Measuring Up:
Applying the Environmental Sustainability Index

By Tanja Srebotnjak and Daniel C. Esty

Environmental policymaking is plagued by uncertainties and the challenge of determining what constitutes good performance. Too often rhetoric and emotion dominate the discussion. Recognizing this deficiency, policymakers have attempted to make the environmental policy field more empirical. The Environmental Sustainability Index (ESI), a composite of twenty-one indicators built on seventy-six underlying datasets, is an invaluable tool for moving environmental decision making onto firmer analytic ground.

The ESI was launched in 2000 to provide policymakers with a tool to gauge relative national environmental performance. It was designed to serve as a counterpoint to GDP growth and competitiveness metrics, which have long received a great deal of attention from policymakers. The ESI's broad-based structure was meant to reflect the range of concerns that fall under the rubric of environmental issues.[1] Just as businesses and governments have long measured their performances against similarly situated peers by economic and other measures, the ESI provides a basis for evaluating comparative national environmental performance. This new application allows policymakers to identify leaders and laggards on an issue-by-issue

Tanja Srebotnjak is Director of the Environmental Performance Measurement Project at the Yale Center for Environmental Policy and Law. **Daniel C. Esty** is Clinical Professor of Environmental Law and Policy at Yale Law School and Professor of Environmental Law and Policy at the Yale School of Forestry and Environmental Studies.

basis, highlight sub-par environmental results, and accurately identify environmental best practices.

The ESI and International Environmental Policy

Although the ESI is a work in progress, it offers several applications for international environmental policy. Its widespread publication and use as a gauge of national environmental sustainability has contributed to the greater acceptance and use of indicators and quantitative environmental performance assessments. The ESI makes an important contribution to environmental policymaking by providing a comprehensive data resource that can be applied in different geographical and policy contexts. It also provides a comparative assessment of national capabilities to manage environmental resources and pollution. Recent important work involving environmental indicators and composite indices includes the efforts of the International Institute for Sustainable Development, the European Environment Agency, the Organization for Economic Cooperation and Development, and the United Nations Commission for Sustainable Development.

The ESI's broad range of indicators makes it a relevant tool for local, national, and international communities. Its broad appeal encourages environmental and development programs to become more accountable and effective in using quantitative performance measures. Several OECD donor countries have already begun to integrate quantitative performance measures into their program designs and evaluation phases.

For example, Australia's international development aid agency, AusAID, has published an environmental management guide for assessing the potential impacts of its overseas aid program.[2] The U.S. government's Millennium Challenge Corporation is also currently developing indicator systems to support the new Compact for Global Development, which calls for greater development assistance from donor countries and increased accountability and responsibility from recipients.

The ESI supports these types of activities by measuring various environmental performance indicators and providing an overall benchmarking tool. Although the ESI is not a policy performance measure, it can be used to identify those national environmental, economic, and societal areas where action is needed; specify appropriate policy targets for improvement; and channel funds into those areas with positive expected returns. Environmental sustainability, as measured in the ESI, can also directly support the environmental targets of the Millennium Development Goals. The ESI contributes to international environmental policymaking by providing a comprehensive data resource and a tool that assesses national capabilities to manage environmental resources and pollution on a sustained basis.

The Structure of the ESI

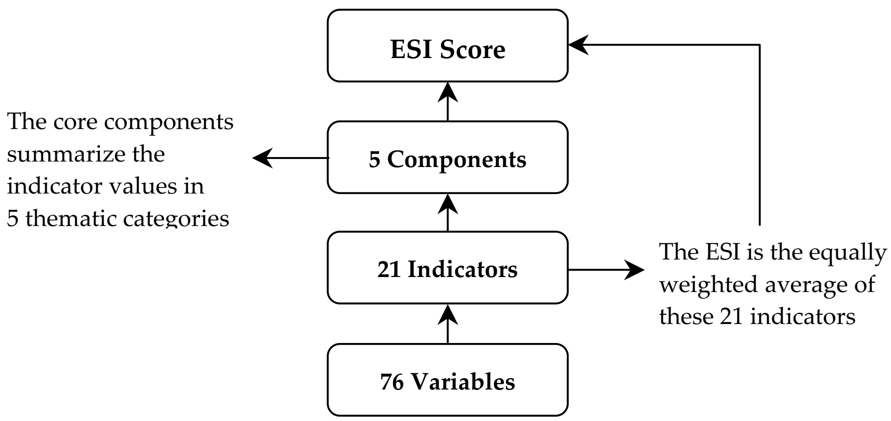
The ESI was first published in 2000 as a pilot study and updated in 2001, 2002, and 2005.[3] Since its inception the index has undergone substantial methodological revisions, but its core conceptual foundation has remained the same. The ESI builds on the concept of sustainable development, measuring the ability of countries to manage various environmental challenges that reflect natural resource endowments, past and current pollution levels, natural resource use, and societal capacities to address current and future problems. At the core of the ESI are twenty-one indicators of environmental sustainability, which reflect five core components. Table 1 illustrates these indicators and components.

TABLE 1: ESI INDICATORS AND COMPONENTS

Indicator	Component
Air Quality	Environmental Systems
Biodiversity	
Land	
Water Quality	
Water Quantity	
Reducing Air Pollution	Reducing Environmental Stresses
Reducing Ecosystem Stress	
Reducing Population Pressure	
Reducing Waste and Consumption Pressures	
Reducing Water Stress	
Natural Resource Management	
Environmental Health	Reducing Human Vulnerability
Basic Human Sustenance	
Reducing Environment-Related Natural Disaster Vulnerability	
Environmental Governance	Social and Institutional Capacity
Eco-Efficiency	
Private Sector Responsiveness	
Science and Technology	
Participation in International Collaborative Efforts	Global Stewardship
Greenhouse Gas Emissions	
Reducing Transboundary Environmental Pressures	

These twenty-one indicators are based on careful reviews of environmental literature, assessments of data availability, and broad-based consultations with scientists and environmental policymakers.[4] Each indicator includes between two and twelve datasets for a total of seventy-six underlying variables. The datasets that make up each indicator provide various measures of the concept in question. For example, the water quality indicator includes data on dissolved oxygen, electrical conductivity, and the concentrations of phosphorus and suspended solids. The standardized scores on each of the twenty-one indicators are averaged to create the overall ESI value for each country. The ESI methodology is summarized in Figure 1 below.

FIGURE 1: CALCULATION OF THE ESI SCORE



ESI scores were calculated for 146 countries that passed selection criteria of data availability, distribution of data coverage across indicators, land area, and population size.[5] Data requirements help ensure the accuracy of the ESI, while the size requirements ensure the comparability of countries. Small countries such as city and island states have sufficiently different environmental and economic characteristics to make cross-country comparisons unsuitable for several ESI indicators. For example, smaller land area affects the validity of biodiversity, protected areas, and pollution measures. Economic dependency on a few sectors with little opportunity to diversify or create economies of scale affects institutional and private-sector capacity measures. Rather than including small states in the ESI, a separate index tailored to the specific conditions in these countries has been created.[6]

While the ESI provides policymakers with a variety of useful information, a lack of data presents a persistent and serious impediment to the creation of a more accurate, data-driven foundation for environmental decision making, especially in the developing world.[7] Approximately 18 percent of the cells in the ESI data matrix are empty. To avoid skewing the calculation of the ESI for countries with extremely uneven indicator coverage, an imputation model has been employed to replace missing values where appropriate.[8]

Using the ESI for National Environmental Decision Making

The ESI provides environmental policymakers with data that, when applied appropriately, can be used to determine large-scale trends. The ESI scores and overall rankings are most useful for rough-cut comparisons of overall country performance. As Table 2 shows, the scores provide an overarching signal of a country's performance with respect to its ability to protect and maintain favorable environmental conditions over the coming generation.

Table 2: Selected Country Rankings and ESI Scores[9]

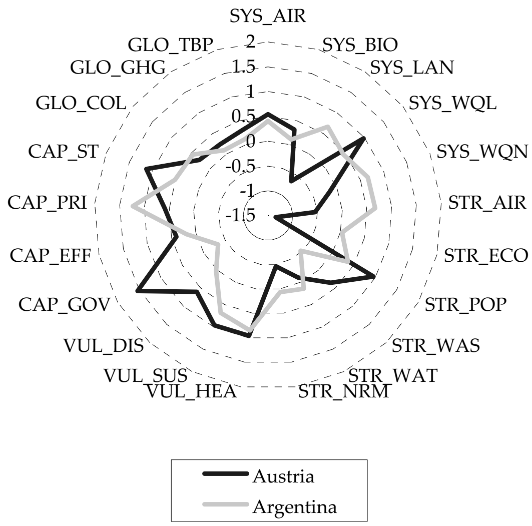
Rank	Country	ESI
1	Finland	75.1
2	Norway	73.4
3	Uruguay	71.8
4	Sweden	71.7
5	Iceland	70.8
6	Canada	64.4
7	Switzerland	63.7
8	Guyana	62.9
9	Argentina	62.7
10	Austria	62.7

Rank	Country	ESI
11	Brazil	62.2
31	Germany	56.9
33	Russia	56.1
36	France	55.2
45	United States	52.9
65	U.K.	50.2
93	South Africa	46.2
95	Mexico	46.2
101	India	45.2
133	China	38.6

Rank	Country	ESI
137	Yemen	37.3
138	Kuwait	36.6
139	Trinid. & Tob.	36.3
140	Sudan	35.9
141	Haiti	34.8
142	Uzbekistan	34.4
143	Iraq	33.6
144	Turkmenistan	33.1
145	Taiwan	32.7
146	North Korea	29.2

Because the ESI score averages twenty-one indicators, countries with similar scores can differ considerably in their performance with regard to any specific indicator. For example, Figure 2 depicts the distribution of indicator scores for Argentina and Austria, two countries with identical overall ESI scores but vastly different environmental conditions and challenges. Despite their similar global stewardship measures, Argentina and Austria differ notably with respect to their environmental systems, stresses, and social and institutional capacity indicators. Therefore, the analysis of specific sustainability issues is best carried out at the indicator and variable levels, not at the broader measurement levels.

FIGURE 2: COMPARISON OF ESI INDICATOR SCORES FOR ARGENTINA AND AUSTRIA; BOTH HAVE IDENTICAL ESI SCORES OF 62.7



SYS_AIR:	Air Quality
SYS_BIO:	Biodiversity
SYS_LAN:	Land
SYS_WQL:	Water Quality
SYS_WQN:	Water Quantity
STR_AIR:	Reducing Air Pollution
STR_ECO:	Reducing Ecosystem Stress
STR_POP:	Reducing Population Pressure
STR_WAS:	Reducing Waste & Consumption Pressures
STR_WAT:	Reducing Water Stress
STR_NRM:	Natural Resource Management
VUL_HEA:	Environmental Health
VUL_SUS:	Basic Human Sustenance
VUL_DIS:	Reducing Environment-Related Natural Disaster Vulnerability
CAP_GOV:	Environmental Governance
CAP_EFF:	Eco-Efficiency
CAP_PRI:	Private Sector Responsiveness
CAP_ST:	Science & Technology
GLO_COL:	Participation in International Collaborative Efforts
GLO_GHG:	Greenhouse Gas Emissions
GLO_TBP:	Reducing Transboundary Environmental Pressures

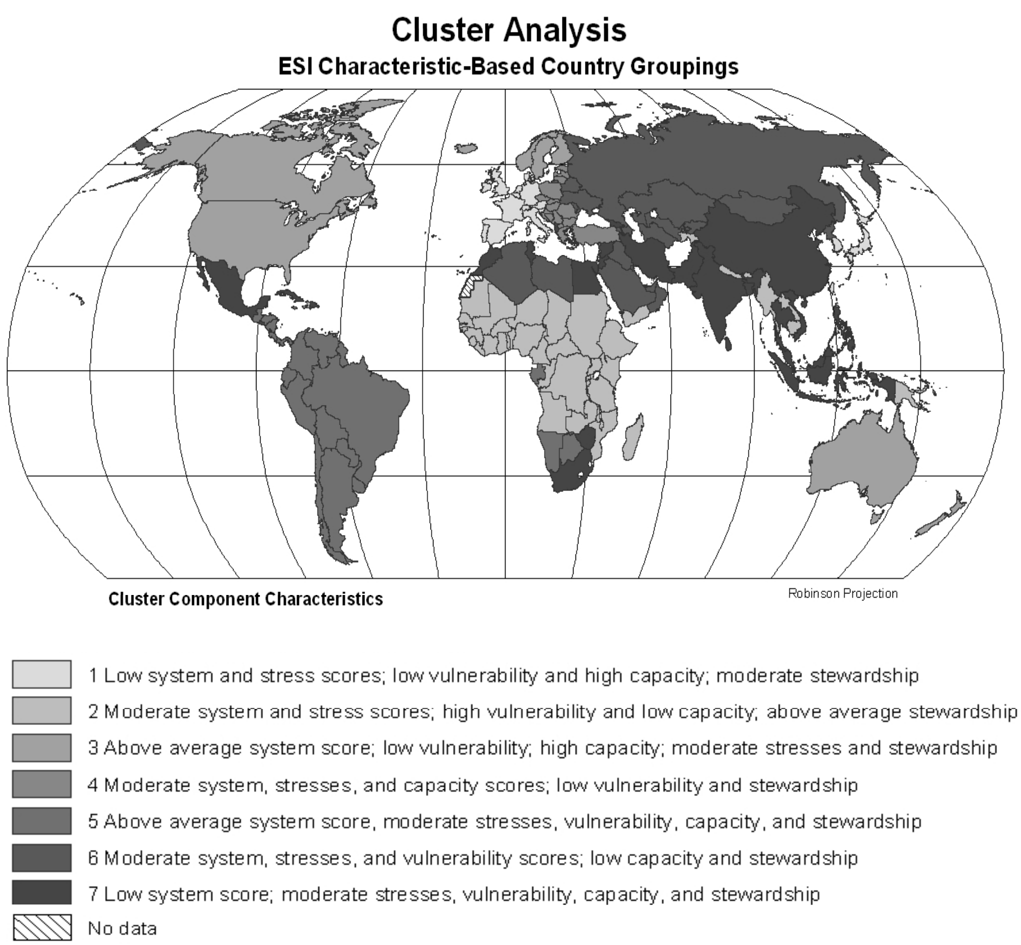
The indicator level is also useful for identifying strategies in countries that have been particularly successful at addressing specific environmental issues. For example, if a country's goal is to combine economic innovation with environmentally friendly regulation, it would be useful to examine the ESI statistics to find countries with above-average scores on the eco-efficiency, private sector environmental responsiveness, innovation, science and technology, and environmental governance indicators. By finding specific countries that are above average and examining their policies, policymakers can identify strategies that work and those that should be avoided.

Peer-Group Analysis

One of the central objectives of the ESI is to identify appropriate peer groups of countries that share similar situations regarding environmental sustainability. These groups are the key to establishing a context for performance evaluation. The 2005 ESI report uses a variety of grouping techniques, including level of development. It also suggests a number of political, economic, and geographical country groupings as reference points for benchmarking performance.[10] The report also employs several methods for organizing data, most notably cluster analysis. This statistical method identifies similar groups of countries on the basis of their indicator scores, and provides a useful illustration of comparisons between countries.

The map in Figure 3 illustrates seven clusters. The basic objective underlying cluster analysis is to group together units that are most similar with respect to a specified distance metric that is calculated on the basis of the standardized, observed data for each unit. The map reveals that environmental characteristics vary based in part on geographical proximity as well as socio-cultural ties. When viewed in this context, the effects of per capita GDP, land area, population density, and governance are especially salient.

FIGURE 3: CLUSTER ANALYSIS SHOWING COUNTRIES WITH SIMILAR INDICATOR SCORES

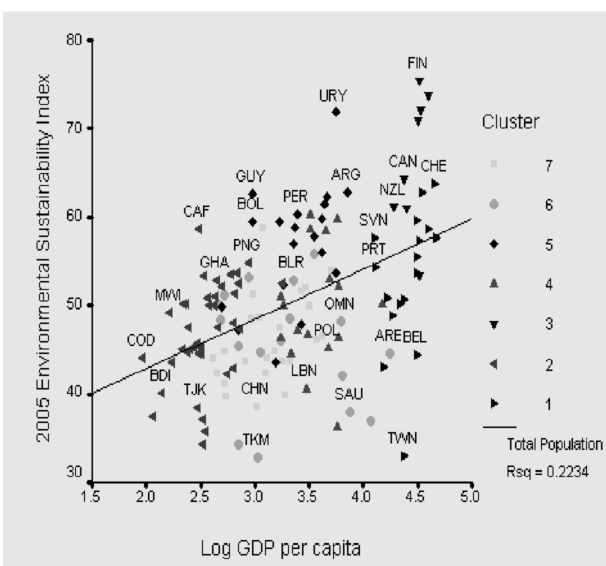


Testing Policy Theories

The ESI can also be used to test common hypotheses regarding environment-economy relationships and other core environmental policy questions. For example, the hypothesis underlying the Environmental Kuznets Curves (EKC) states that the impact of economic development on environmental pollution follows an inverted U-shaped distribution. In the pre-development stage, pollution levels are low because there is little industrialization and resource use. As economic growth and industrialization take off, pollution levels and resource use rise and, because of relative poverty and lack of institutional capacity, demand for environmental protection is minimal. As per capita incomes continue to rise with industrialization, so does demand for environmental quality, translating into greater investments in pollution control and, ultimately, reduced pollution. EKC analyses have found inverted U-shaped pollution curves for selected pollutants and sectors, but the overall relationship remains inconclusive.[11]

ESI scores are also particularly useful when they are compared to per capita income levels (Figure 4). When GDP per capita is regressed on the ESI component scores (Table 3, overleaf), the results reveal that developed and developing countries face distinct environmental challenges. Wealthy countries face environmental stresses but tend to score high in social and institutional capacity, giving them an abil-

FIGURE 4: ESI SCORES V. LOG GDP PER CAPITA



Countries Shown According to Cluster: Cluster 1: Taiwan (TWN), Argentina (ARG), Belarus (BLR), Belgium (BEL), Portugal (PRT), Slovenia (SVN), Switzerland (CHE); Cluster 2: Democratic Republic of the Congo (COD), Bolivia (BOL), Burundi (BDI), Tajikistan (TJK), Malawi (MWI), Ghana (GHA), Canada (CAN), Central African Republic (CAF), Papua New Guinea (PNG); Cluster 3: New Zealand (NZL), Canada (CAN), Finland (FIN); Cluster 4: Poland (POL), Lebanon (LBN); Cluster 5: Uruguay (URY) Peru (PER), Guyana (GUY), Bolivia (BOL); Cluster 6: United Arab Emirates (ARE), Oman (OMN), Saudi Arabia (SAU), Turkmenistan (TKM); Cluster 7:China (CHN).

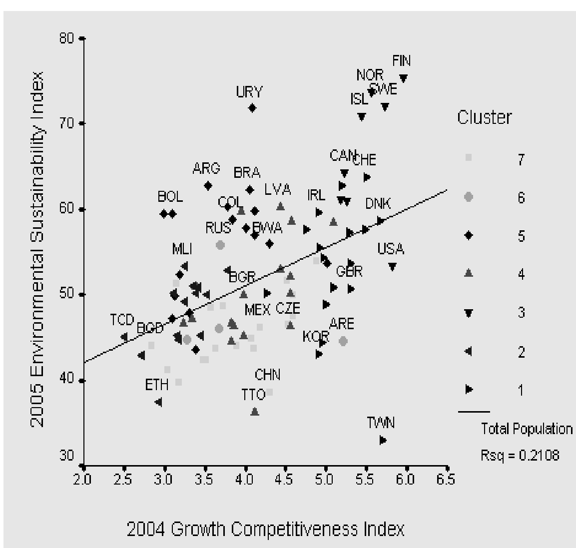
Data source: GDP per capita, PPP, World Development Indicators 2004, World Bank.

TABLE 3: RELATIONSHIPS BETWEEN 2005 ESI COMPONENTS AND GDP PER CAPITA

	OECD Countries		Non-OECD Countries	
Component	Average Component Score (s.d.)	Correlation with Log GDP/Cap	Average Component Score (s.d.)	Correlation with Log GDP/Cap
Environmental Systems	49.3 (18.6)	—	50.0 (14.4)	—
Reducing Environmental Stresses	39.4 (9.0)	—	52.3 (8.5)	-0.26**
Reducing Human Vulnerability	75.2 (5.9)	—	44.7 (20.2)	0.76***
Social and Institutional Capacity	76.5 (11.6)	0.87***	41.0 (13.0)	0.49***
Global Stewardship	49.3 (18.7)	0.73***	50.5 (19.8)	-0.44***

— Not Statistically Significant; *** Significant with P-Value < 0.001; ** Significant with P-Value < 0.01
s.d. Denotes the Standard Deviation

FIGURE 5: ESI SCORES V. 2004 GROWTH COMPETITIVENESS INDEX



Countries Shown: Angola (AGO), Argentina (ARG), Bangladesh (BGD), Belgium (BEL), Bolivia (BOL), Botswana (BWA), Brazil (BRA), Bulgaria (BGR), Canada (CAN), Chad (TCD), China (CHN), Colombia (COL), Czech Republic (CZE), Denmark (DNK), Ethiopia (ETH), Finland (FIN), Germany (DEU), Iceland (ISL), Ireland (IRL), Italy (ITA), Latvia (LVA), Mali (MLI), Mexico (MEX), Norway (NOR), Paraguay (PRY), Russia (RUS), South Korea (KOR), Sweden (SWE), Switzerland (CHE), Taiwan (TWN), Trinidad & Tobago (TTO), United Arab Emirates (ARE), United Kingdom (GBR), United States (USA), Uruguay (URY).

Data Source: Growth Competitiveness Index, 2004/5 Global Competitiveness Report, World Economic Forum, Geneva, Switzerland.

ity to manage the issues they must address. Poorer countries tend to have fewer environmental stresses and less damaged environmental systems. But because of their limited environmental response capacities, they have more problems with current or sudden threats.

The data also reveal that global stewardship has no clear relationship to income. This may in part reflect the low stewardship scores of several relatively wealthy oil-producing countries. However, the lack of a clear relationship may also be indicative of the need for better variables that measure active participation and contributions toward global environmental responsibilities.

ESI scores are also applicable to larger theoretical policy questions. Given the increasing competitive pressures in today's global markets, is it reasonable to argue that a country can invest in environmental protection while maintaining or enhancing its economic competitiveness? In analyzing this issue, it is useful to compare a country's ESI score with its ability to produce leading-edge economic results. The Growth Competitiveness Index published by the World Economic Forum (WEF) is a comprehensive gauge of the extent to which a country excels in innovation, high productivity, and adaptive flexibility. The results, shown in Figure 5, demonstrate a positive linear relationship between the ESI and the WEF's 2004 Growth Competitiveness Index.

Although high competitiveness correlates with above-average performance in the ESI, revealing that economic success does not have to advance at the expense of the environment, ESI performance varies substantially at every competitiveness level. This finding suggests that some countries are better than others at pursuing economic growth and environmental progress simultaneously. Taiwan, the United States, and South Korea, for example, are among the most competitive economies in the world but are outranked in their environmental stewardship by Finland, Norway, and Sweden in competitiveness.

The Role of Governance

Research on the relationships between governance and the environment has grown substantially in recent years.[12] While it is beyond the scope of this paper to prove a causal relationship between a functioning governance system and positive outcomes in the ESI, several results support the hypothesis that good governance is necessary for long-term environmental protection. The environmental governance indicator in the ESI includes the largest number of variables (twelve) and tracks a broad array of a societies' capacities to govern progressively, taking into account measures of political freedom, government effectiveness, correct pricing of polluting goods, and contribution to scientific knowledge. Although the governance indicator is weighted equally with the other twenty ESI indicators, environmental governance proves to be among the most determinative indicators of environmental sustainability. The five variables with the strongest linear correlation with the ESI belong to the environmental governance indicator, including civil and political liberties, environmental governance, and the rule of law.[13] Table 4 details these relationships.

TABLE 4: VARIABLES CORRELATING MOST STRONGLY WITH 2005 ESI

Variable Code	Variable with Statistically Significant Correlation with ESI	Correlation Coefficient*
CIVLIB	Civil and Political Liberties	0.59
WEFGOV	World Economic Forum Survey on environmental governance	0.54
GOVEFF	Government effectiveness	0.51
POLITY	Democratic institutions	0.50
LAW	Rule of Law	0.50
PARTICIP	Participation in international environmental agreements	0.49

* Correlation coefficients statistically significant at <0.01 level for all variables.

At the indicator level, environmental governance correlates positively with nine of the twenty remaining indicators. Strong governance results tend to coincide with strong performance on pollution abatement, environmental quality improvements, and protection from environmental hazards. Conversely, the negative correlation between environmental governance and natural resource management measures disappears when income per capita is accounted for, indicating that unsustainable natural resource use is largely a function of consumptive demands in wealthier countries.

Although good governance correlates positively with income, low per capita GDP is not necessarily a barrier to improving government effectiveness, reducing corruption, or setting the right market prices for environmental goods. Countries such as Costa Rica and Botswana demonstrate that good governance can translate into positive environmental outcomes at any stage of development. South Korea and Taiwan, both high-income countries with ESI scores well below what would be expected, are also characterized by relatively strong governmental and regulatory systems, which suggests that they are well positioned to improve their ESI scores in the medium- to long-term. While the environmental governance indicator is useful in evaluating specific countries, it is also valuable for determining relevant peer groups and for discriminating among countries with respect to their positions in the ESI quintiles. Seven of the top ten countries for this indicator are in the top 20 percent of the ESI and all belong to high-income country groups.

Conclusion

Although aggregated quantitative information in the form of indices and benchmarks is used routinely in fields such as economics, finance, health, and education, it has not yet been sufficiently integrated into the field of environmental policy. The ESI has proven to be a useful analytical tool for policymakers, both practically and theoretically. It has enabled policymakers to identify problems, set priorities, target environmental investments, and evaluate the effectiveness of environmental programs. More research is required to analyze further the complex circumstances surrounding environmental governance, natural resource endowments, past and current pollution trends, and methods for how the majority of countries can move forward. The ESI is currently the most effective tool for systematically evaluating and analyzing specific environmental issues. Further application of clustering techniques, in conjunction with the ESI, may also be useful in this regard, as it could help to identify similarities among countries and facilitate setting realistic environmental goals and the adoption of environmental best practices.

NOTES

[1] D.C. Esty, "Why Measurement Matters," *Environmental Performance Measurement: The Global 2001-2002 Report*, ed. D.C. Esty and P. Cornelius (New York: Oxford University Press, 2002); D.C. Esty, M. Levy, T. Srebotnjak, and A. de Sherbinin, *The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship* (New Haven: Yale Center for Environmental Law and Policy, 2005).

[2] http://www.developmentgateway.com.au/jahia/Jahia/cache/offonce/lang/en/pid/1692.

[3] "Pilot Environmental Sustainability Index," World Economic Forum (Geneva, 2000-2); Esty et al., *The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*.

[4] Esty et al., *The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*.

[5] The exact selection criteria are: variable coverage of at least 60 percent; coverage across all indicators with the exception of air quality and water quality, which have notoriously low data density but are judged too important to be excluded from the analysis; land area of at least 5,000 square kilometers; and population size of at least 100,000.

[6] See Appendix E in Esty et al., *The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*.

[7] United Nations, "Program of Action for Sustainable Development, United Nations Conference on Envi-

ronment and Development (UNCED)," Agenda 21. Rio de Janeiro, 3-14 June 1992; United Nations General Assembly, "United Nations Millennium Declaration." 55th Session. A/Res/55/2, 2000; "Global Earth Observation System of Systems (GEOSS)," U.S. Environmental Protection Agency, 2005. http://www.epa.gov/geoss/.

[8] Details on this imputation process can be found in Appendix A of Esty et al., *The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*.

[9] Because the ESI score averages twenty-one indicators, countries with similar scores can differ considerably in their performance with regard to any specific indicator.

[10] Esty et al., *The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*.

[11] K. Fonkych, "Assessment of Environmental Kuznets Curves and Socioeconomic Drivers in IPCC's SRES Scenarios," *The Journal of Environment and Development* 14:1 (2005): 27-47; D. L. Millimet, J. A. List, and T. Stengos, "The Environmental Kuznets Curve: Real Progress or Misspecified Models?" *The Review of Economics and Statistics* 85:4 (2005): 1038-1047.

[12] E. Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, 10th ed. (New York: Cambridge University Press, 1990); P.M. Haas, R.O. Keohane, and M.A. Levy, *Institutions for the Earth: Sources of Effective International Environmental Protection* (Cambridge, MA: MIT Press, 1993); P.M. Haas and H. Hveem, eds., *Complex Cooperation: Institutions and Processes in International Resource Management*, 1994; O. R. Young, *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms* (Cambridge: MIT Press, 1999); D.C. Esty, "Why Measurement Matters," *Environmental Performance Measurement: The Global 2001-2002 Report*, D.C. Esty and P. Cornelius, eds. (New York: Oxford University Press, 2002).

[13] This variable is derived from the World Economic Forum's survey on environmental governance. For more information, see http://www.weforum.org/site/knowledgenavigator.nsf/Content/KB+Country+Profiles.