke, Brian Leaderer, Denise Mauzerall, Charles McNeill, Sascha Müller-Kraenner, John O'Connor, Chad Oliver, Kiran Pandey, Bradley Parks, Thomas Parris, G. P. Patil, Vincent Pérez, László Pintér, Nigel Purvis, Robert Repetto, H. Phillip Ross, David Runnalls, Michaela Saisana, Andrea Saltelli, Kim Samuel-Johnson, Eric Sanderson, Guido Schmidt-Traub, David Skelly, Kirk Smith, Moo-Jo Son, David Stanners, Kazushige Tanaka, Dan Tunstall, Charles Vörösmarty, Yu Ling Yang, Erica Zell, and Robert Zomer.

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In constructing the Pilot 2006 EPI, we have built upon the work of a range of data providers, including our own prior data development work for the 2005 Environmental Sustainability Index. The data are drawn primarily from international, academic, and research institutions with subject-area expertise, long-term practice in delivering operational data products, and the capacity to produce policy-relevant interdisciplinary information tools. Moving environmental decisionmaking toward more rigorous, quantitative foundations depends on their experience and commitment to the collection of high quality information. We are indebted to all the data collection agencies listed in the data appendix (Appendix H) who provide the fundamental groundwork for all indicator work.

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Data Sources

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Executive Summary

Quantitative performance measurement has proven enormously valuable in fields such as economics, health care management, and education, where policies are driven by indicators such as the unemployment rate, infant mortality, and standardized test scores. While lagging behind these other domains, policymakers in the environmental field have also begun to recognize the importance of data and analytically rigorous foundations for decisionmaking.

The need for carefully constructed metrics for pollution control and natural resource management is made more urgent by the United Nations' Millennium Development Goals (MDGs), which commit the nations of the world to progress on a range of critical development issues. The MDGs include specific targets for poverty alleviation, improved health care, and education as well as a commitment to environmental sustainability. However, the environmental dimension of the MDGs has been criticized as insufficiently defined and inadequately measured. The Pilot 2006 Environmental Performance Index (EPI) shows how this gap might be filled.

The EPI centers on two broad environmental protection objectives: (1) reducing environmental stresses on human health, and (2) promoting ecosystem vitality and sound natural resource management. Derived from a careful review of the environmental literature, these twin goals mirror the priorities expressed by policymakers—most notably the environmental dimension of the MDGs. Environmental health and ecosystem vitality are gauged using sixteen indicators tracked in six well-established policy categories: Environmental Health, Air Quality, Water Resources, Productive Natural Resources, Biodiversity and Habitat, and Sustainable Energy.

The Pilot 2006 EPI deploys a proximity-to-target methodology focused on a core set of environmental outcomes linked to policy goals for which every government should be held accountable. By identifying specific targets and measuring how close each country comes to them, the EPI provides a factual 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.

The real value of the EPI lies not in the overall rankings but comes from careful analysis of the underlying data and indicators. In displaying the results by issue, policy category, peer group, and country, the EPI makes it easy to spot leaders and laggards, highlight best policy practices, and identify priorities for action. More generally, the EPI provides a powerful tool for evaluating environmental investments and improving policy results.

While a lack of time-series data and other data gaps constrain the current effort, over time, this methodology should facilitate rankings based on rate of progress toward established goals and enable global-scale assessments of the world's environmental trajectory.

Table 1 below presents the Pilot EPI scores and rankings with "sparklines" highlighting the relative performance of each country in addressing (1) environmental health challenges, and (2) the five underlying policy categories that contribute to ecosystem vitality.

Top-ranked countries—New Zealand, Sweden, Finland, the Czech Republic, and the United Kingdom—all commit significant resources and effort to environmental protection, resulting in strong performance across most of the policy categories. The five lowest-ranked countries—Ethiopia, Mali, Mauritania, Chad, and Niger—are underdeveloped nations with little capacity to invest in environmental infrastructure (drinking water and sanitation systems) or aggressive pollution control and systematic natural resource management.

A number of policy conclusions can be drawn from the Pilot 2006 Environmental Performance Index and analysis of the underlying indicators:

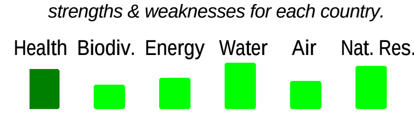
- In spite of data gaps, methodological limitations, and serious scientific uncertainties, the EPI demonstrates that environmental policy results can be tracked with the same outcome-oriented and performance-based rigor that applies to poverty reduction, health promotion, and other global development goals.
- If environmental protection efforts are to be made more empirically grounded and analytically rigorous, policymakers need to (1) set clearer targets, especially on the range of important issues for which none now exist, (2) invest in serious data monitoring, indicator tracking, and evaluation programs, and (3) incorporate targets and reporting into policy formation and implementation efforts at the global, regional, national, state/provincial, and local scales.
- Target-based environmental performance benchmarks make cross-country comparisons possible on an issue-by-issue and aggregate basis. Comparative analysis provides information on policy options, a context for evaluating performance, and a basis for holding governments accountable for environmental results.
- Every country confronts critical environmental challenges. Developed countries often suffer from pollution and degraded ecosystems. Developing countries must face the additional burden of investing in water and sanitation systems while establishing governance structures to support pollution control and natural resource management.
- Wealth and a country's level of economic development emerge as significant determinants of environmental outcomes. But policy choices also affect performance. At every level of development, some countries achieve environmental results that far exceed their peers. In this regard, good governance appears highly correlated with environmental success.
- The EPI provides a basis for examining the relationship between economic competitiveness and environmental protection. Top-ranked EPI countries emerge as among the most productive and competitive in the world. But industrialization and economic development do lead to environmental stresses, the risk of degradation of ecosystems, and the depletion of natural resources.

The Pilot 2006 EPI represents a "work in progress" meant to stimulate debate on appropriate metrics and methodologies for tracking environmental performance, enable analysis of the determinants of environmental success, and highlight the need for increased investment in environmental indicators and data. The Pilot EPI will be refined as existing conceptual, methodological, and data challenges are overcome.

Table 1: EPI Scores (0–100)

Rank	Country	EPI Score	Policy Categories*	Rank	Country	EPI Score	Policy Categories*	Rank	Country	EPI Score	Policy Categories*
1	New Zealand	88.0		47	Unit. Arab Em.	73.2		93	Kenya	56.4	
2	Sweden	87.8		48	Suriname	72.9		94	China	56.2	
3	Finland	87.0		49	Turkey	72.8		95	Azerbaijan	55.7	
4	Czech Rep.	86.0		50	Bulgaria	72.0		96	Papua N. G.	55.5	
5	Unit. Kingdom	85.6		51	Ukraine	71.2		97	Syria	55.3	
6	Austria	85.2		52	Honduras	70.8		98	Zambia	54.4	
7	Denmark	84.2		53	Iran	70.0		99	Viet Nam	54.3	
8	Canada	84.0		54	Dom. Rep.	69.5		100	Cameroon	54.1	
9	Malaysia	83.3		55	Philippines	69.4		101	Swaziland	53.9	
10	Ireland	83.3		56	Nicaragua	69.2		102	Laos	52.9	
11	Portugal	82.9		57	Albania	68.9		103	Togo	52.8	
12	France	82.5		58	Guatemala	68.9		104	Turkmenistan	52.3	
13	Iceland	82.1		59	Saudi Arabia	68.3		105	Uzbekistan	52.3	
14	Japan	81.9		60	Oman	67.9		106	Gambia	52.3	
15	Costa Rica	81.6		61	Thailand	66.8		107	Senegal	52.1	
16	Switzerland	81.4		62	Paraguay	66.4		108	Burundi	51.6	
17	Colombia	80.4		63	Algeria	66.2		109	Liberia	51.0	
18	Norway	80.2		64	Jordan	66.0		110	Cambodia	49.7	
19	Greece	80.2		65	Peru	65.4		111	Sierra Leone	49.5	
20	Australia	80.1		66	Mexico	64.8		112	Congo	49.4	
21	Italy	79.8		67	Sri Lanka	64.6		113	Guinea	49.2	
22	Germany	79.4		68	Morocco	64.1		114	Haiti	48.9	
23	Spain	79.2		69	Armenia	63.8		115	Mongolia	48.8	
24	Taiwan	79.1		70	Kazakhstan	63.5		116	Madagascar	48.5	
25	Slovakia	79.1		71	Bolivia	63.4		117	Tajikistan	48.2	
26	Chile	78.9		72	Ghana	63.1		118	India	47.7	
27	Netherlands	78.7		73	El Salvador	63.0		119	D. R. Congo	46.3	
28	United States	78.5		74	Zimbabwe	63.0		120	Guin.-Bissau	46.1	
29	Cyprus	78.4		75	Moldova	62.9		121	Mozambique	45.7	
30	Argentina	77.7		76	South Africa	62.0		122	Yemen	45.2	
31	Slovenia	77.5		77	Georgia	61.4		123	Nigeria	44.5	
32	Russia	77.5		78	Uganda	60.8		124	Sudan	44.0	
33	Hungary	77.0		79	Indonesia	60.7		125	Bangladesh	43.5	
34	Brazil	77.0		80	Kyrgyzstan	60.5		126	Burkina Faso	43.2	
35	Trin. & Tob.	76.9		81	Nepal	60.2		127	Pakistan	41.1	
36	Lebanon	76.7		82	Tunisia	60.0		128	Angola	39.3	
37	Panama	76.5		83	Tanzania	59.0		129	Ethiopia	36.7	
38	Poland	76.2		84	Benin	58.4		130	Mali	33.9	
39	Belgium	75.9		85	Egypt	57.9		131	Mauritania	32.0	
40	Ecuador	75.5		86	Côte d'Ivoire	57.5		132	Chad	30.5	
41	Cuba	75.3		87	Cen. Afr. Rep.	57.3		133	Niger	25.7	
42	South Korea	75.2		88	Myanmar	57.0					
43	Jamaica	74.7		89	Rwanda	57.0					
44	Venezuela	74.1		90	Romania	56.9					
45	Israel	73.7		91	Malawi	56.5					
46	Gabon	73.2		92	Namibia	56.5					

** This column contains sparklines for each of the 6 EPI policy categories showing the relative strengths & weaknesses for each country.*



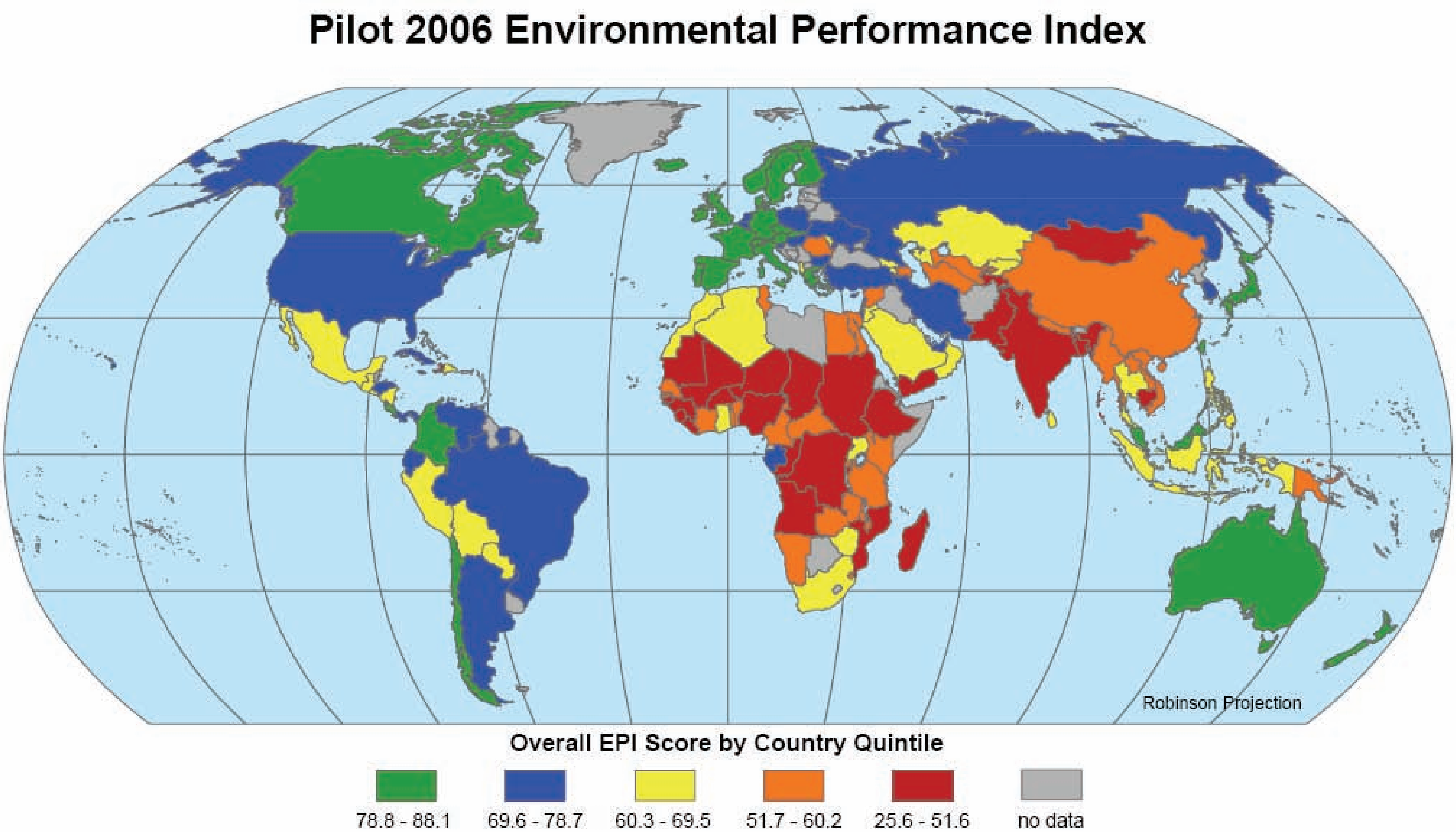


Figure 1: Map of Overall EPI Country Scores by Quintile

Table 2: Country Performance by Quintile (sorted alphabetically)

First Quintile (green)	Second Quintile (blue)	Third Quintile (yellow)	Fourth Quintile (orange)	Fifth Quintile (red)
Australia	Argentina	Albania	Azerbaijan	Angola
Austria	Belgium	Algeria	Benin	Bangladesh
Canada	Brazil	Armenia	Cameroon	Burkina Faso
Chile	Bulgaria	Bolivia	Central Afr. Rep.	Burundi
Colombia	Cuba	El Salvador	China	Cambodia
Costa Rica	Cyprus	Georgia	Côte d'Ivoire	Chad
Czech Rep.	Dominican Rep.	Ghana	Egypt	Congo
Denmark	Ecuador	Guatemala	Gambia	Dem. Rep. Congo
Finland	Gabon	Indonesia	Kenya	Ethiopia
France	Honduras	Jordan	Laos	Guinea
Germany	Hungary	Kazakhstan	Malawi	Guinea-Bissau
Greece	Iran	Kyrgyzstan	Myanmar	Haiti
Iceland	Israel	Mexico	Namibia	India
Ireland	Jamaica	Moldova	Papua New Guinea	Liberia
Italy	Lebanon	Morocco	Romania	Madagascar
Japan	Panama	Nepal	Rwanda	Mali
Malaysia	Poland	Nicaragua	Senegal	Mauritania
Netherlands	Russia	Oman	Swaziland	Mongolia
New Zealand	Slovenia	Paraguay	Syria	Mozambique
Norway	South Korea	Peru	Tanzania	Niger
Portugal	Suriname	Philippines	Togo	Nigeria
Slovakia	Trinidad & Tobago	Saudi Arabia	Tunisia	Pakistan
Spain	Turkey	South Africa	Turkmenistan	Sierra Leone
Sweden	Ukraine	Sri Lanka	Uzbekistan	Sudan
Switzerland	United Arab Em.	Thailand	Viet Nam	Tajikistan
Taiwan	United States	Uganda	Zambia	Yemen
United Kingdom	Venezuela	Zimbabwe		

1. The Need for Environmental Performance Indicators

Environmental policymaking is a difficult endeavor. Decisionmakers must address a wide range of pollution control and natural resource management challenges in the face of causal complexity, incomplete data, and a myriad of other uncertainties. Without careful analysis based on solid factual foundations, bad choices get made, investments in environmental protection under-perform, and political divisions widen.

Shifting environmental policymaking onto firmer analytic underpinnings and giving it a more empirical cast is thus a matter of some urgency. In this regard, better measurement and data are crucial.

A number of existing quantitative environmental metrics, including the 2005 Environmental Sustainability Index (Esty, Levy et al., 2005), have been criticized for being overly broad—and not focused enough on current results to be useful as a policy guide. The concept of *sustainability* itself is partly at fault. Its comprehensive and long-term focus requires that attention be paid to natural resource endowments, past environmental performance, and the ability to change future pollution and resource use trajectories—as well as present environmental results.

The Pilot 2006 EPI attempts to address this critique and focuses on countries' current environmental performance within the context of sustainability. It more narrowly tracks actual results for a core set of environmental issues for which governments can be held accountable. In gauging present performance on 16 indicators of environmental health and ecosystem vitality, it serves as a complement to measures of sustainability.

In addition to providing governments with policy guidance, the EPI promises to help break the stalemate that exists in some quarters over how best to advance environmental protection. Insofar as uncertainty over the seriousness of environmental threats, the direction of pollution and natural resource trends, or the efficacy of policy interventions is in doubt, the EPI provides a tool for clarifying issues, trends, and policy options.[1]

Driven in part by the 2000 Millennium Declaration and the MDGs, major efforts are underway to make global-scale progress in the areas of education, health, and poverty reduction.[2] While environmental sustainability was recognized in *MDG Goal 7* alongside these other agenda items, the environmental policy thrust is not keeping pace. Moreover, promising areas of synergy between the environment and these other policy domains are going unrealized. The lag in environmental policy dynamism has been traced, in part, to an inability to identify the most pressing problems, quantify the burden imposed, measure policy progress, and assure funders in both the private and public sectors that their investments in response strategies will pay off. Thus, pollution control and natural resource management issues have tended to be shuffled to the back burner.

A major effort to construct a policy-relevant set of environmental performance indicators is needed to jumpstart environmental progress in the context of sustainable development and the

[1] See also the summary report of the Millennium Project Task Force 6 on Millennium Development Goal 7 "Ensuring Environmental Sustainability."
[2] This sentiment was repeatedly expressed at the recent High Level Plenary of the General Assembly in New York, which reviewed the progress achieved in meeting the Millennium Development Goals (MDGs). Professor Jeffrey Sachs, Director of the Earth Institute at Columbia University and special advisor to the UN Secretary General on the MDGs, among others, called particular attention to this failure. UNDP/UNEP "Environment for the MDGs" policy dialogue, 14 September 2005.

MDGs. More generally, better data and analysis might help to revolutionize environmental protection, shifting governmental efforts toward more effective and efficient market mechanisms and information-based regulation (Esty, 2004).

Although the financing required for a major environmental indicator initiative would not be trivial, it is eminently affordable.[3] As a way to track the returns on environmental investments and unleash a competitive dynamic to spur better performance, metrics are very helpful.

The fundamental premise of this report is that qualitative information and subjective evaluation provide an insufficient foundation for policymaking in the environmental realm. In such a world, expectations are hard to evaluate, governments explain away sub-par performance, priorities cannot easily be set, and the limited financial resources available for environmental protection are often poorly deployed.

Quantitative measurement is needed to create a context for sound decisionmaking. Indicators that permit cross-country comparisons provide a further foundation for evaluating results, benchmarking performance, and clarifying what might be achieved in particular circumstances.

By choosing a proximity-to-target approach (see Chapter 2), the Pilot EPI seeks to meet the needs of governments to track actual, on-the-ground environmental results.[4] It offers a way to assess the effectiveness of their environmental policies against relevant performance goals. It is specifically designed to help policymakers:

- spot environmental problems;
- track pollution control and natural resource management trends;
- identify priority environmental issues;
- determine where current policies are producing good results—and where they are insufficient;
- provide a baseline for cross-country and cross-sectoral performance comparisons;
- find "peer groups" and identify leaders and laggards on an issue-by-issue basis; and
- identify best practices and successful policy models.

The Environmental Performance Index looks toward a world in which environmental targets are set explicitly, in which progress toward these goals is measured quantitatively, and policy evaluation is undertaken rigorously. As better data becomes 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. In addition, as greater consensus emerges over long-term environmental targets, the EPI methodology will permit global aggregations that will help to establish how close the world community is to an environmentally sustainable trajectory.

More generally, the EPI team hopes to spur action on better data collection across the world—facilitating movement towards a more empirical mode of environmental protection grounded on solid facts and careful analysis. By being forthright about the limitations of this Pilot Environmental Performance Index, the Yale Center for Environmental Law and Policy and CIESIN teams hope to advance the debate over the proper issues to track and the best methodology for constructing a composite environmental performance index.

[3] Consumers Union spends approximately $200 million per year measuring the performance characteristics of commercial products for the U.S. market.(http://www.consumerreports.org/annualreport/financialreport.pdf). This is approximately ten times the amount budgeted to monitor the MDG water and sanitation goals.
[4] In deploying the proximity-to-target approach, we build upon the Environmental Vulnerability Index (SOPAC, 2003).

2. The EPI Framework

The Pilot 2006 EPI offers a composite index of current national environmental protection results. Recognizing that on-the-ground conditions are the ultimate gauge of environmental performance, it focuses on measurable outcomes that can be linked to policy targets and, in principle, tracked over time.

The EPI builds on measures relevant to the goal of reducing environmental stresses on human health, which we call the Environmental Health objective. It also includes measures relevant to the goal of reducing the loss or degradation of ecosystems and natural resources—we call this the Ecosystem Vitality objective.

The quantitative metrics of the EPI encompass 16 indicators or datasets. These indicators were chosen through a broad-based review of the environmental policy literature, the policy consensus emerging from the Millennium Development Goal dialogue, and expert judgment. Together they span the range of priority environmental issues that are measurable through currently available data sources.

For each indicator, we have also identified a relevant long-term public health or ecosystem sustainability goal. Drawn from international agreements, standards set by international organizations or national authorities, or prevailing consensus among environmental scientists, the targets do not vary by country. Rather, they serve as absolute benchmarks for long-term environmental sustainability.

For each country and each indicator, we calculate a proximity-to-target value. Our data matrix covers 133 countries for which we have values across the 16 indicators. Data gaps mean that 60-plus countries cannot be ranked in the Pilot 2006 EPI.

Using the 16 indicators, we are able to evaluate environmental health and ecosystem vitality performance at three levels of aggregation.

First, we calculate scores, building on two to five underlying indicators, within six core policy categories—Environmental Health, Air Quality, Water Resources, Biodiversity and Habitat, Productive Natural Resources, and Sustainable Energy. This level of aggregation permits countries to track their relative performance within these well-established policy lines.

Second, we calculate scores within the two broad objectives—Environmental Health and Ecosystem Vitality. In the latter category, we draw upon the five policy category scores linked to this second objective.

Finally, we calculate an overall Environmental Performance Index, which is the average of the two broad objective scores.

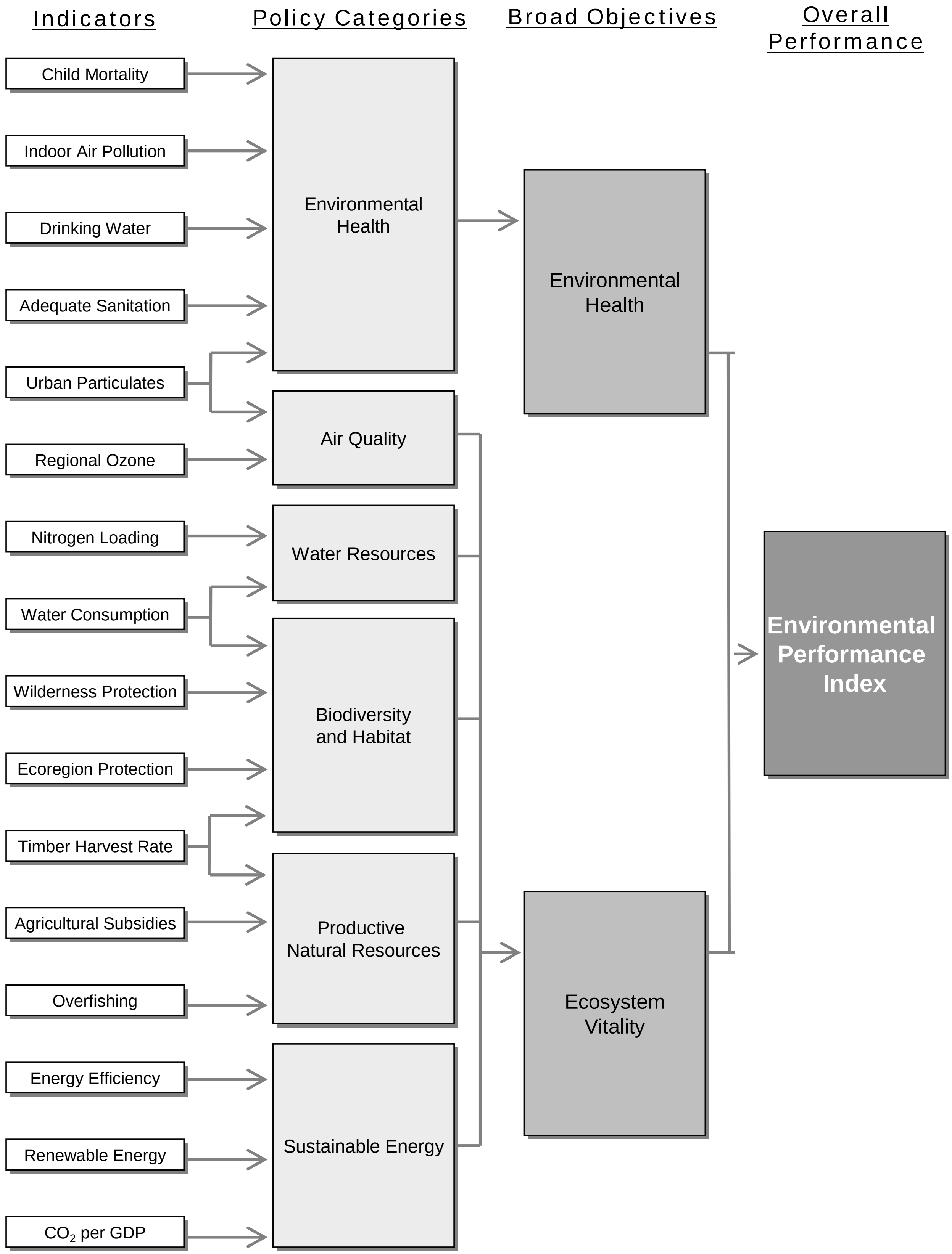


Figure 2: Construction of the EPI

2.1. Indicator Selection

Indicators were sought to cover the full spectrum of issues underlying each of the major policy categories identified. This exercise began with an effort to specify the relevant MDG issues in each policy category as established by reference to the environmental science and policy literature. For each issue identified, the EPI team attempted to find one or more datasets suitable for indicator construction. But the attempt to be comprehensive was constrained by a lack of reliable data, as discussed in more detail below.

To ensure the use of the most relevant and best available 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, including various geographic, climatic, and economic conditions.
- *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, ability to track changes over time, and transparency as to data sources and methods.
- *Data quality*. The data used by the indicator should meet basic quality requirements—and represent the best measure available.

2.2. Data Gaps and Country Coverage

The Pilot 2006 EPI builds on the best environmental data available. But much of it is not very good, and the gaps are significant. A lack of reliable data and limited country coverage severely constrain this effort to provide a firmer analytic foundation for environmental decisionmaking. Dozens of countries cannot be included in the EPI because data are not available for one or more of the 16 EPI indicators. And we lack reliable measures for many critical issues including: basic air pollutant emissions, such as SO_2 and VOCs; water pollution, such as fecal coliform and salinity; human exposures to toxic chemicals and heavy metals; and hazardous waste management and disposal (See Box 1 below). We looked for data across each of the 16 indicators for all countries. We found sufficient data for 133 countries.

Because most of the indicators are unrelated to other measures and because of our focus on *actual* policy results, we chose not to do imputations to fill holes in the data matrix. There were three exceptions to this rule. First, because of their high degree of correlation, countries with data points for either access to water or access to sanitation were included even if the other data point was missing. Second, countries without natural or plantation forests were given the value of zero for the timber harvest rate. Landlocked countries were given "no data" for the overfishing indicator, which measures a country's fish catch relative to productivity in its own coastal waters.

2.3. Targets

Research and policy dialogues concerning the measurement of environmental performance have long recognized the benefits arising from the use of absolute reference points rather than relative measures of country performance. Absolute targets provide more useful information about country-specific conditions and policy results, as well as areas in need of increased attention, resources, and worldwide trajectories. A country in 30^{th} place in a comparative ranking might be one of many nations very close to an ultimate target—meaning that the issue probably does not deserve priority attention. On the other hand, it could be that the top 30 countries are all very far from the ultimate target—and the issue should be a point of policy focus for everyone. In short, a proximity-to-target measure helps to clarify a comparative ranking and highlight policy priorities.

Box 1: Data Gaps

The Pilot 2006 EPI falls short of covering the full spectrum of Environmental Health and Ecosystem Vitality challenges in many respects. A number of important issues are not reflected in the index due to a lack of data. Notably, we have no reliably constructed indicators with broad-based country coverage of:

- human exposure to toxic chemicals;
- waste management and disposal practices;
- SO_2 emissions and acid rain;
- recycling and reuse rates;
- lead and mercury exposure;
- wetlands loss;
- soil productivity and erosion;
- greenhouse gas emissions (beyond CO_2);
- and ecosystem fragmentation.

Absent time series data on most of the 16 indicators, we cannot calculate (as we had hoped to) a Rate of Progress Index, meaning that we are unable to report on which countries are gaining (or losing) ground most quickly on the policy targets.

To develop the targets for the Pilot 2006 EPI, we screened international agreements, environmental and public health standards generated by international organizations and national governments, the scientific literature, and expert opinion from around the world. The targets should not be construed as policy goals specifically for industrialized nations with the resources to invest in pollution abatement technology and clean-up programs. On the contrary, though ambitious, obtaining or moving toward these targets is crucial for all countries regardless of development stage. And, in fact, some developing countries are closer than developed countries to the targets. Notably, with regard to sustainable energy and protecting biodiversity and habitat, many developing countries have high scores.

In practice, we found that four of the five Environmental Health indicators had explicit consensus targets already established. Only four of the twelve Ecosystem Vitality indicators had such targets established. This suggests that there is a clear need for the international policy community to sharpen its focus on desired outcomes and the requirements for long-term environmental sustainability.

2.4. Calculating the EPI

To make the 16 indicators comparable, each was converted to a proximity-to-target measure with a theoretical range of zero to 100. To avoid extreme values skewing aggregations, the indicator values for "outlier" countries were adjusted to make them equal to the value of the 5^{th} percentile country, a recognized statistical technique called winsorization. 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—stretching the observed values onto a zero to 100 scale where 100 corresponded to the target and zero to the worst observed value.

To help identify appropriate groupings and weights for each indicator, we carried out a principal component analysis (PCA). The PCA helped identify three clear groups of variables, corresponding to the Environmental Health, Sustainable Energy, and Biodiversity and Habitat categories. We used the statistically derived PCA factor loads as weights for these indicators. The other three categories did not have clear referents in the PCA results but emerged from our literature search and expert consultations. Absent a PCA-derived basis for weighting the indicators in these three categories, equal weights were used.

Table 3: EPI Indicators, Targets, and Weighting

Objective	Policy Category	Indicator*	Data Source*	Target	Target Source	Weight within Category	Weight within EPI
Environmental Health		Urban Particulates	World Bank, WHO	10 µg/m^3	Expert judgment [a]	.13	.50
		Indoor Air Pollution	WHO	0% of house-holds using solid fuels	Expert judgment [b]	.22	
		Drinking Water	WHO-UNICEF Joint Monitoring Program	100% access	MDG 7, Target 10, Indicator 30	.22	
		Adequate Sanitation	WHO-UNICEF Joint Monitoring Program	100% access	MDG 7, Target 10, Indicator 31	.22	
		Child Mortality	UN Population Division	0 deaths per 1,000 pop aged 1-4	MDG 4, Target 5, Indicator 13	.21	
Ecosystem Vitality and Natural Resource Management	Air Quality	Urban Particulates	World Bank, WHO	10 µg/m^3	Expert judgment [a]	.50	.10
		Regional Ozone	MOZART model	15 ppb	Expert judgment [c]	.50	
	Water Resources	Nitrogen Loading	UNH Water Systems Analysis Group	1 mg/liter	GEMS/Water expert group	.50	.10
		Water Consumption	UNH Water Systems Analysis Group	0% oversub-scription	By definition	.50	
	Biodiversity and Habitat	Wilderness Protection	CIESIN, Wildlife Conservation Society	90% of wild areas protected	Linked to MDG 7, Target 9	.39	.10
		Ecoregion Protection	CIESIN	10% for all biomes	Convention on Biological Diversity	.39	
		Timber Harvest Rate	FAO	3%	Expert judgment [d]	.15	
		Water Consumption	UNH Water Systems Analysis Group	0% oversub-scription	By definition	.07	
	Productive Natural Resources	Timber Harvest Rate	FAO	3%	Expert judgment [d]	.33	.10
		Overfishing	South Pacific Applied Geosciences Commission	No overfishing	By definition	.33	
		Agricultural Subsidies	WTO, USDA-ERS	0%	GATT and WTO agreements	.33	
	Sustainable Energy	Energy Efficiency	Energy Information Administration	1,650 Terajoules per million $ GDP	Linked to MDG 7, Target 9, Indicator 27	.43	.10
		Renewable Energy	Energy Information Administration	100%	Johannesburg Plan of Implementation	.10	
		CO_2 per GDP	Carbon Dioxide Information Analysis Center	0 net emissions	Expert judgment [e]	.47	

** Note: Full indicator names, definitions, and data sources are provided in Appendix H.*
[a] Determined in consultation with Kiran Pandey from the World Bank and other air pollution experts;
[b] Determined in consultation with Kirk Smith and Daniel Kammen at UC Berkeley and the indoor air pollution literature;
[c] Determined in consultation with Denise Mauzerall and her air pollution team at Princeton University;
[d] Determined in consultation with Lloyd Irland and Chad Oliver from the Yale School of Forestry and Environmental Studies;
[e] Strict interpretation of the goal of the 1992 UN Framework Convention on Climate Change.

3. Results and Analysis

The Pilot EPI results provide fertile ground for the analysis of country-level environmental performance. They also let us assess the prospects for making greater use of target-oriented decisionmaking in the sphere of environmental sustainability. The findings, and a review of global leaders and laggards in environmental performance, confirm some common perceptions about the determinants of policy success. But they also reveal some surprises and otherwise unexpected relationships among countries.

3.1. Overall EPI Results

The top five countries in the Pilot 2006 EPI are New Zealand, Sweden, Finland, the Czech Republic, and the United Kingdom. The lowest five ranked countries are Ethiopia, Mali, Mauritania, Chad, and Niger. Mid-ranked performers of note include the United States (28), Russia (32), Brazil (34), Mexico (66), South Africa (76), and China (94).

Table 1 shows that most of the top performers in the EPI are developed economies with high capacity for sophisticated environmental protection. The leaders, including industrialized countries in Europe, Asia, and the Americas, all invest heavily in protecting the environmental health of their citizens. Of the 20 countries with the highest EPI scores, all but two have Environmental Health scores in the high 90s. However, these top-ranked countries show considerable spread in their Ecosystem Vitality scores. Average scores for each of the five policy areas that fall within the Ecosystem Vitality objective range from 60 to 81, corresponding to Ecosystem Vitality ranks ranging from 9th to 88th. For example, New Zealand's management of productive natural resources shows plenty of room for improvement. And Sweden's biodiversity and habitat protection emerges as sub-par.

The countries at the bottom of the EPI rankings are more diverse than those at the top. Niger and Chad, for example have extremely low Environmental Health scores. Pakistan and Mongolia, however, also have EPI scores in the bottom 20 but have Environmental Health scores in the middle of the pack. There are not many surprises among the worst performing countries. For the most part these are either densely populated industrializing countries with stressed ecosystems (Bangladesh, India, and Pakistan), arid states with limited natural resource endowments (Mauritania, Mali, and Yemen), or very poor countries (Ethiopia, Chad, and Niger). In every case, the countries with low EPI scores have under-invested in environmental infrastructure (drinking water and sanitation systems) and lack the capacity for aggressive pollution control or systematic natural resource management.

Among the middle-rank countries, performance is often uneven. Russia, for example, has top-tier scores in water but disastrously low sustainable energy results. Likewise, Brazil has very high water scores but low biodiversity indicators. The United States stands near the top in environmental health, but ranks near the bottom in management of productive natural resources.

Table 4: EPI scores (alphabetical, 0-100)

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
57	Albania	68.9	58	Guatemala	68.9	62	Paraguay	66.4
63	Algeria	66.2	113	Guinea	49.2	65	Peru	65.4
128	Angola	39.3	120	Guinea-Bissau	46.1	55	Philippines	69.4
30	Argentina	77.7	114	Haiti	48.9	38	Poland	76.2
69	Armenia	63.8	52	Honduras	70.8	11	Portugal	82.9
20	Australia	80.1	33	Hungary	77.0	90	Romania	56.9
6	Austria	85.2	13	Iceland	82.1	32	Russia	77.5
95	Azerbaijan	55.7	118	India	47.7	89	Rwanda	57.0
125	Bangladesh	43.5	79	Indonesia	60.7	59	Saudi Arabia	68.3
39	Belgium	75.9	53	Iran	70.0	107	Senegal	52.1
84	Benin	58.4	10	Ireland	83.3	111	Sierra Leone	49.5
71	Bolivia	63.4	45	Israel	73.7	25	Slovakia	79.1
34	Brazil	77.0	21	Italy	79.8	31	Slovenia	77.5
50	Bulgaria	72.0	43	Jamaica	74.7	76	South Africa	62.0
126	Burkina Faso	43.2	14	Japan	81.9	42	South Korea	75.2
108	Burundi	51.6	64	Jordan	66.0	23	Spain	79.2
110	Cambodia	49.7	70	Kazakhstan	63.5	67	Sri Lanka	64.6
100	Cameroon	54.1	93	Kenya	56.4	124	Sudan	44.0
8	Canada	84.0	80	Kyrgyzstan	60.5	48	Suriname	72.9
87	Central Afr. Rep.	57.3	102	Laos	52.9	101	Swaziland	53.9
132	Chad	30.5	36	Lebanon	76.7	2	Sweden	87.8
26	Chile	78.9	109	Liberia	51.0	16	Switzerland	81.4
94	China	56.2	116	Madagascar	48.5	97	Syria	55.3
17	Colombia	80.4	91	Malawi	56.5	24	Taiwan	79.1
112	Congo	49.4	9	Malaysia	83.3	117	Tajikistan	48.2
15	Costa Rica	81.6	130	Mali	33.9	83	Tanzania	59.0
86	Côte d'Ivoire	57.5	131	Mauritania	32.0	61	Thailand	66.8
41	Cuba	75.3	66	Mexico	64.8	103	Togo	52.8
29	Cyprus	78.4	75	Moldova	62.9	35	Trinidad & Tobago	76.9
4	Czech Rep.	86.0	115	Mongolia	48.8	82	Tunisia	60.0
119	Dem. Rep. Congo	46.3	68	Morocco	64.1	49	Turkey	72.8
7	Denmark	84.2	121	Mozambique	45.7	104	Turkmenistan	52.3
54	Dominican Rep.	69.5	88	Myanmar	57.0	78	Uganda	60.8
40	Ecuador	75.5	92	Namibia	56.5	51	Ukraine	71.2
85	Egypt	57.9	81	Nepal	60.2	47	United Arab Em.	73.2
73	El Salvador	63.0	27	Netherlands	78.7	5	United Kingdom	85.6
129	Ethiopia	36.7	1	New Zealand	88.0	28	United States	78.5
3	Finland	87.0	56	Nicaragua	69.2	105	Uzbekistan	52.3
12	France	82.5	133	Niger	25.7	44	Venezuela	74.1
46	Gabon	73.2	123	Nigeria	44.5	99	Viet Nam	54.3
106	Gambia	52.3	18	Norway	80.2	122	Yemen	45.2
77	Georgia	61.4	60	Oman	67.9	98	Zambia	54.4
22	Germany	79.4	127	Pakistan	41.1	74	Zimbabwe	63.0
72	Ghana	63.1	37	Panama	76.5			
19	Greece	80.2	96	Papua New Guinea	55.5			

3.2. EPI Results by Peer Group

While each country has unique socio-economic and geographic characteristics, risk preferences, environmental policy priorities, and development goals, cross-country comparisons nevertheless yield useful insights. "Peer group" analysis provides performance comparisons of countries that are similar with respect to certain characteristics, such as socio-economic development, climate, land area, and population density. This analysis allows the identification of leaders and laggards and the exchange of information on policy experiences and best practices.

Nations at a similar level of development (e.g. OECD, LDCs) provide a starting point for comparative analysis. Other points of comparison include: regional groupings; (e.g. ASEAN, NIS); political associations or free-trade areas (e.g. EU, FTAA); and those with similar climatic circumstances (e.g. desert countries) or demographic structures (e.g. high population density). We present all these potential peer groups below.

Grouping OECD countries highlights many of the EPI's top performers (Table 5). Twenty-one of the OECD countries rank within the top 25 countries overall, and all OECD countries rank in the top half of the EPI rankings. By comparing countries that are at a similar level of development, these high achievers are able to adequately benchmark themselves against other countries facing the challenges inherent in developed nations. For instance, while developed countries generally perform better on water quality and access, air quality, and environmental health indicators, these same countries can look to one another to determine how to improve energy efficiency, reduce CO_2 emissions, and better protect biodiversity and habitat.

Grouping Least Developed Countries (LDCs) highlights the relationship between economic capacity and environmental performance (Table 6). All of the LDCs rank within the bottom half of the EPI, and make up eight of the ten lowest scoring countries. The limited financial resources of these countries severely constrain their ability to meet environmental policy targets, particularly those within the air quality and environmental health policy categories.

Table 5: OECD Member Countries — Organisation for Economic Co-operation and Development member countries

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	New Zealand	88.0	11	France	82.5	21	Slovakia	79.1
2	Sweden	87.8	12	Iceland	82.1	22	Netherlands	78.7
3	Finland	87.0	13	Japan	81.9	23	United States	78.5
4	Czech Rep.	86.0	14	Switzerland	81.4	24	Hungary	77.0
5	United Kingdom	85.6	15	Norway	80.2	25	Poland	76.2
6	Austria	85.2	16	Greece	80.2	26	Belgium	75.9
7	Denmark	84.2	17	Australia	80.1	27	South Korea	75.2
8	Canada	84.0	18	Italy	79.8	28	Turkey	72.8
9	Ireland	83.3	19	Germany	79.4	29	Mexico	64.8
10	Portugal	82.9	20	Spain	79.2			

Table 6: LDCs — Least Developed Countries

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Uganda	60.8	12	Gambia	52.3	23	Mozambique	45.7
2	Nepal	60.2	13	Senegal	52.1	24	Yemen	45.2
3	Tanzania	59.0	14	Burundi	51.6	25	Sudan	44.0
4	Benin	58.4	15	Liberia	51.0	26	Bangladesh	43.5
5	Central Afr. Rep.	57.3	16	Cambodia	49.7	27	Burkina Faso	43.2
6	Myanmar	57.0	17	Sierra Leone	49.5	28	Angola	39.3
7	Rwanda	57.0	18	Guinea	49.2	29	Ethiopia	36.7
8	Malawi	56.5	19	Haiti	48.9	30	Mali	33.9
9	Zambia	54.4	20	Madagascar	48.5	31	Mauritania	32.0
10	Laos	52.9	21	Dem. Rep. Congo	46.3	32	Chad	30.5
11	Togo	52.8	22	Guinea-Bissau	46.1	33	Niger	25.7

Note: Countries identified are those listed by the United Nations Office of the High Representative for the Least Developed Countries, Land-Locked Developing Countries and Small Island Developing States' List of Least Developed Countries found at http://www.un.org/special-rep/ohrlls/ldc/list.htm.

Table 7: High Population Density Countries — Countries and territories in which more than half the land area has a population density above 100 persons per square kilometer

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Japan	81.9	7	Belgium	75.9	13	Nepal	60.2
2	Italy	79.8	8	South Korea	75.2	14	Rwanda	57.0
3	Germany	79.4	9	Jamaica	74.7	15	Burundi	51.6
4	Netherlands	78.7	10	Philippines	69.4	16	Haiti	48.9
5	Trinidad & Tobago	76.9	11	Sri Lanka	64.6	17	India	47.7
6	Lebanon	76.7	12	El Salvador	63.0	18	Bangladesh	43.5

Note: Countries identified using CIESIN's PLACE dataset (CIESIN 2003).

Table 8: Desert Countries — Countries that are more than 50% desert (WWF Biome Classification)

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Israel	73.7	6	Morocco	64.1	11	Turkmenistan	52.3
2	Iran	70.0	7	Kazakhstan	63.5	12	Uzbekistan	52.3
3	Oman	67.9	8	Egypt	57.9	13	Pakistan	41.1
4	Algeria	66.2	9	Namibia	56.5	14	Mauritania	32.0
5	Jordan	66.0	10	Azerbaijan	55.7	15	Niger	25.7

Note: Countries identified using CIESIN's PLACE dataset (CIESIN 2003)

Table 9: FTAA Member Countries — Free Trade Area of the Americas Member Countries

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Canada	84.0	9	Panama	76.5	17	Guatemala	68.9
2	Costa Rica	81.6	10	Ecuador	75.5	18	Paraguay	66.4
3	Colombia	80.4	11	Jamaica	74.7	19	Peru	65.4
4	Chile	78.9	12	Venezuela	74.1	20	Mexico	64.8
5	United States	78.5	13	Suriname	72.9	21	Bolivia	63.4
6	Argentina	77.7	14	Honduras	70.8	22	El Salvador	63.0
7	Brazil	77.0	15	Dominican Rep.	69.5	23	Haiti	48.9
8	Trinidad & Tobago	76.9	16	Nicaragua	69.2			

Table 10: EU Member Countries — European Union Member Countries

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Sweden	87.8	8	Portugal	82.9	14	Slovakia	79.1
2	Finland	87.0	9	France	82.5	15	Netherlands	78.7
3	Czech Rep.	86.0	10	Greece	80.2	16	Slovenia	77.5
4	United Kingdom	85.6	11	Italy	79.8	17	Hungary	77.0
5	Austria	85.2	12	Germany	79.4	18	Poland	76.2
6	Denmark	84.2	13	Spain	79.2	19	Belgium	75.9
7	Ireland	83.3						

Table 11: ASEAN (Plus Three) Countries — Association of Southeast Asian Nations Member Countries and China, Japan, and South Korea

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Malaysia	83.3	5	Thailand	66.8	9	Viet Nam	54.3
2	Japan	81.9	6	Indonesia	60.7	10	Laos	52.9
3	South Korea	75.2	7	Myanmar	57.0	11	Cambodia	49.7
4	Philippines	69.4	8	China	56.2			

Table 12: African Union Member Countries

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Gabon	73.2	14	Malawi	56.5	27	Guinea	49.2
2	Algeria	66.2	15	Namibia	56.5	28	Madagascar	48.5
3	Ghana	63.1	16	Kenya	56.4	29	Guinea-Bissau	46.1
4	Zimbabwe	63.0	17	Zambia	54.4	30	Mozambique	45.7
5	South Africa	62.0	18	Cameroon	54.1	31	Nigeria	44.5
6	Uganda	60.8	19	Swaziland	53.9	32	Sudan	44.0
7	Tunisia	60.0	20	Togo	52.8	33	Burkina Faso	43.2
8	Tanzania	59.0	21	Gambia	52.3	34	Angola	39.3
9	Benin	58.4	22	Senegal	52.1	35	Ethiopia	36.7
10	Egypt	57.9	23	Burundi	51.6	36	Mali	33.9
11	Côte d'Ivoire	57.5	24	Liberia	51.0	37	Mauritania	32.0
12	Central Afr. Rep.	57.3	25	Sierra Leone	49.5	38	Chad	30.5
13	Rwanda	57.0	26	Congo	49.4	39	Niger	25.7

Table 13: NIS Member Countries — Russia and Newly Independent States that were republics of the former Soviet Union

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Russia	77.5	5	Moldova	62.9	9	Turkmenistan	52.3
2	Ukraine	71.2	6	Georgia	61.4	10	Uzbekistan	52.3
3	Armenia	63.8	7	Kyrgyzstan	60.5	11	Tajikistan	48.2
4	Kazakhstan	63.5	8	Azerbaijan	55.7			

Table 14: APEC Member Countries — Asia-Pacific Economic Cooperation Member Countries

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	New Zealand	88.0	7	United States	78.5	13	Mexico	64.8
2	Canada	84.0	8	Russia	77.5	14	Indonesia	60.7
3	Malaysia	83.3	9	South Korea	75.2	15	China	56.2
4	Japan	81.9	10	Philippines	69.4	16	Papua New Guinea	55.5
5	Australia	80.1	11	Thailand	66.8	17	Viet Nam	54.3
6	Chile	78.9	12	Peru	65.4			

Densely populated countries are dispersed throughout the EPI rankings, with the highest (Japan) ranking 14th in the EPI and the lowest (Bangladesh) ranking 125th (Table 7). These disparate rankings mirror the varied socio-economic and regional affiliations of these countries. This peer group makes it clear that demography is not destiny. Low-performing high population density countries clearly would benefit from adoption of the best practices of high-performers on issues that relate to their common circumstances. In particular, sharing information on how to protect wilderness and control urban air pollution would be useful.

The Desert Countries peer grouping takes into consideration the unique ecological challenges these countries face (Table 8). The top ten countries fall into the mid-range of the EPI ranking and the last three countries in this peer group—Pakistan, Mauritania, and Niger—rank in the lowest ten overall. This peer group permits policy comparisons related to dealing with aridity and the subsequent water management and ecosystem vulnerability issues that arise.

Peer groups based on free-trade areas tend to overlap and coincide with regional groupings. In the case of the FTAA, member countries range from 8th ranked (Canada), to 114th ranked (Haiti), demonstrating the vast range in environmental performance across the FTAA, which may become a source of trade tensions (Table 9). All of the EU countries, on the other hand, rank within the top third of the EPI, leaving much less scope for trade disputes arising from disparate environmental standards or performance (Table 10).

Regional associations provide a natural basis for peer grouping. Shared geography represents an important point of similarity, and countries often think of themselves as being similar to their neighbors. In tables 12 through 13 above, the member countries are sometimes similarly ranked, as in the case of the African Union and NIS. In other cases, their ranks are vastly disparate, as in the case of APEC.

3.3. Cluster Analysis

Countries may have similar EPI scores but very different patterns across the 16 indicators and policy categories. To help governments identify peer countries that are similarly situated with respect to the individual indicators, we carried out a statistical procedure known as cluster analysis (for more information, refer to Appendix F). This process allowed us to group countries in terms of overall similarity across the 16 indicators. This process generated six country clusters that seem useful as a way to help countries look beyond their income-level or geographic peer groups for models of environmental success in countries facing similar challenges. See Figures 3-9 for spider graphs and a map of the cluster analysis peer groupings.

Cluster One

Cluster One is a combination of oil-rich countries from the Middle East and other Eastern European and Central Asian countries with growing economies and significant water stress. On average, these countries are fairly close to targets for the Environmental Health and Productive Natural Resources indicators, but they are very far from targets concerning the Sustainable Energy and Biodiversity and Habitat indicators. They also exhibit high levels of air pollution.

Cluster Two

Cluster Two combines primarily Latin American and Asian countries with relatively intact natural systems but growing resource pressures. These countries are characterized by good water systems but poor air quality. They have mid-range scores on the other measures.

Cluster Three

The countries in this cluster, which includes some of the world's largest and most rapidly industrializing nations, face the challenges of building environmental infrastructure as well as developing systems to control air and water pollution and protect ecosystems. Pollution and resource management challenges are growing in all of these countries. Air Quality and Biodiversity and Habitat scores are particularly low.

Cluster Four

Cluster Four contains most of the less developed economies of Sub-Saharan Africa and a few from Asia. They all face serious sustainable development challenges and environmental health threats. Many of these countries have suffered recent conflicts. All are characterized by very poor scores on Environmental Health but mid-range to good scores on the other measures, reflecting low levels of industrialization and therefore limited pollution and ecosystem degradation.

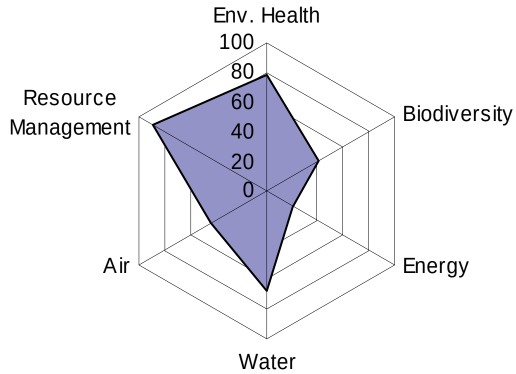
Cluster Five

Cluster Five is made up of European and major Asian economies as well as the United States and Venezuela. This is one of two groupings dominated by wealthy countries. Compared to the other wealthy countries, this group does significantly worse in terms of natural resource management and slightly better in terms of biodiversity protection.

Cluster Six

Cluster Six is made up of European countries with a few additional resource-rich countries. This is the other group that contains primarily wealthy countries. These countries show somewhat better management of productive natural resources and somewhat worse biodiversity protection than their counterparts in Cluster Five.

Cluster One Attributes

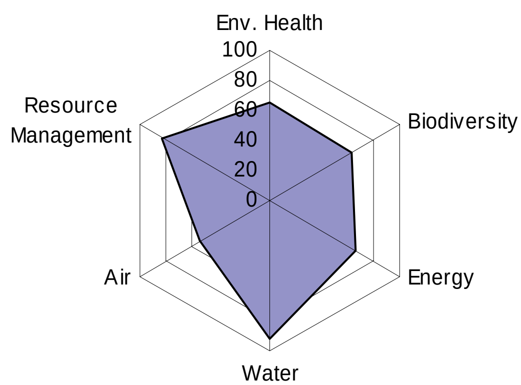


Countries in Cluster

- Armenia
- Azerbaijan
- Bulgaria
- Iran
- Kazakhstan
- Moldova
- Oman
- Russia
- Saudi Arabia
- Syria
- Trinidad & Tobago
- Turkmenistan
- Ukraine
- United Arab Emirates
- Uzbekistan

Figure 3: Cluster One

Cluster Two Attributes

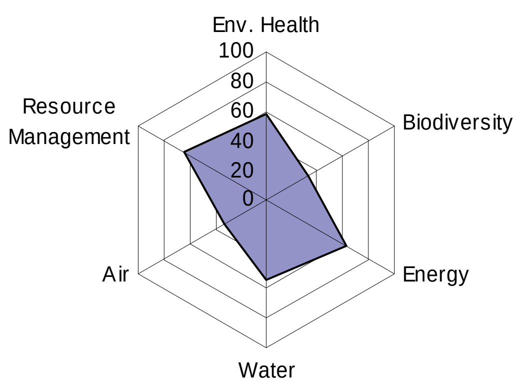


Countries in Cluster

- Bolivia
- Brazil
- Colombia
- Costa Rica
- Cuba
- Dominican Republic
- Ecuador
- Gabon
- Georgia
- Guatemala
- Honduras
- Indonesia
- Jamaica
- Kyrgyzstan
- Malaysia
- Myanmar
- Nepal
- Nicaragua
- Panama
- Paraguay
- Peru
- Philippines
- Sri Lanka
- Suriname
- Tajikistan
- Thailand
- Vietnam
- Zimbabwe

Figure 4: Cluster Two

Cluster Three Attributes

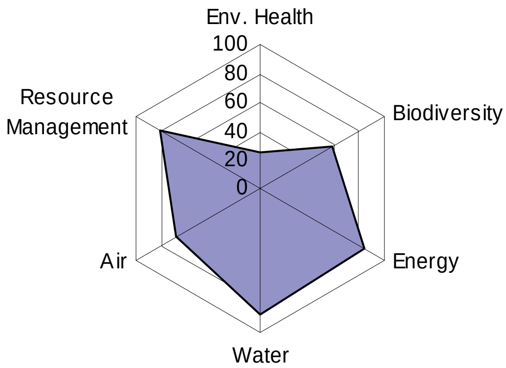


Countries in Cluster

- Algeria
- Bangladesh
- China
- Egypt
- El Salvador
- Haiti
- India
- Mauritania
- Mexico
- Mongolia
- Morocco
- Pakistan
- Romania
- Tunisia
- Yemen

Figure 5: Cluster Three

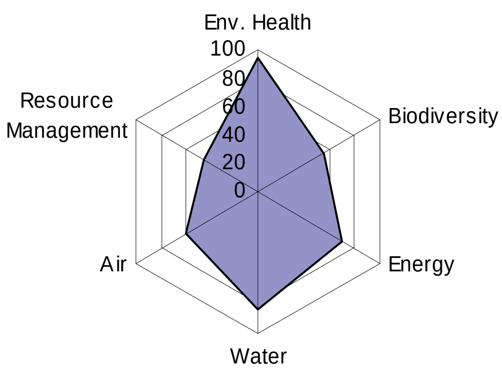
Cluster Four Attributes	Countries in Cluster



- Angola
- Benin
- Burkina Faso
- Burundi
- Cambodia
- Cameroon
- Central Af. Rep.
- Chad
- Congo Côte d'Ivoire
- Dem. Rep. Congo
- Ethiopia
- Gambia
- Ghana
- Guinea
- Guinea-Bissau
- Kenya
- Laos
- Liberia
- Madagascar
- Malawi
- Mali
- Mozambique
- Namibia
- Niger
- Nigeria
- Papua New Guinea
- Rwanda
- Senegal
- Sierra Leone
- Sudan
- Swaziland
- Tanzania
- Togo
- Uganda
- Zambia

Figure 6: Cluster Four

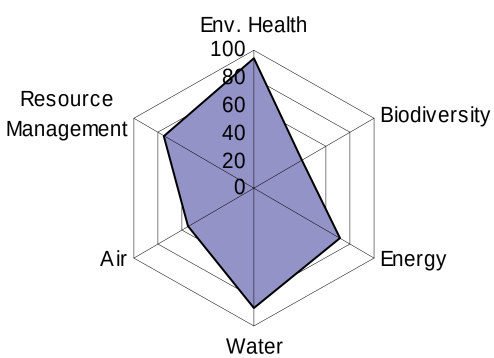
Cluster Five Attributes	Countries in Cluster



- Cyprus
- France
- Hungary
- Iceland
- Israel
- Italy
- Japan
- Jordan
- New Zealand
- Norway
- Slovakia
- Slovenia
- South Africa
- South Korea
- Spain
- Switzerland
- Taiwan
- United States
- Venezuela

Figure 7: Cluster Five

Cluster Six Attributes	Countries in Cluster



- Albania
- Argentina
- Australia
- Austria
- Belgium
- Canada
- Chile
- Czech Republic
- Denmark
- Finland
- Germany
- Greece
- Ireland
- Lebanon
- Netherlands
- Poland
- Portugal
- Sweden
- Turkey
- United Kingdom

Figure 8: Cluster Six

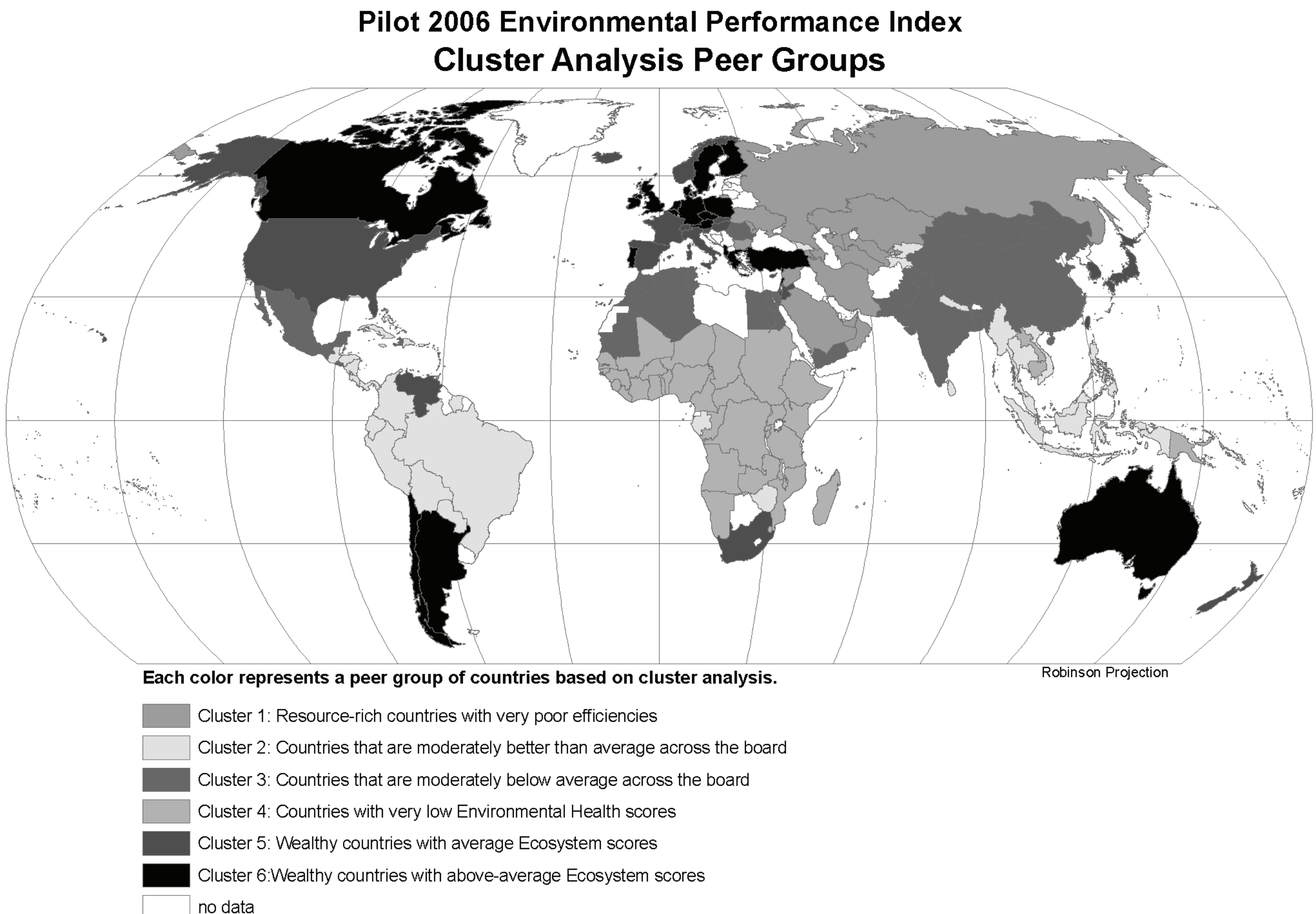


Figure 9: Map of Cluster Analysis

3.4. EPI Drivers

This section analyzes the EPI scores in relation to possible determinants of environmental policy success. In particular, we explore the correlation between the EPI and (1) GDP per capita; (2) good governance; and (3) the Human Development Index (HDI). We also explore whether environmental success must be sacrificed to achieve economic competitiveness, as traditional economic theory has suggested.

GDP per capita

There is a statistically significant correlation between GDP per capita and the EPI. Nevertheless, at every income level there is some variation in EPI scores. The spread in scores is greatest at the lowest levels of income. For example, Tanzania does far better than Niger at a similar level of income. The most developed countries consistently have scores in the top half of the EPI distribution. But even here, countries such as Sweden and Belgium differ markedly in their scores.

A plot of EPI scores against GDP (log) shows that countries with per capita incomes above $10,000 all have EPI scores greater than 65. Yet there is little relationship between per-capita income and EPI scores among these wealthy countries. Likewise, among the poor countries there is considerable variation in EPI scores, even though the very poorest all have scores below 60.

Beneath the aggregation level of the EPI, the only policy category that demonstrates a strong relationship to income is the Environmental Health category. This correlation makes sense, since most of the indicators included in this category—water and sanitation, child mortality, indoor air pollution, and urban particulates concentrations—depend on resource capacity and investment. None of the other policy categories showed a strong correlation with income, although the Productive Natural Resources category has a weak negative correlation with income. Thus, it appears that at every level of development, some nations are managing their pollution control and natural resource management challenges relatively well. Others with the same economic capacity are performing much less well.

We examined the relationship between per capita income and some of the individual indicators to get a more precise picture of how income levels affect environmental performance. As already noted, the Environmental Health scores have the highest correlation with per capita income. Conceptually, they have the strongest relationship to economic development, therefore this result is not surprising. The indicators that are strongly negatively correlated with per capita income reflect a mix of dynamics. The Regional Ozone indicator reflects both the fact that regional ozone concentrations have not been the focus of major policy action (as compared to urban particulates), and that long-range transport dynamics tend to circulate the highest ozone levels within a range of latitudes dominated by wealthier countries.

The other indicators for which poorer countries tend to be closer to the targets primarily reflect differences in economic opportunity. For example, to seriously engage in overfishing requires the ability to build, operate and finance large sophisticated fishing fleets. It is not surprising, therefore, that no country below the median income level has the highest intensity of overfishing. By contrast, more than 25% of the countries in the wealthiest decile have the highest score possible. In a similar vein, one reason that most wealthy countries tend to have poorer energy efficiency and renewable energy scores is that they have economies that bring greater economic returns from energy consumption. Likewise, the high scores for protection of wilderness in poor countries reflect in part their lack of economic development and therefore relatively pristine land.

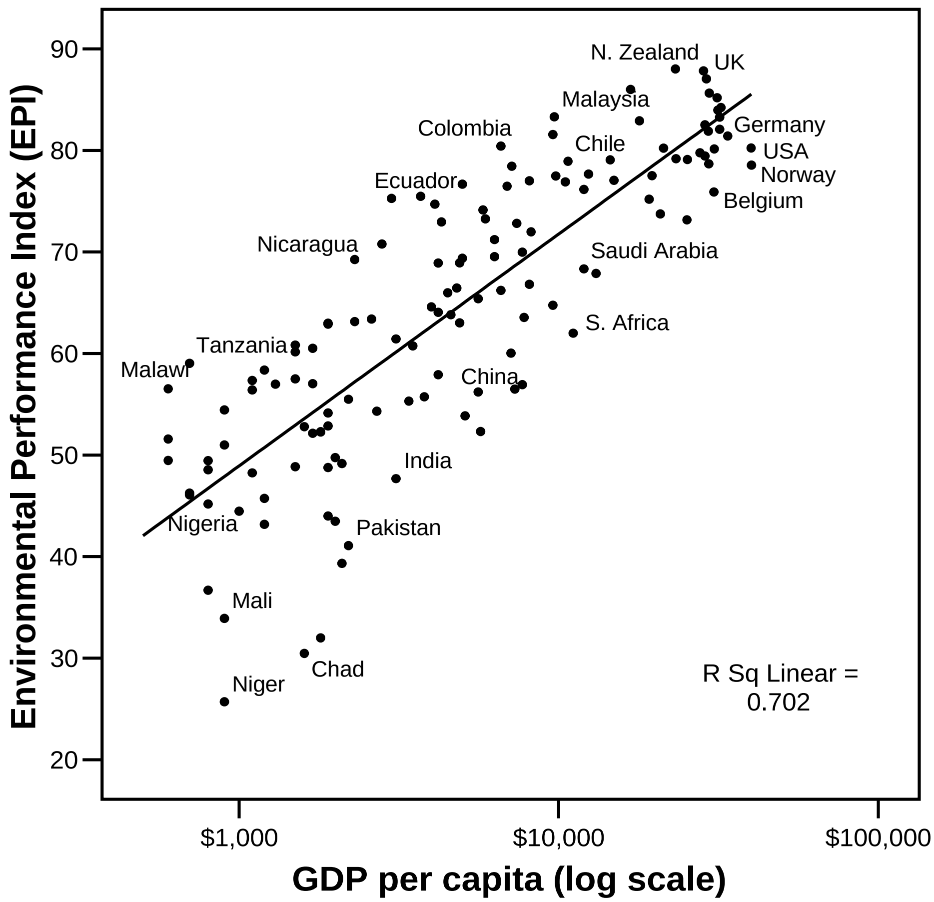


Figure 10: Relationship of 2006 EPI and GDP per capita

Table 15: Correlation between GDP per capita and EPI Indicators

Significant and Positive		**Significant and Negative**		**Not Significant**	
Indoor Air Pollution	0.875	Agricultural Subsidies	-0.570	Nitrogen Loading	0.114
Adequate Sanitation	0.851	Regional Ozone	-0.493	CO2 per GDP	0.068
Drinking Water	0.787	Energy Efficiency	-0.224	Water Consumption	-0.114
Child Mortality	0.772	Overfishing	-0.211	Ecoregion Protection	-0.129
Urban Particulates	0.447	Renewable Energy	-0.199		
Timber Harvest Rate	0.290	Wilderness Protection	-0.192		

Note: Pearson's Correlation Coefficient. T value significance determined at .001 level or better.

Good Governance

The figure below shows a strong relationship between environmental results and good governance as measured in the 2005 ESI. The governance measure in the ESI encompassed a dozen variables including: corruption; rule of law; regulatory effectiveness; and the vigor of debate on environmental issues. Indeed, governance explains a significant part of the variance in EPI scores. This result provides support for the policy emphasis being placed on governance in the international arena.

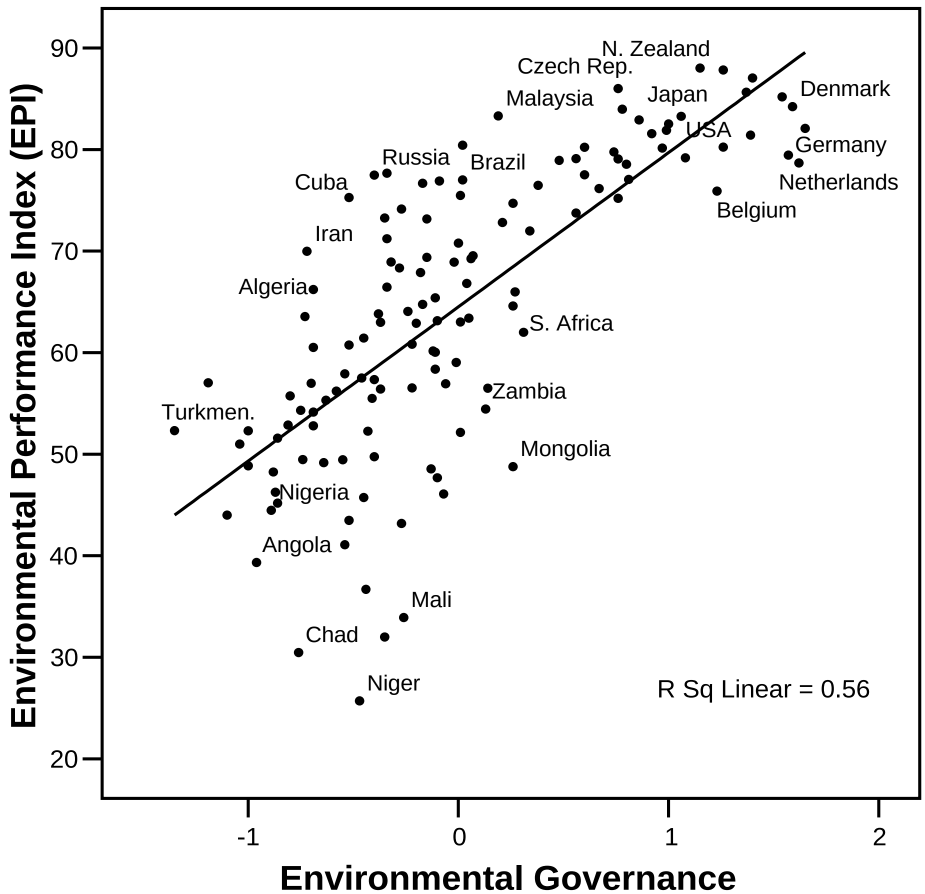


Figure 11: Relationship of 2006 EPI and Governance

(from the 2005 Environmental Sustainability Index)

EPI versus Human Development Index

The relationship between the EPI and the Human Development Index (HDI) is very similar to that between the EPI and per capita income. In general, the countries with the highest HDI scores also have the lowest variance in environmental performance and show up in the top half of the EPI distribution. Countries with lower HDI scores almost always show less strong environmental performance.

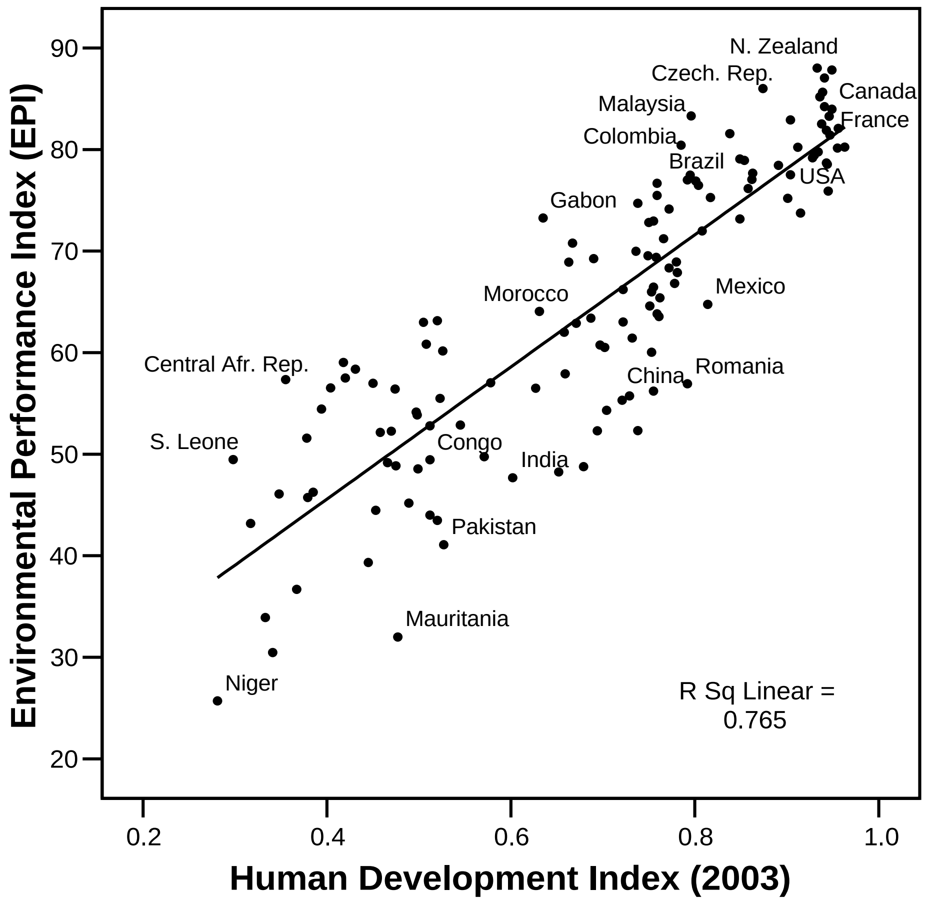


Figure 12: Relationship of 2006 EPI and Human Development Index

EPI versus Competitiveness

The positive relationship between the EPI and as measured by the World Economic Forum's 2005 Global Competitiveness Index (GCI) (Lopez-Claro, 2005) suggests that good environmental results do not have to be sacrificed to achieve economic success (see Figure 13). But this result may be explained by the high degree of correlation between both of these measures and GDP. There is considerable spread in environmental performance among less competitive economies, with countries such as Pakistan and the Philippines sharing similar GCI scores but very different environmental performance profiles.

The correlation revealed between environmental performance and competitiveness tends to be consistent with the Porter Hypothesis (suggesting that demanding environmental standards will spur innovation and competitive advantage) (Porter, 1991). But absent time-series data, this relationship cannot be confirmed as a causal linkage.

We can, however, explore the relationship between competitiveness and ecosystem degradation and the depletion of natural resources, as measured by the Ecosystem Vitality scores within the EPI. The results, shown in Figure 14, show no clear pattern. This suggests that some countries may be choosing to enhance their competitiveness by pursuing economic growth with little regard to the environmental consequences. Other countries are achieving strong competitive positions without diminishing ecosystem vitality. More work needs to be done, however, to make fuller sense of the competitiveness-environmental relationship.

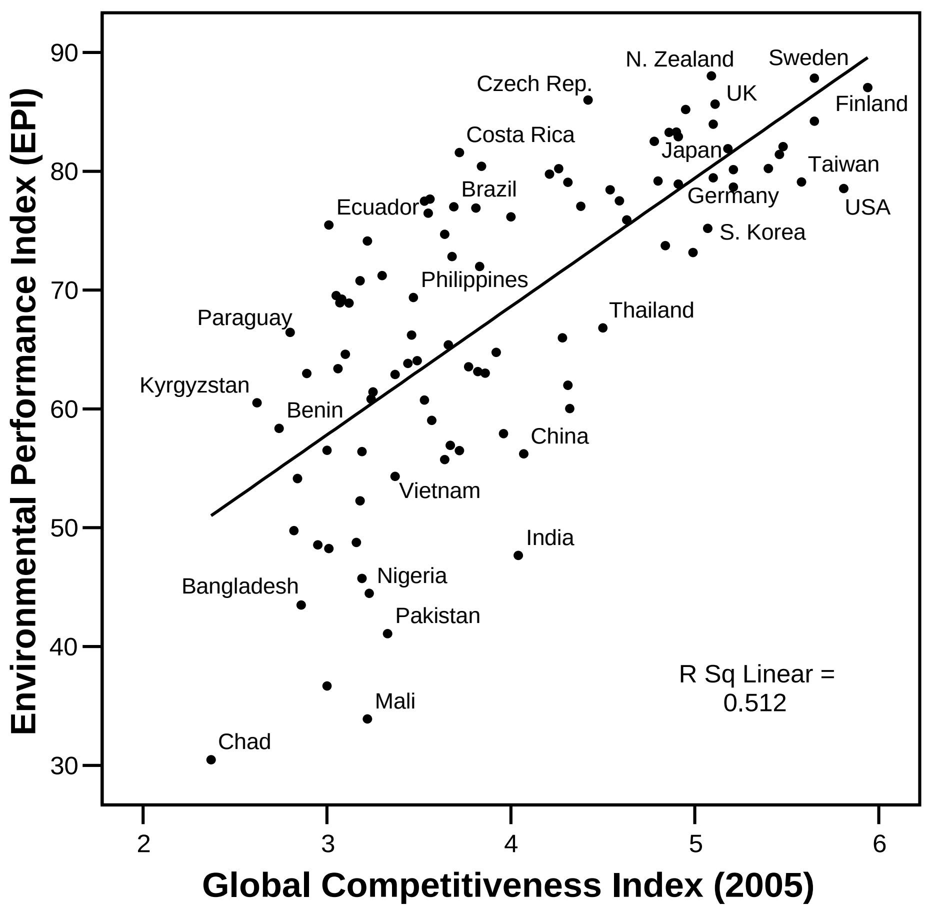


Figure 13: Relationship of 2006 EPI and Competitiveness

(From the Global Competitiveness Report (Porter et al., 2005)

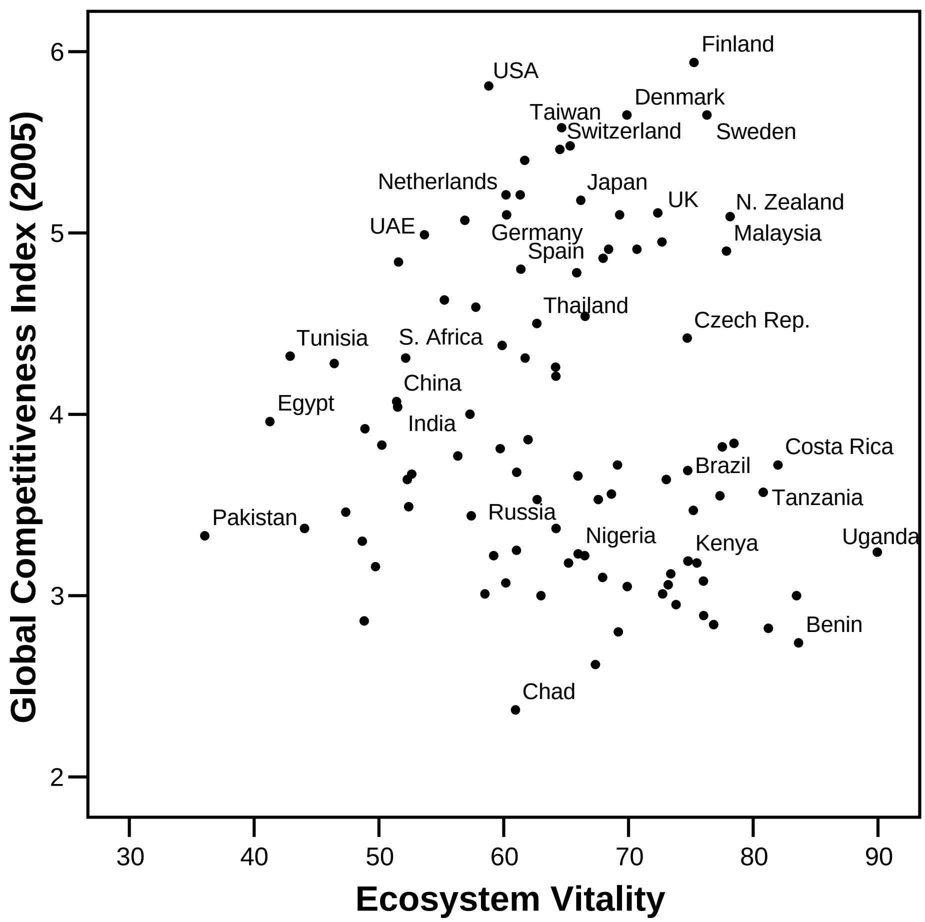


Figure 14: Relationship of Competitiveness and Ecosystem Vitality

3.5. Implications for Global Policymaking

An examination of the proximity-to-target scores can give us some insights into the nature of global policy challenges from the perspective of environmental sustainability. We can graphically summarize these scores across the 16 indicators with "box plot" diagrams.

Figure 15 portrays the distribution of proximity-to-target scores, according to the following conventions:

- The range of values seen in the middle 50% of countries is represented by the shaded bar.
- The median value is represented by the thick vertical line within the shaded bars.
- The thin horizontal line extends a distance of 1.5 times the length of the shaded bar (or less if the values do not extend this far). It is used to identify outliers; under conditions of normal distribution 99% of the cases would be within the range defined by these thin lines.
- The outlier values are marked by circles (○); the extreme outliers (located at a distance from the shaded bar edge that is more than three times the width of the shaded bar) are marked by stars (*).

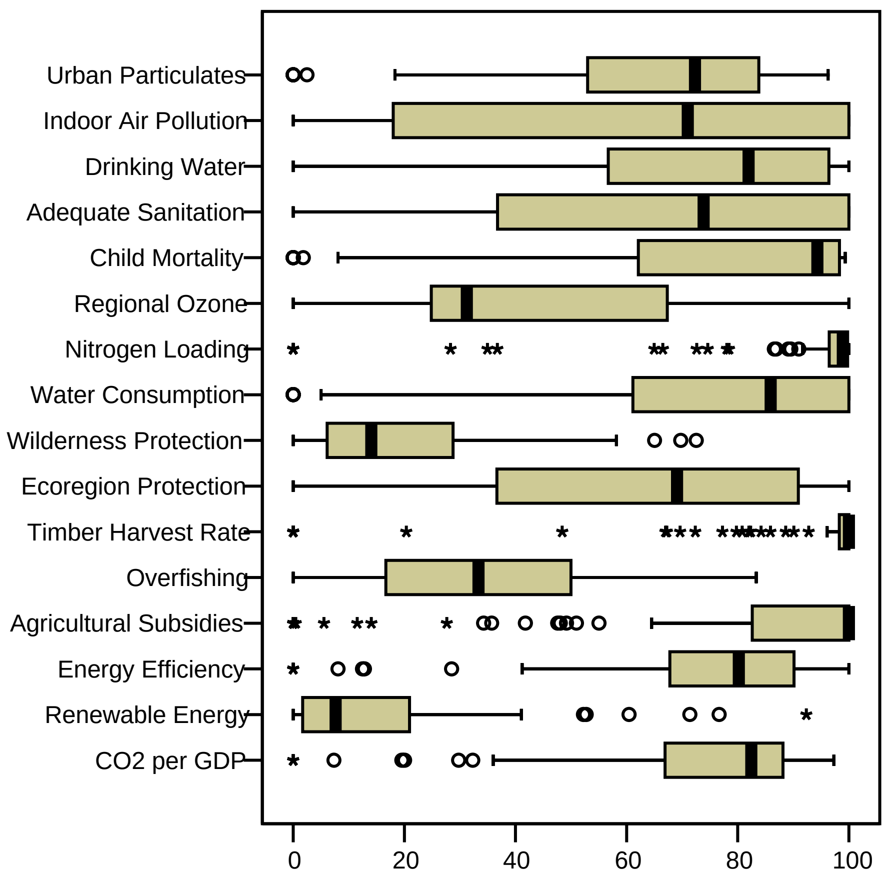


Figure 15: Distribution of Proximity-to-Target Scores for All Countries

For the indicators that show relatively wide shaded bars and few outliers, the policy action required is likely to consist of broad programmatic interventions aimed at improving large groups of countries. For the most part these indicators are likely to be well suited to MDG-type attention, in which international targets are agreed to and implementation measures are incorporated into the actions of international agencies, NGOs, national governments, and the private sector.

In other indicators, by contrast, most countries are near the target already, distributions are highly uneven, and extreme outliers dominate the overall picture. This is especially true for the Nitrogen Loading, Timber Harvest Rate, and Agricultural Subsidies indicators. Policy action in these issues may require a more focused approach aimed at the special circumstances in the extreme outlier countries.

There are three indicators where the majority of countries are less than 50% of the way to the target—Wilderness Protection, Overfishing, and Renewable Energy. These represent distinct and difficult policy challenges. Wilderness Protection is an issue for which there is not any significant international policy action. This inaction contributes to the small number of high scores on this indicator. There has been policy coordination on protected areas more generally, and some of the success of this coordination shows up in the higher scores on Ecoregion Protection. One of the key global policy challenges moving ahead is to extend protection into high-priority wilderness regions. Clearly there is much work to be done to ensure appropriate habitat preservation and biodiversity protection globally.

Overfishing represents quite a different challenge. Declining fish stocks have been a focus of international policy discussions for a long time. Governments have engaged in various modes of collaboration, target-setting, and implementation. But, these policy actions have been highly ineffective. The challenge in the fishing arena is to devise new approaches that might yield better results. Recent discussions concerning large-scale marine sanctuaries constitute one promising example. But effectively enforced quotas limiting fishing in depleted fisheries will also be needed.

Finally, renewable energy represents a domain that has been the subject of coordinated policy action for a relatively short period of time. The Johannesburg Plan of Implementation, endorsed at the World Summit on Sustainable Development in 2002, called on countries to make progress in increasing their use of renewable energy. Other regional bodies and national governments have taken on this target as well. Here the challenge is to build on this consensus, create incentives to promote technological innovation, and find ways to ensure that implementation occurs.

4. Results by Policy Category

Much of the policy value of the EPI comes not from the overall scores or rankings, but from a careful analysis of the individual policy categories and the underlying indicators. This section reviews the importance of each policy category and presents category-by-category results. Tables showing country scores for each policy category can be found in Appendix A. Additional detail on the logic for the each category's policy context, indicators chosen, and future prospects for expanded performance-based measurement can be found in Appendix D. The raw data for the underlying indicators can be found in Appendix H.

Core Area:
Environmental Public Health

4.1. Environmental Health

Reducing the environmental burden of disease is a globally recognized priority that has been embedded in the MDGs through a variety of indicators, such as those relating to water supply, sanitation, and child mortality. The EPI utilizes these indicators (Drinking Water, Adequate Sanitation, and Child Mortality) together with two measures of air quality (Urban Particulates and Indoor Air Pollution) to rank countries in terms of their performance on environmental health.

Mortality rates for children between one and four years of age provide a good indicator of the effect of the environment on human health, particularly in the developing world. Poor air quality and an inadequate or unsanitary water supply in a country often manifest themselves in respiratory and intestinal problems and disease. These effects can be seen most often in children, as they are more sensitive to poor environmental quality. By considering only mortality rates for children one to four years of age, we better focus on the impact of environmental conditions as opposed to health care infrastructure.

Air pollution is a threat to human health for many reasons, but especially because poor air quality can lead to respiratory distress. From a public health perspective, air pollutants are responsible for nearly five percent of the global burden of disease (UNEP 2002). Air pollution aggravates asthma and other allergic respiratory diseases, and can result in adverse pregnancy outcomes, such as stillbirth and low birth weight. Studies also show that human life can be cut short due to indoor and urban air pollution—including exposure to particulates (WHO 2002).

The health and well-being of humans and ecosystems in countries also depends heavily on the quantity and quality of water resources available. Clean drinking water is essential to human health. Unhealthy or inadequate water and sanitation can result in diarrhea and other intestinal problems, which is a leading cause of death among children in developing countries (Bryce et al. 2005).

The quality of environmental health in a country is highly correlated with wealth. Countries at higher levels of development generally have the capacity to invest in environmental infrastructure so their people have better access to safe drinking water and adequate sanitation. They also have little need to light indoor fires indoors for heating and cooking, and therefore tend to have significantly less indoor air pollution (Ezzati and Kammen, 2002). Top performers have low rates of child mortality, indicating that they perform well in areas related to environmental health that could not be directly measured through available datasets. From the figure below, it appears that environmental health gains are greatest as countries approach per capita incomes of $10,000, after which performance tends to level off (see Figure 16).

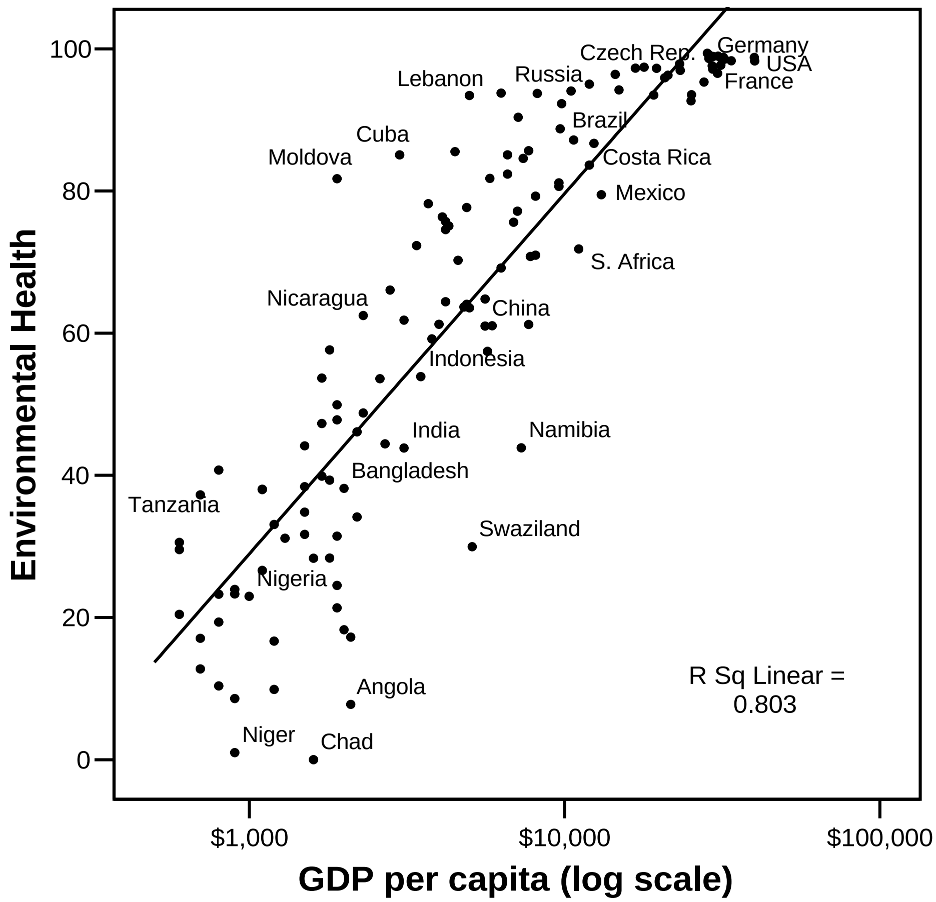


Figure 16: Relationship of Environmental Health and GDP per capita

Core Area:
Ecosystem Vitality and Natural Resource Management

4.2. Air Quality

Air pollution comes from a variety of sources—power generation, industrial production, vehicles, and residential heating and cooking. It arises at a range of different levels from the individual household to the global scale. In relation to Ecosystem Vitality, air pollution is a leading cause of soil and water acidification, which results in declining fish stocks, decreasing biological diversity in acid-sensitive lakes, the degradation of forests and soils, and lost agricultural productivity. Fossil fuel combustion is the major source of air pollution, generating particulates, VOCs, SO_2, NO_2, and CO_2. From an ecosystem perspective, reactive chemicals such as benzene, SO_2, and NO_2 are the most relevant.

It would be useful to track all of these pollutants, but data are not available on a reliable world-wide basis for most of them. Thus, the EPI Air Quality policy category includes just two indicators: urban particulate concentrations (Urban Particulates) and regional ozone concentrations (Regional Ozone). Urban particulates, for which city-level data are available for most countries in the world, must presently serve as a proxy for the broader set of concerns that should be monitored. The lack of local-level data on reactive chemical concentrations is partially made up for by the inclusion of regional ozone levels. Ground-level ozone is formed by the interaction of hydrocarbons (unburned or evaporated gasoline) and nitrogen oxides in the presence of sunlight. Ozone creates smog and can reduce the ability of plants to photosynthesize, thereby reducing crop and forest productivity.

The Air Quality category scores are presented in Table A2 in Appendix A. The top-ranked countries are in tropical Africa, where regional ozone concentrations are low due to low levels of industrialization and vehicle use. Urban particulates are not a significant problem for the same reasons. The top-ranked industrialized countries are Sweden and Finland. In general, island countries such as New Zealand and the UK demonstrate above-average performance because air pollution from upwind sources gets dispersed to other locations. India and China are in the bottom decile, as are several other South Asian nations, reflecting their rapid industrialization with limited pollution control.

4.3. Water Resources

The health and well-being of ecosystems depends heavily on the quantity and quality of the water resources available. Water is necessary for all biological life, and also underpins global food production by providing the fundamental resource upon which agriculture, livestock production, fisheries, and aquaculture depend. Water serves numerous roles in the industrial and municipal sectors as well.

Given water's crucial role in maintaining healthy ecosystems as well as facilitating and regulating bio-geochemical cycles, there is growing concern that human impacts on water resources are reaching critical thresholds. The impacts are of three main kinds: over-subscription of available water resources (consumption in excess of recharge); engineering works for flood control or to support power generation; and pollutant discharges into water bodies. Natural freshwater scarcity can exacerbate each of these problems.

While we would like measures of all the impacts noted above, data limitations again make this difficult. The only indicators available for the Water Resources policy category are nitrogen loading per average flow of a country's river basins (Nitrogen Loading) and the percentage of territory that is affected by oversubscription of water resources (Water Consumption). These indicators address two of the critical human impacts on water systems. The third area of concern, engineering works, proved difficult to assess given competing human and ecological needs (see Appendix D, Box D2 for details). Notably, while dams and channelization destroy habitat and disrupt hydrological flows that may be important for ecosystem vitality, they provide hydropower, flood control, irrigation systems, and drinking water—all of which enhance human welfare.

Nitrogen loading is a widespread phenomenon caused by atmospheric nitrogen deposition, plant nitrogen fixation, nitrogenous fertilizer loads, livestock nitrogen loading, and human nitrogen loading. Increases in the global nitrogen cycle are resulting in eutrophication of water bodies and areas of anoxic conditions (or "dead zones") from excessive algae growth in coastal zones. Oversubscription of water resources in any portion of a country's territory means that ecosystems are likely not receiving sufficient water flows to preserve their functioning and their potential to dilute water pollutants is reduced.

Performance with respect to water resources shows no clear pattern in relation to GDP per capita. Some wealthy countries confront serious water challenges; others do not. Similarly, some poor nations face water problems while other developing countries do not. Rather, climatic factors and natural endowments appear to be key determinants of the ranking of countries in this policy category. Water abundant countries generally do well on this measure—with several tropical water-abundant countries performing in the top 10 (see Appendix A, Table A3). Densely settled European countries generally perform in the middle third. Spain, Belgium and the Netherlands are all in the bottom third, however. At the 96th rank, the United States performs surprisingly poorly—probably owing to high input agriculture and the large portions of the American West where water resources are heavily oversubscribed. The worst performers are all arid or semi-arid countries, with limited water with which to work and population levels that outstrip supply.

4.4. Productive Natural Resources

Productive natural resources such as forests, soils (agriculture), freshwater, and fisheries are crucial to economic activities. Many of these resources and the ecosystems on which they depend are being lost or degraded. According to the recently completed Millennium Ecosystem Assessment, "over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history" (Millennium Ecosystem Assessment, 2005). The scientists involved in the Assessment warn that the coming years bring an increased likelihood of non-linear changes to ecosystems (such as accelerating, abrupt, and irreversible changes) that could have significant impacts on human well-being.

The agricultural, forestry, and fishing sectors are heavily dependent on natural resources. If managed improperly, these economic activities degrade the surrounding resources. Agricultural cropland takes up 23% of the terrestrial land surface globally. Unsustainable farming contributes to soil nutrient depletion, erosion, and water pollution. Timber extraction for construction, fuel wood, and paper has translated into unsustainable rates of deforestation in many of the world's regions, particularly in the tropics. The 2005 Forest Resources Assessment, authored by the FAO, found a net forest loss (deforestation offset by aforestation) of 7.3 million hectares per year—an area about the size of Sierra Leone or Panama (FAO, 2005). Finally, global fisheries are being depleted due to industrial fishing practices and the lack of a global regulatory framework to support sustainable fishing. The latest figures from the FAO suggest that 52% of commercial fish species are fully exploited, 17% overexploited, and eight percent depleted (FAO, 2004).

Given limited data, only three indicators are available to reflect these sectors: agricultural subsidies adjusted for environmental payments as percent of agricultural value added (Agricultural Subsidies); timber harvest as a percentage of standing forests (Timber Harvest Rate); and productivity overfishing (Overfishing). The Agricultural Subsidies measure nets out so-called "green-box" subsidies, which support sustainable practices, and thereby measures only those subsidies that are likely to create incentives for excessive chemical use, farming on marginal lands, and other ecologically damaging practices. Although an imperfect measure, the Subsidies indicator captures an important aspect of agricultural sustainability (see Appendix D, Section 5).

Lacking a well-defined metric for sustainable forestry, we rely upon data for timber harvests as a percentage of total forests. The Timber Harvest Rate indicator reflects round wood production in cubic meters as a fraction of the total standing forest volume. Forestry experts suggest that culling three percent of standing forest volume annually would represent a sustainable rate of forest exploitation in most circumstances. This target is admittedly crude, but must suffice until better data on forest management are available.

The third Productive Natural Resources indicator provides a measure of overfishing. Calculated by fisheries experts at the University of British Columbia, this indicator records each country's total fish catch relative to the tons of carbon per square kilometer of ocean shelf.[5] Although this metric only captures overfishing within a country's exclusive economic zone—and thus does not count flag ship fishing on the high seas—it offers a starting point for tracking national fishing practices.

The imperfect and indirect nature of these metrics is disappointing. Because of the important impact sustainable management of productive natural resources has on a country's successful development and long-term prosperity, this policy category emerges as a priority for future indicator development.

Countries that perform poorly in this category tend to have very low scores for at least two of the three indicators. A number of low-income countries outperform high-income countries because their use of productive natural resources is limited (Figure 17). OECD countries, for instance, tend to be some of the worst performers in this category (the United States (124), Japan (131), and Norway (131), for example) due to substantial agricultural subsidization and a high degree of overfishing. Pakistan (121) and Bangladesh (124) also fall near the bottom of the range of scores. Their poor performance arises from overfishing and a high rate of timber harvest relative to forest volume.

The top performers in the category of Productive Natural Resources are a mixture of two types of countries (see Appendix A, Table A4). One set of leading-edge countries has sizeable endowments of natural resources and is doing a good job of managing them. Paraguay (1) and Bolivia (4) are good examples of this set. The other top-performing group has less substantial endowments of natural resources but also uses them less intensively. These countries include former Soviet republics, such as Armenia, Kazakhstan, Kyrgyzstan, Azerbaijan, Uzbekistan, Turkmenistan, and Tajikistan. Ranking among the twenty best performers in the category, they all have little or no agricultural subsidies and relatively modest timber harvesting, rather than good management practices *per se*. As landlocked countries, they have no overfishing.

[5] Note that land-locked countries were not required to have this variable in order to calculate the natural resource policy category score.

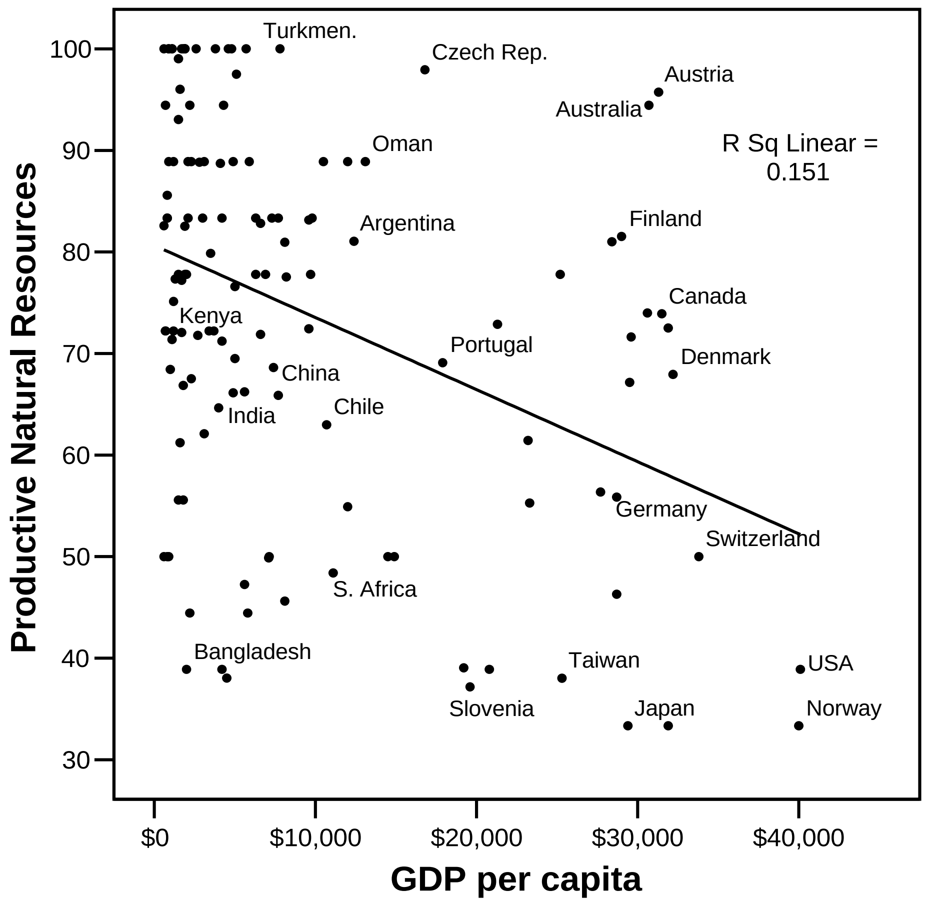


Figure 17: Relationship of Productive Resource Management and GDP per capita

4.5. Biodiversity & Habitat

Biodiversity and the habitat and ecosystem services it provides are increasingly recognized as an important component of sustainable development. The value of the goods and services provided by biodiversity was estimated at 33 billion dollars per year in 1997, and the benefits derived from biodiversity conservation are estimated to exceed its costs by 100:1 (Balmford, 2002; Costanza, 1997). Despite the importance of biological diversity to human well-being, anthropogenic environmental alteration and rates of biodiversity loss have reached unprecedented levels.

Both biodiversity and habitat protection are difficult to measure. Few datasets exist in this policy category, never mind ones that would provide an accurate gauge of performance. Given these limitations, we have relied upon two indicators related to protected areas: a measure of the evenness of protected areas coverage by biome (Ecoregion Protection) and a measure of the degree to which the country's wildest areas are protected (Wilderness Protection).

The former is important because the internationally recognized goal of protecting 10% of a country's territory (absent some effort to evenly protect all biomes in a country) can result in under-representation and loss of key ecosystems. The latter recognizes that establishing protected areas will be easiest in those regions of a country that are least developed. Beyond these two measures, we include the indicators of Water Consumption and Timber Harvest Rates, which reflect the important role that water plays in sustaining ecosystems and the significant concentration of biodiversity in forest areas.

High scores in this category are split between two different types of countries—those with large endowments of biodiversity that are going to great lengths to protect them, and those that have very small endowments that have to do very little in terms of ecosystem protection (see Appendix A, Table A5). Venezuela (2), Panama (4), Costa Rica (7), and Honduras (9) fall into the former category, while Benin (1) and Mongolia (15) fall into the latter category.

The bottom twenty is made up of two types of countries: (A) OECD countries like Austria, Switzerland, the Netherlands, Germany, and Belgium that have been developing for centuries and now have populations spread over most of the landscape, leaving little scope for habitat protection, and (B) less developed countries like Haiti, Syria, Yemen, Mauritania, and Tunisia that both lack substantial natural endowments and show little concern (often reflecting little capacity) for the protection of biodiversity and habitat.

4.6. Sustainable Energy

Climate change—and its potential impacts, including global warming, sea level rise, increased severity of windstorms, and changed rainfall patterns—represents perhaps the most serious environmental threat facing the world today. Much of the problem with greenhouse gas (GHG) emissions arises from fossil fuel burning. Energy therefore emerges as a fundamental policy category for tracking and analysis.

In this policy category, the EPI relies upon three indicators: energy consumption per unit GDP (Energy Efficiency), renewable energy production as a percentage of total domestic energy consumption (Renewable Energy), and carbon dioxide (CO_2) emissions per GDP (CO_2 per GDP). These measures provide a gauge of each country's progress toward a sustainable energy future with a reduced exposure to climate change. Additional details concerning these indicators are provided in Appendix D.

We measure energy efficiency (denominating energy use by GDP) and CO_2 per GDP because absolute measures are driven largely by economic growth and population expansion—not policy prescription. From a greenhouse gas control perspective, the absolute level of emissions globally is critical. Developing countries, however, need growth to alleviate poverty and meet other development needs of their people. So a metric that puts emphasis on decoupling energy and CO_2 emissions from economic growth provides a better gauge of policy "success," particularly given the need for a single global target and the preponderance of developing nations in the EPI rankings.

In the category of sustainable energy, the best performing countries are also among the world's poorest—Uganda, Mali, Cambodia, Laos, and Chad. The high scores reflect the fact that these countries use little energy and emit low levels of GHGs as a result of their limited industrialization and general underdevelopment (see Appendix A, Table A6). More industrialized economies were found dispersed throughout this category. Switzerland (18), Austria (34), Denmark (37), and Ireland (39) emerge as the best performers. OPEC nations, the former Soviet republics, and Arab States utilize little to no renewable energy, have low levels of energy efficiency, and also generate significant CO_2 emissions, resulting in the worst scores in this category.

5. EPI Sensitivity Analysis

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The robustness of the EPI cannot be fully assessed without evaluation of uncertainties underlying the index and an evaluation of the sensitivity of the country scores and rankings to the structure and aggregation approach utilized. To test this robustness, the EPI team has continued its partnership with the Joint Research Centre (JRC) of the European Commission in Ispra, Italy. A summary of the JRC sensitivity analysis follows. The more detailed version is included in Appendix G.

Every composite index, including the EPI, involves subjective judgments such as the selection of indicators, the choice of aggregation model, and the weights applied to the indicators. Because the quality of an index depends on the soundness of its assumptions, good practice requires evaluating confidence in the index and assessing the uncertainties associated with its development process. To ensure the validity of the policy conclusions extracted from the EPI, it is important that the sensitivity of the index to alternative methodological assumptions be adequately studied.

Sensitivity analysis lets one examine the framework of a composite index by looking at the relationship between information flowing in and out of it (Saltelli, Chan et al., 2000). Using sensitivity analysis, we can study how variations in EPI scores and ranks derive from different sources of variation in the assumptions.

Sensitivity analysis also demonstrates how each indicator depends upon the information that composes it. It is thus closely related to uncertainty analysis, which aims to quantify the overall uncertainty in a country's score (or rank) as a result of the uncertainties in the index construction. A combination of uncertainty and sensitivity analyses can help to gauge the robustness of the EPI results, to increase the EPI's transparency, to identify the countries that improve or decline under certain assumptions, and to help frame the debate around the use of the index.

The validity of the EPI scoring and respective ranking is assessed by evaluating how sensitive it is to the assumptions that have been made about its structure and the aggregation of the 16 indicators. The sensitivity analysis is mainly related to: (1) variability in the target values (2) equal weighting versus principal component analysis weighting of indicators (3) aggregation at the indicator level versus the policy category level.

How do the EPI ranks compare to the most likely ranks under alternative methodological approaches?

The most likely (median) rank of a country considering all combinations of assumptions in the sensitivity analysis rarely deviates substantially from its EPI rank. For 95 out of 133 countries the difference between the EPI rank and the most likely (median) rank is less than 15 positions. The modest sensitivity of the EPI ranking to the choice of the target values, indicator weighting, and aggregation level implies a reasonably high degree of robustness of the index.

Which are the most volatile countries and why?

The top four ranking countries in the EPI all have modest volatility (one to two positions). This small degree of sensitivity implies a robust evaluation of performance for those countries. The countries that present the highest volatility (between 50 and 63 positions) are Slovenia (rank: 31) and Laos (rank: 102). Slovenia's volatility is entirely due to the combined effect of all three assumptions. Laos's high volatility is mainly attributable to the aggregation level and to its combined effect with the other two assumptions about weighting and target values.

What if alternative target values for the indicators are used instead of the current ones?

If one were to change the target value to the 90th percentile value for all indicators, such that 10% of countries achieve the target, it would play only a minor role in the sensitivity of the EPI ranking. For the set of 133 countries, the assumption regarding target values has an average impact of only two ranks. However, Chile and Egypt are among the countries that are most affected by this assumption — which improve or worsen their rank by eight positions, respectively.

What if equal weighting within each category is used, instead of the PCA-derived weights?

An equal weighting approach within each of the six policy categories affects the indicators within Environmental Health, Biodiversity and Energy Components, for which there were clear referents in the PCA results. Using equal weights within each category has a pronounced positive effect on the rank of a few countries such as Trinidad and Tobago and Papua New Guinea, but a negative effect on others such as Egypt, Spain, and Jordan. Overall, the analysis shows only a small sensitivity to the weighting assumption with an average impact of three ranks.

What if aggregation is applied at the indicator level, instead of the category level?

Weighting the 16 indicators equally contributes to the variance of the EPI scores and ranks more than any of the other two changes does. Zambia and Uganda would rise by more than 50 positions in the ranking if aggregation were done at the indicator level rather than the category level. Conversely, Ukraine, Jordan, and Moldova would fall by more than 40 positions. The reason for this effect lies in the fact that aggregation at the indicator level gives added weight to PM10, INDOOR, WATSUP, ACSAT and reduces the weight of RENPC.[6] Overall, the level at which aggregation to the EPI takes place has an average impact of 18 ranks.

Figure 18 presents an analysis of the variability of the EPI scores and the scores in six underlying policy categories. The box plots also show how well the countries of the world are doing in each category and whether the performance varies widely across countries. Looking at the global scale, the world performs best on the water issues as measured in the EPI. The weakest performance emerges in the biodiversity component. As Table 16 shows, even when acknowledging uncertainties, the confidence intervals for the median values for these six components are rather narrow.

[6] Codes, acronyms, and general metadata for all EPI indicators can be found in Appendix H.

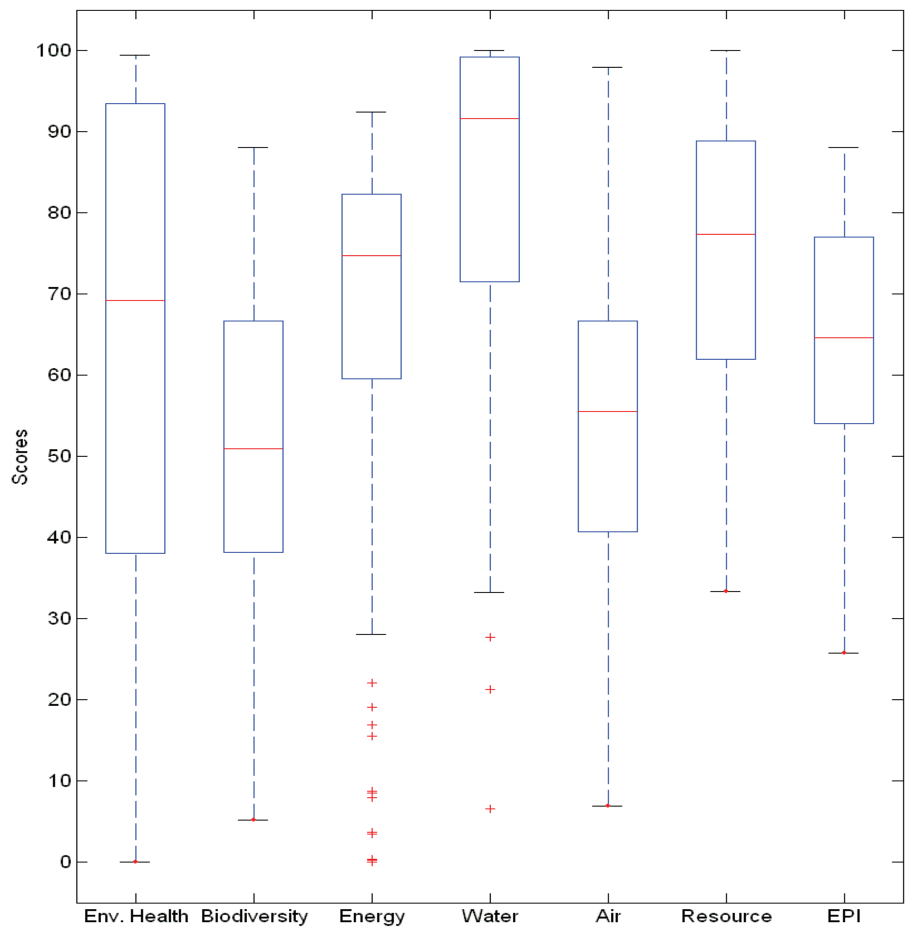

Figure 18: Boxplots of EPI & Categories Scores Across the 133 countries.

Note: The box has lines at the lower quartile, median, and upper quartile values. The whiskers are lines extending from each end of the box to show the extent of the rest of the data. Outliers (+) are data with values beyond the ends of the whiskers. If there is no data outside the whisker, a dot is placed at the bottom whisker.

Table 16: Statistics on the EPI & Categories scores

Category	25th percentile across 133 countries	75th percentile across 133 countries	Median across 133 countries	Range for the median (due to uncertainties)
Env. Health	38.0	93.4	69.2	[68.4, 70.4]
Biodiversity	38.3	66.6	50.9	[50.9, 67.1]
Energy	59.7	82.2	74.7	[57.8, 78.1]
Water	71.5	99.2	91.7	91.7
Air	40.7	66.4	55.5	[55.5, 61.5]
Resource	62.1	88.9	77.3	[77.3, 83.3]
EPI	54.1	77.0	64.6	[62.2, 67.4]

6. Conclusions

The Pilot 2006 EPI introduces a composite index of current national environmental performance based on proximity to defined policy targets. The aggregate and issue-by-issue rankings provide a basis for benchmarking pollution control and natural resource management results and clarifying which governments are performing well—and why. The data also permit analysis along a number of dimensions such as the drivers of environmental success and best policy practices adopted by leading performers.

In a realm plagued by uncertainty and often dominated by rhetoric and emotion rather than systematic analysis, the EPI shows how data-driven policymaking might enable movement toward a more fact-based, empirical, and analytically rigorous approach to environmental protection. The promise of improved results—and the ability to measure the contribution of environmental programs to better outcomes—is essential to further investments in environmental protection, particularly in the context of the environmental aspects of the Millennium Development Goals.

The EPI centers on two basic objectives: (1) protecting human health from environmental stresses, and (2) promoting ecosystem vitality and sound natural resource management. It tracks six underlying policy categories—Environmental Health, Air Quality, Water Resources, Biodiversity and Habitat, Productive Natural Resources, and Sustainable Energy—using 16 baseline datasets and associated policy targets. The proximity-to-target measures provide a way to gauge environmental results in general and a concrete set of metrics for tracking progress toward the environmental dimensions of the MDGs in particular.

The EPI report highlights a range of peer groups for each country. By grouping countries that are at the same level of development, in the same geographic region, or statistically similar (as determined by the clustering process), the EPI provides environmental decisionmakers with a way to establish a context for their policy choices and performance outcomes.

The sensitivity analysis independently conducted by the Joint Research Center of the European Commission (JRC) shows how the results of the EPI might vary if other methodological assumptions were adopted. This analysis allows us to say that alternate assumptions, with regard to the choice of indicators, aggregation methodology, and the weighting of the indicators and categories, would change the rankings, but these differences are not great except in a few cases. Thus, we can be reasonably confident in the robustness of the EPI scores and rankings—and the indicative sense they provide about which countries are performing well in response to the challenges of environmental protection.

While the Pilot EPI's usefulness is limited by data problems, methodological questions, and the inherent uncertainties of the environmental field, it still offers a valuable tool for environmental policymakers. In particular, the EPI enables them to track environmental outcomes, benchmark performance, and identify appropriate policy options. To achieve the full promise of the EPI, much better environmental data will need to be collected and disseminated.

Analysis of the EPI rankings and underlying data reveal a number of key points:

- Despite significant data shortcomings and the conceptual complexity of bringing the range of issues that fall under the environmental rubric into a single index, the EPI shows that environmental performance can be tracked in a rigorous and quantitative fashion.

- Efforts to refine the methodology for construction of composite environmental performance indices promise dividends in the policy context. Tools for moving countries quickly toward best practices are especially important in the context of achieving the environmental aspects of the Millennium Development Goals.

- Every country faces substantial challenges in reducing environment-related human health stresses and in promoting ecosystem vitality and natural resource management. No country has obtained a position of long-term environmental sustainability.

- The cross-country comparisons facilitated by the EPI provide a useful way to identify leaders, laggards, and best practices on an issue-by-issue and aggregate basis. Every country lags in performance on some issues. Each country has issues on which it can learn from the success of peer nations.

- While substantial progress has been made in some countries on many issues and in most countries on some issues, the planet remains on a less-than-sustainable course in certain important respects, notably with regard to biodiversity, energy, and climate change.

- A country's level of development emerges as an important driver of environmental performance. At every level of development, however, some countries show much better results than their peers. This suggests that policy choices (and perhaps other factors) are also important determinants of environmental performance.

- Good environmental results correlate significantly with good governance. Policy emphasis at the national and global levels on establishing the rule of law, eliminating corruption, promoting a robust policy dialogue, and setting up effective regulatory institutions appears fully justified.

- Efforts to shift environmental policymaking onto a more empirical and analytically rigorous foundation require action on a number of fronts, including: better defined policy targets, investment in data collection and indicator tracking, and use of quantitative metrics and analysis in policy formation and evaluation.

The 2006 EPI is a *pilot* index. It is very much a work in progress. Feedback on any element of the index and its underlying components would be most welcome (www.yale.edu/epi). We are eager to receive help identifying better data sources and to work with data collectors in improving the metrics and information available for policymakers and researchers. We encourage suggestions for refining the Pilot EPI methodology or reconceptualizing how environmental performance is tracked.