2012 Environmental Performance Index
and
Pilot Trend
Environmental Performance Index

Yale Center for Environmental Law & Policy
Yale University

Center for International Earth Science Information Network
Columbia University

In collaboration with
World Economic Forum, Geneva, Switzerland
Joint Research Centre of the European Commission, Ispra, Italy

http://epi.yale.edu

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AUTHORS

Yale Center for Environmental Law & Policy,
Yale University
http://www.yale.edu/envirocenter

John W. Emerson
Principal Investigator

Daniel C. Esty
Director

Angel Hsu
Project Director

Center for International Earth Science Information Network, Columbia University
http://ciesin.columbia.edu

Marc A. Levy
Deputy Director

Alex de Sherbinin
Senior Research Associate

Valentina Mara
Senior Research Associate

Malanding Jaiteh
GIS Specialist

In collaboration with THE WORLD ECONOMIC FORUM and the JOINT RESEARCH CENTRE (JRC), EUROPEAN COMMISSION

EXPERT CONTRIBUTORS

Thorsten Arndt
Pan European Forest Council

Kym Anderson
University of Adelaide

Mark Ashton
Yale School of Forestry and Environmental Studies

Sandra Baptista
Columbia University

Rahmalan bin Ahmad
Technological University of Malaysia

Bastian Bertzky
UN Environment Program-World Conservation Monitoring Centre

Charles Besancon
UN Environment Program-World Conservation Monitoring Centre

Alex Blackburn
International Energy Agency

Jennifer Blanke
World Economic Forum

Matthias Bruckner
UN Department of Economic and Social Affairs

Edwin Castellanos
Universidad del Valle de Guatemala

Aaron Cohen
AGI Health Effects Institute

Thomas Damassa
World Resources Institute

Winston Dang
Republic of Taiwan

Vinay Dharmadhikari
Government of India

John Dixon
World Bank (Former)

Petra Döll
Johann Wolfgang Goethe-Universität Frankfurt

Gehan El-Sakka
Egyptian Environmental Affairs Agency

Jill-Engel Cox
Battelle Memorial Institute

Balazs Fekete
City University of New York

Yasmine Fouad
Egyptian Environmental Affairs Agency

Jennifer Gee
University of Victoria

Andres Gomez
American Museum of Natural History

Matt Hansen
University of Maryland

Gye-yeong Hwang
Korean Ministry of Environment

Lloyd Irland
Yale University

Hoi-Seong Jeong
Asian Institute for Energy, Environment, and Sustainability (AIEES)

Hye-Jin Jung
Asian Institute for Energy, Environment, and Sustainability (AIEES)

Bruno Kestemont
Statistiks Belgium

Chan-Kook Kim
Asian Institute for Energy, Environment, and Sustainability (AIEES)

Ki-Ho Kim
Asian Institute for Energy, Environment, and Sustainability (AIEES)

Kristin Kleisner
University of British Columbia

Steve Morse
University of Surrey

John O'Conner
OconEco

Thomas Parris
iSciences – New England

Daniel Pauly
University of British Columbia

Carmen Revenga
The Nature Conservancy

Phil Ross
Statlogic

Michaela Saisana
Joint Research Centre, European Commission

Andrea Saltelli
Joint Research Centre, European Commission

Han Shi
City University of Hong Kong

Benjamin Skolnik
American Bird Conservancy

Tanja Srebotnjak
Ecologic Institute

Karen Treanton
International Energy Agency

Jacqueline M. Tront
U.S. Department of State

Tristan Tyrrell
Tentera

John Volpe
University of British Columbia

Charles Vorosmarty
City University of New York

Stephanie Weber
Battelle Memorial Institute

Louisa Wood
UN Environment Program-World Conservation Monitoring Centre

Yu Ling Yang
Taiwan Environmental Protection Administration

Semee Yoon
Asian Institute for Energy, Environment, and Sustainability (AIEES)

Erica Zell
Battelle Memorial Institute

RESEARCH STAFF

Yale Center for Environmental Law & Policy:

William E. Dornbos
Associate Director

Ysella Edyvean
Program Manager

Susanne Stahl
Communications Associate

Research Assistants
Eliza Cava
Gang Chen
Diana Connett
Laura Johnson
Ainsley Lloyd
Jing Ma
Anuj Patel
Noah Walker
Dylan Walsh

Mosaicology
Website design

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DISCLAIMERS

The 2012 Environmental Performance Index (EPI) tracks national environmental results on a quantitative basis, measuring proximity to policy targets using the best data available. Although more rigorous criteria were used for data inclusion in this version of the EPI compared to earlier ones, data constraints and methodological considerations still make this a work in progress. Comments, suggestions, feedback, and referrals to better data sources are welcome at http://epi.yale.edu or epi@yale.edu.

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

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The 2012 EPI is built upon the work of a range of data providers, including our own prior data development work for the Pilot 2006 EPI, 2008 EPI, 2010 EPI and the 2005 Environmental Sustainability Index. The data are drawn primarily from international, academic, and research institutions with subject-area expertise, success in delivering operational data, and the capacity to produce policy-relevant interdisciplinary information tools. We are indebted to the data collection agencies listed in the Methodology Section.

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Executive Summary

Twenty years after the landmark Rio Earth Summit, governments still struggle to demonstrate improved environmental performance through quantitative metrics across a range of pollution control and natural resource management challenges. With budgetary constraints an issue around the world, governments face increasing pressure to show tangible results from their environmental investments.

The 2000 Environmental Sustainability Index (ESI), the predecessor to the Environmental Performance Index (EPI), first responded to the growing need for rigorous, data-driven environmental performance measurement. The 2012 EPI, the seventh iteration of this environmental measurement project, adds to the foundation of empirical support for sound policymaking and breaks further ground, establishing for the first time a basis for tracking changes in performance over time. The EPI and the Pilot Trend Environmental Performance Index (Trend EPI) rank countries on 22 performance indicators spanning ten policy categories reflecting facets of both environmental public health and ecosystem vitality. The methodology facilitates country comparisons and provides a way to assess the global community's performance over time with respect to established environmental policy goals.

The 2012 EPI ranks 132 countries on 22 performance indicators in the following ten policy categories:

- Environmental Health
- Water (effects on human health)
- Air Pollution (effects on human health)
- Air Pollution (ecosystem effects)
- Water Resources (ecosystem effects)
- Biodiversity and Habitat
- Forests
- Fisheries
- Agriculture
- Climate Change

These policy categories track performance and progress on two broad policy objectives: Environmental Health and Ecosystem Vitality. Each indicator has an associated environmental public health or ecosystem sustainability target. The full report, including a complete description of the performance indicators, underlying data sets, and methodology is available on the web at http://epi.yale.edu.

We believe that a number of interesting conclusions can be drawn from the results of the 2012 EPI, the Trend EPI, and the underlying indicators:

- The latest EPI rankings reveal a wide range of environmental sustainability results. Many countries are making progress on at least some of the challenges they face. At the indicator level, our analysis suggests that some issues are being successfully addressed, although performance on some other challenges, notably climate change, has declined globally.

- The Environmental Health scores, in particular, reveal a significant relationship with GDP per capita. EPI scores are also correlated with wealth, although there is a diversity of performance within every level of economic development. The pattern of results make clear that environmental challenges come in several forms and vary with country-specific circumstances as well as the level of development. Some issues arise from the resource and pollution impacts of industrialization, such as greenhouse gas emissions and rising levels of waste. These impacts largely affect developed countries. Other challenges are commonly associated with poverty and underinvestment in basic environmental amenities, such as access to safe drinking water and basic sanitation. These problems primarily affect developing nations.

- A number of countries that lag on the overall EPI have impressive results on the Trend EPI. For countries that have been at the high end of the EPI ranking over the last decade, the trend results are less meaningful. We note that the overall EPI and Trend EPI rankings by themselves should be understood only as indicative. More insight will often be obtained by looking at the individual indicator and policy category results.

- The Trend EPI reveals improvements for many countries on a significant number of issues. In the Environmental Health objective, global trends show decreasing child mortality as well as increasing access to sanitation and drinking water. However, persistent challenges remain in the Ecosystem Vitality objective. In particular, with respect to climate change, greenhouse gas emissions continue to rise globally with few countries on a sustainable emissions trajectory.

- A comparison of the 2012 EPI and Trend EPI exposes persistent gaps in environmental governance and management over time. In general, the performance leaders continue to improve while the laggards fall farther behind, particularly with regard to the Ecosystem Vitality objective. In contrast, most countries exhibit gains on the Environmental Health objective across all levels of performance measured by the EPI.

- The 2012 EPI highlights an array of challenges constraining movement toward data-driven and analytically rigorous environmental policymaking. These issues include unreliable data sources, gaps in data coverage, limited time series metrics, persistent methodological weaknesses, and the lack of a systematic process for verifying the environmental data reported by governments. The more rigorous data standards used in the 2012 EPI resulted in the replacement or omission of some indicators used in previous indices. We are particularly distressed by the lack of global, accurate, and comparative data on waste management, recycling, toxic exposures, and several other critical policy concerns. Likewise, the low quality and limited availability of comparative data for issues such as agricultural sustainability and water quality as well as quantity is disappointing. Simply put, the world needs better data collection, monitoring, consistent reporting, analysis, and mechanisms for independent data verification.

Environmental Performance Index– Ranking & Scores

EPI Rank	Country	Trend EPI Rank
1	Switzerland	89
2	Latvia	1
3	Norway	84
4	Luxembourg	106
5	Costa Rica	113
6	France	19
7	Austria	71
8	Italy	12
9	United Kingdom	20
9	Sweden	63
11	Germany	56
12	Slovakia	7
13	Iceland	64
14	New Zealand	50
15	Albania	4
16	Netherlands	92
17	Lithuania	104
18	Czech Republic	25
19	Finland	54
20	Croatia	74
21	Denmark	45
22	Poland	107
23	Japan	60
24	Belgium	9
25	Malaysia	33
26	Brunei Darussalam	119
27	Colombia	34
28	Slovenia	51
29	Taiwan	34
30	Brazil	23
31	Ecuador	65
32	Spain	30
33	Greece	81
34	Thailand	10
35	Nicaragua	15
36	Ireland	8
37	Canada	52
38	Nepal	14
39	Panama	103
40	Gabon	57
41	Portugal	24
42	Philippines	43
43	South Korea	13
44	Cyprus	116

EPI Rank	Country	Trend EPI Rank
45	Hungary	18
46	Uruguay	115
47	Georgia	68
48	Australia	79
49	United States of America	77
50	Argentina	112
50	Cuba	101
52	Singapore	36
53	Bulgaria	16
54	Estonia	128
55	Sri Lanka	11
56	Venezuela	85
57	Zambia	48
58	Chile	117
59	Cambodia	44
60	Egypt	5
61	Israel	78
62	Bolivia	122
63	Jamaica	53
64	Tanzania	93
65	Belarus	40
66	Botswana	21
67	Ivory Coast	42
68	Zimbabwe	87
69	Myanmar	47
70	Ethiopia	70
71	Honduras	86
72	Dominican Republic	88
73	Paraguay	46
74	Indonesia	66
75	El Salvador	108
76	Guatemala	31
77	United Arab Emirates	27
78	Namibia	98
79	Viet Nam	73
80	Benin	120
81	Peru	96
82	Saudi Arabia	130
83	Kenya	105
84	Mexico	22
85	Togo	90
86	Algeria	58
87	Malta	97
88	Romania	3

EPI Rank	Country	Trend EPI Rank
89	Mozambique	102
90	Angola	6
91	Ghana	28
92	Dem. Rep. Congo	83
93	Armenia	49
94	Lebanon	91
95	Congo	99
96	Trinidad & Tobago	114
97	Macedonia	75
98	Senegal	39
99	Tunisia	40
100	Qatar	121
101	Kyrgyzstan	127
102	Ukraine	82
103	Serbia	109
104	Sudan	94
105	Morocco	37
106	Russia	132
107	Mongolia	54
108	Moldova	67
109	Turkey	17
110	Oman	80
111	Azerbaijan	2
112	Cameroon	110
113	Syria	62
114	Iran	118
115	Bangladesh	32
116	China	100
117	Jordan	76
118	Haiti	111
119	Nigeria	59
120	Pakistan	72
121	Tajikistan	38
122	Eritrea	26
123	Libya	61
124	Bosnia & Herzegovina	129
125	India	95
126	Kuwait	131
127	Yemen	29
128	South Africa	124
129	Kazakhstan	126
130	Uzbekistan	69
131	Turkmenistan	123
132	Iraq	125

Top 10 Trend Index Performers
Lowest 10 Trend Index Decliners

1. Introduction

Twenty years after the landmark Rio Earth Summit, governments still struggle to demonstrate improved environmental performance through quantitative metrics across a range of pollution control and natural resource management challenges. With budgetary constraints an issue around the world, governments face increasing pressure to show tangible results from their environmental investments.

The Yale Center for Environmental Law and Policy (YCELP) and the Center for Earth Information Science Information Network (CIESIN) at Columbia University first responded to this need for sustainability metrics in 2000 with the Environmental Sustainability Index (ESI). The ESI, the predecessor to the Environmental Performance Index (EPI), was launched as a complement to the Millennium Development Goals (MDGs) and a counterpoint to gross domestic product (GDP), which for too long had been the sole measure of wellbeing. The objective of the ESI was to provide science-based quantitative metrics as an aid to achieving long-term sustainable development goals. Although the Millennium Declaration included environmental sustainability as a goal, it contained virtually no relevant quantitative metrics to support this goal – in sharp contrast to the other goals such as poverty reduction, health care and education. The ESI, published the same year, helped address the lack of relevant quantitative metrics to support the MDGs and helped governments around the world incorporate sustainability into mainstream policy goals.

The ESI was a first attempt to rank countries on 76 different elements of environmental sustainability, including natural resource endowments, past and present pollution levels, environmental management efforts, contributions to the protection of the global commons, and a society's capacity to improve environmental performance over time. This broad scope ultimately limited the ESI's utility as a concrete and pragmatic policymakers' guide.

To address this challenge, the Yale-Columbia research team shifted in 2006 to an Environmental Performance Index (EPI) that focuses on a narrower set of environmental issues for which governments can be held accountable. The EPI tracks outcome-oriented indicators based on best available data in core policy categories. In addition, the EPI seeks to promote action through transparent and easily visualized metrics that allow political leaders to see the strengths and weaknesses of their nation's performance compared to peer countries. The analysis centers on two overarching environmental objectives: 1) reducing environmental stresses on human health and 2) promoting ecosystem vitality and sound natural resource management.

The 2012 EPI and Pilot Trend EPI

The 2012 EPI reflects a methodological refinement intended to make the EPI more useful for policymakers by focusing on a slightly smaller set of core indicators that meet higher standards, including direct measurement (rather than modeled data), consistent time series, and institutional commitments to maintain these data streams into the foreseeable future.[1] The application of these more stringent criteria enabled us to track performance over time and should enable us to continue tracking performance using a more consistent set of indicators into the future.

These changes allowed us to develop – and now introduce – the Pilot Trend Environmental Performance Index (Trend EPI), which ranks countries on the change in their environmental performance over the last decade. As a complement to the EPI, the Trend EPI shows which countries are improving and which countries are declining over time. By using the Trend EPI, countries will now be able to assess their environmental progress through time as well as the efficacy of policies implemented to address issues surrounding their performance.

Our final innovation in the 2012 EPI is an attempt to create greater awareness of the of the environmental performance indicators' practical applications in policy and management contexts, drawing attention to innovation and success in these areas and supporting efforts to identify and share best practices. A separate sub-report accordingly highlights examples of what we term "Indicators in Practice:" best practices in the practical application of environmental performance measurement.

Report Organization

The structure of the report is as follows: Section 2 outlines the methodology used for the 2012 EPI, including the indicator framework, data selection process, indicator selection, weighting determination, and aggregation. We also include an explanation of how we conducted the time series analysis. Section 3 summarizes key results and findings. In Section 4, we provide detailed descriptions of each policy category included in the 2012 EPI. We also include Appendix 1: Indicator Profiles (Metadata) and Appendix 2: Preliminary Sensitivity Analysis.

[1] Unfortunately, we occasionally had to set aside this principle on high priority issues for which we lacked either direct observation, a consistent time series, or both. These included indicators in the Water Resources and Forests policy categories. More details are provided in Appendix 1: Indicator Profiles (Metadata).

2. Methodology

The 2012 EPI and Pilot Trend EPI build on a historical time series that for the first time allows countries to track environmental performance over the past decade. To consider an indicator for inclusion, we required in almost all cases (except Change in Water Quantity and Forest Loss) the existence of time series data spanning the last decade. The result is that the Indicator Framework for the 2012 EPI and Trend EPI represent a set of core indicators that meet higher standards, including more direct measurements where possible, consistent time series, and institutional commitments to maintain these datasets into the foreseeable future.

The following sections describe in detail the Indicator Framework (Section 2.1), Data Selection (2.2), Indicator Construction (2.3), Aggregation and Weighting (2.4), Materiality Filters (2.5), and the Trend EPI methodology (2.6).

2.1 Framework

The 2012 EPI is grounded in two core objectives of environmental policy: Environmental Health, which measures environmental stresses to human health, and Ecosystem Vitality, which measures ecosystem health and natural resource management. The EPI evaluates countries on 22 performance indicators spanning ten policy categories that reflect facets of both environmental public health and ecosystem vitality. These policy categories include:

- Environmental Health
- Water (effects on human health)
- Air Pollution (effects on human health)
- Air Pollution (ecosystem effects)
- Water Resources (ecosystem effects)
- Biodiversity and Habitat
- Forests
- Fisheries
- Agriculture
- Climate Change & Energy

Each policy category is made up of one or more environmental indicators; some indicators represent direct measures of issue areas, while others are proxy measures that offer a rougher gauge of policy progress by tracking a correlated variable (more information on data selection is provided in Section 2.3). For each country and indicator, a proximity-to-target value is calculated based on the gap between a country's current results and the policy target (for more information on indicator targets see Section 2.4). See Figure 2.1 for the complete 2012 EPI policy objective and indicator structure. Section 2.2 discusses the data selection process within policy categories and an important new time series component to the EPI (also discussed in Section 2.6).

2.2 Data Selection

Data sources for the 2012 EPI come from international organizations, research institutions, government agencies, and academia. Sources of data include:

- official statistics that are measured and formally reported by governments to international organizations that may or may not be independently verified;
- spatial data compiled by research or international organizations;
- observations from monitoring stations; and
- modeled data.

We employed stricter criteria for the 2012 EPI that reduced reliance on modeled data. A thorough expert review process was conducted to identify datasets that could be used to measure performance on pressing environmental concerns. Each dataset was then evaluated using the following criteria:

> *Relevance*: The indicator tracks the environmental issue in a manner that is applicable to countries under a wide range of circumstances.
>
> *Performance orientation*: The indicator provides empirical data on ambient conditions or on-the-ground results for the issue of concern, or is a "best available data" proxy for such outcome measures.
>
> *Established scientific methodology*: The indicator is based on peer reviewed scientific data or data from the United Nations or other institutions charged with data collection.
>
> *Data quality*: The data represent the best measure available. All potential datasets are reviewed for quality and verifiability. Those that do not meet baseline quality standards are discarded.
>
> *Time series availability:* The data have been consistently measured across time, and there are ongoing efforts to continue consistent measurement in the future.
>
> *Completeness:* The dataset needs to have adequate global and temporal coverage to be considered.

While every attempt was made to find datasets meeting all criteria, in some cases data availability dictated final indicator selection. For example, a hierarchy of data suitability was applied to the criterion of *Performance orientation.* The first tier of data included measures of direct environmental harm or quality, such as ambient pollution levels to assess air quality. When direct measures were not available, proxy measures (the second tier) were considered as best available substitutes. An example in the Agriculture policy category is the use of agricultural subsidies to gauge agricultural sustainability. Finally, if none of the above tiers of data were available, evaluations of policy intent or motivation were used. An example of this type of indicator is the Persistent Organic Pollutants (POPs) indicator, also in the Agriculture policy category.

A complete description of the data used to construct the 2012 EPI indicators can be found in Appendix I: Indicator Descriptions (Metadata). It is important to bear in mind that the data and indicators selected for inclusion in the 2012 EPI are not perfect and could be further improved, given advancements in data monitoring, reporting, and verification. Instead, the data and indicators represent the "best available" data at this time. Because of data gaps, limited country coverage, and lack of time series, some critical policy relevant and scientifically important issues could not be included in the 2012 EPI. Some of these issues are discussed in Box 2.1.

BOX 2.1 DATA GAPS

After more than a decade of work on environmental indicators, significant gaps in environmental data and monitoring remain. Environmental data and monitoring gaps include insufficient information related to the following:

- toxic chemical exposures;
- heavy metals (lead, cadmium, mercury);
- municipal and toxic waste management;
- nuclear safety;
- pesticide safety;
- wetlands loss;
- species loss;
- freshwater ecosystems health;
- water quality (sedimentation, organic and industrial pollutants);
- recycling;
- agricultural soil quality and erosion;
- desertification;
- comprehensive greenhouse gas emissions; and
- climate adaptation.

As data become available, future versions of the EPI may be able to include relevant indicators. However, considerable investment in data monitoring and reporting is needed. The scope of these gaps in data on critical environmental issues stresses the severity of shortcomings in international sustainability reporting. We hope that countries strive to achieve greater data coverage as technology and financial resources become available.

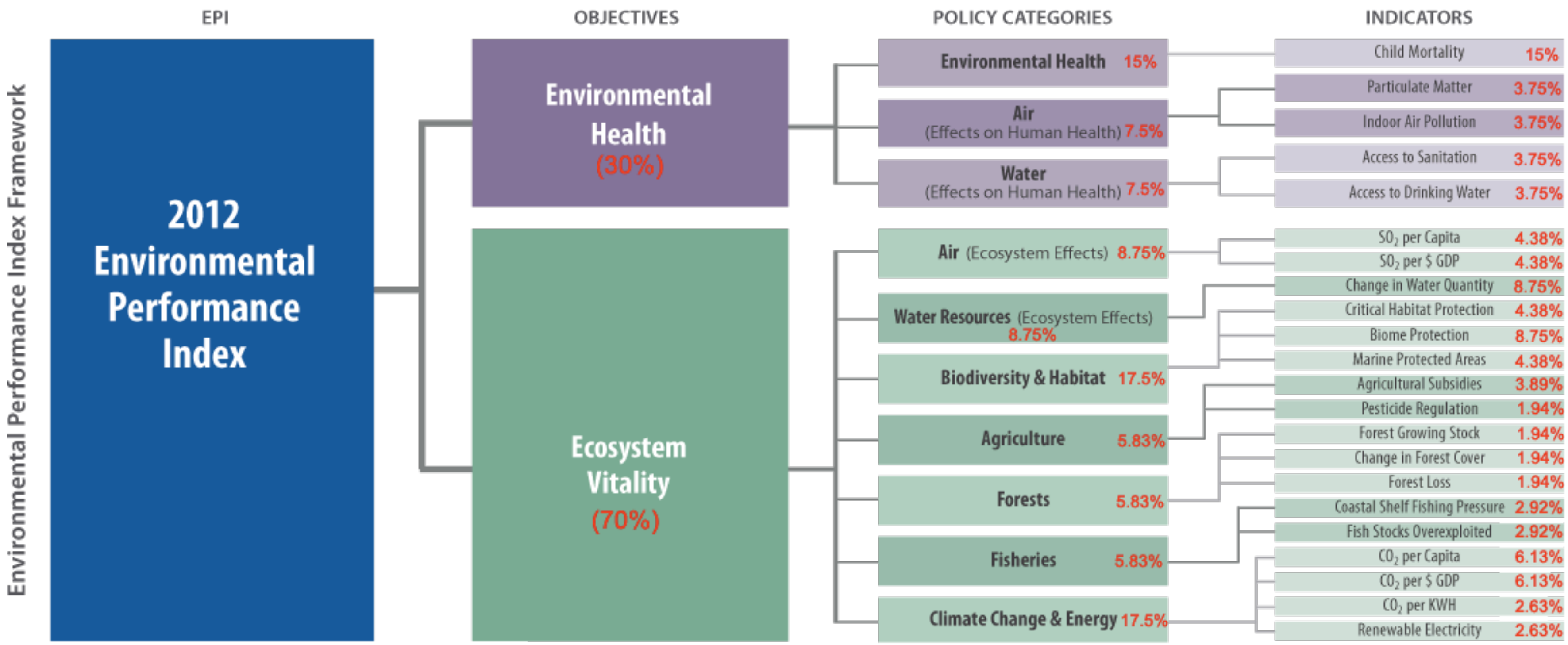


Figure 2.1. The Indicator Framework of the 2012 Environmental Performance Index. The percentages indicate the weightings used for aggregation (discussed in Section 2.4).

2.3 Indicator Construction

Indicator construction is a several step process. First, the raw datasets are cleaned and prepared for use; in particular, missing values and their nature (e.g. country not included in the source data set, country included but value missing, or not applicable) are carefully noted. Second, raw data values (e.g. total emissions) need to be transformed by dividing by population, GDP, or some other denominator in order to make the data comparable across countries. Common normalizations include percent change (e.g., rates of deforestation over some time period), units per economic output (e.g., energy use per GDP), units per area (e.g., percent territory where water extraction exceeds a certain threshold), or units per population (e.g., CO2 emissions per capita). Note that the denominator in each case should be relevant for the environmental issue of interest. In some cases it may also be useful to weight exposure (e.g., air pollution) by the population exposed. If ambient air pollution is higher in heavily populated urban areas where 75 percent of the population lives, it makes sense for the ambient levels in urban areas to contribute 75 percent to the score for that unit and in rural areas to contribute only 25 percent.

Second, because the transformed data are often heavily skewed, we perform a logarithmic transformation on most of the indicators. This serves two purposes. First, and most importantly, if an indicator has a sizeable number of countries very close to the target, a logarithmic scale more clearly differentiates among the best environmental performers. Using raw (untransformed) data ignores small differences among top-performing countries and only acknowledges more substantial differences between leaders and laggards. The use of the log transformation has the effect of "spreading out" leaders, allowing the EPI to reflect important differences not only between the leaders and laggards, but among best-performing leaders as well. Secondly, logarithmic transformation improves the interpretation of differences between sub-national units at opposite ends of the scale. As an example, consider two comparisons of particulate matter (PM10): top-performers Venezuela and Grenada (having PM10 values of 10.54 and 20.54, respectively), and low performers Libya and Kuwait (87.63 and 97.31, respectively). Both comparisons involve differences of 10 units on the raw scale (μg/m3), but they are substantively different. Venezuela is an order of magnitude better than Grenada, while Libya and Kuwait differ by a much smaller amount in percentage terms. Compared to the use of the raw measurement scale, the log scale somewhat downplays the differences between the leaders and laggards, while more accurately reflecting the nature of differences at all ranges of performance. This data transformation can encourage continued improvements by the leaders, where even small improvements can be difficult to make, but provides relatively fewer rewards for the same amount of improvement among the laggards.

Third, the transformed and logged data are converted into indicators, which create a common unit of analysis and permit comparability across indicators and aggregation up to an index. Different indices use different indicators, such as the ESI's z-score, the Ecological Footprint's "hectares of biologically productive land," and the Green GDP's use of US dollars. The EPI is based on a proximity-to-target methodology whereby each country's performance on any given indicator is measured based on its position within a range established by the lowest performing country (equivalent to 0 on a 0-100 scale) and the target (equivalent to 100). This methodology is illustrated in Figure 2.2.

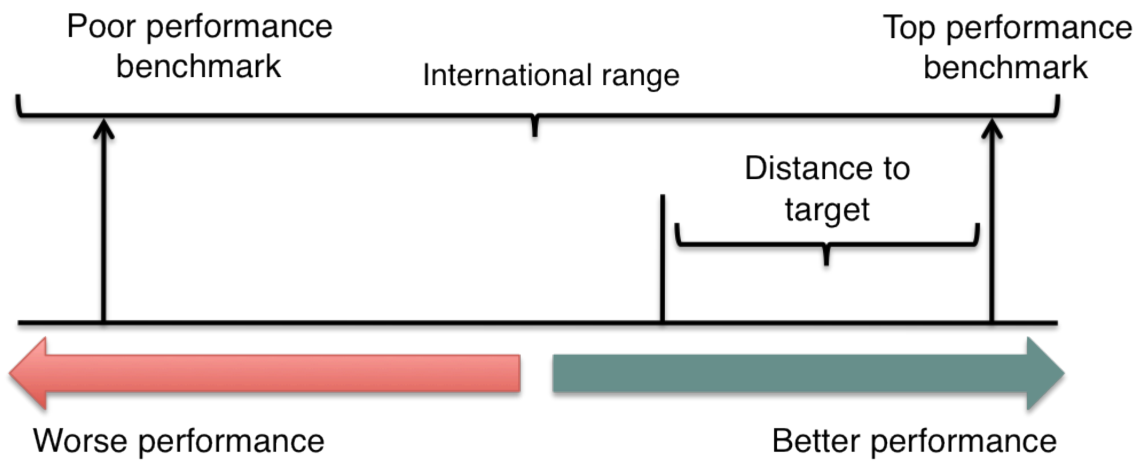


Figure 2.2 Diagram illustrating the proximity-to-target methodology used to calculate performance indicators.

The generic formula for the proximity-to-target indicator calculation in the context of the global EPI is as follows:

$$\frac{(\text{international range}) - (\text{distance to target})}{(\text{international range})} \times 100$$

For example, the score for the indicator Access to Sanitation (i.e., percent of population with access to adequate sanitation) is calculated as follows:

- The target is 100% access to sanitation.
- The worst performer might have 5% of its population with access to adequate sanitation.
- Another country's access to sanitation might be 65%.
- The international range is 100-5 = 95.
- For the country with 65% access to sanitation, its proximity-to-target score is calculated as follows: (95-35/95) x 100 = 63.1.

Fourth, since targets are essential to the indicator calculation, the next step is to identify potential targets for each indicator. International targets (e.g. from environmental treaties or global organizations such as the World Health Organization), scientific criteria, or expert judgment may be used. In the EPI, achieving or exceeding the target is equivalent to a score of 100 on the 0-100 scale. It is also necessary to establish the low performance benchmark, which is the low end of the EPI range (equivalent to 0 on the 0-100 scale). For EPIs the low performance benchmark is usually established by the worst performing country on that particular indicator, although winsorization (trimming the tails) at the 95th percentile may also be used to establish this benchmark. For the 2012 EPI and the Pilot Trend EPI, we set the low performance benchmark by using the entire time series data (e.g., the lowest performance over a 20 year time series).

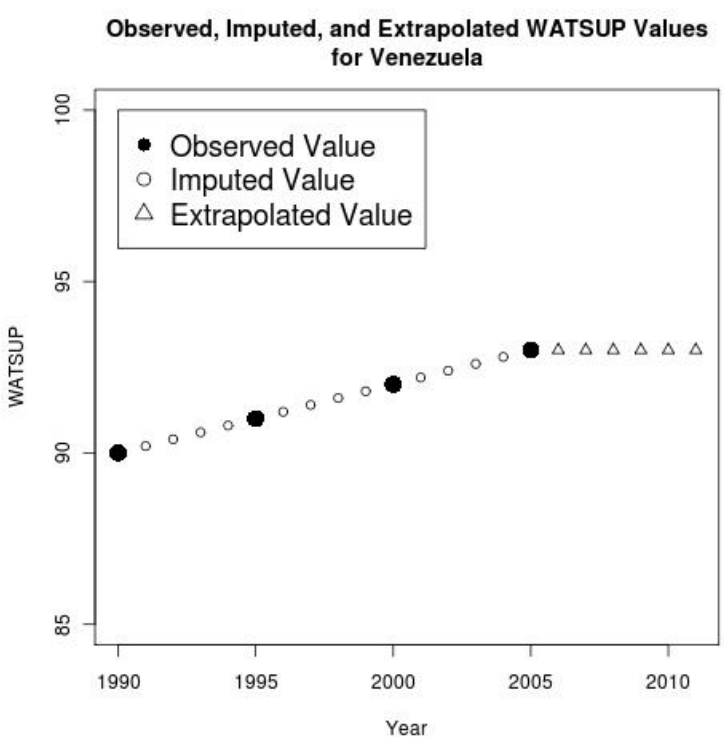
The 2012 EPI targets were established using input from five sources:

- treaties or other internationally agreed-upon goals;
- standards set by international organizations;
- leading national regulatory requirements;
- expert judgment based on prevailing scientific consensus; and
- ranges of values observed in the data over the duration of the time series.

Detailed information regarding the exact targets used for each indicator is available in Appendix 1: Indicator Descriptions (Metadata).

BOX 2.2 THE CHALLENGE OF TIME SERIES DATA

In spite of the data selection criterion requiring historical data availability as well as the promise of future measurement, data sources vary greatly with respect to the nature of time series coverage. With Forest Loss, for example, calculated changes in forest coverage from satellite measures is only available in five-year increments, for 2000 and 2005, and in practice we had to combine these two time periods because we did not have a forest cover baseline for 2005. In other cases much more detailed time series data are available, but even these cases suffer from data gaps in the middle or at the beginning and ends of the series for some countries. In order to support the calculation of the Pilot Trend Series EPI, we filled in missing values wherever possible using the simplest possible method that remains as close as possible to available data values.



When missing values occur as gaps in the interior of a series, we impute values linearly based on closest available data points. When missing values occur at the beginning or end of a series, we extrapolate using the closest year of available data. The figure to the left provides the example of both techniques for Venezuela's Access to Drinking Water (WATSUP) time series. Data from the WHO / UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation are only available for 1990, 1995, 2000, 2005, and 2008, and Venezuela's 2008 value was missing. A total of twelve points interior to the observed data were imputed, and values for 2006-2011 were extrapolated from the 2005 value of 93 percent. We conducted such imputations to create a complete time series for each transformed dataset and each country with at least one data point from 1980 to 2011.

2.4 Constructing the EPI – Weighting and Aggregation

In the field of composite indices, the issues of weighting and aggregation are particularly sensitive and subjective. There is no clear consensus among the expert community on composite index construction as to how to best determine a methodological strategy for combining diverse issues, such as those represented in the EPI. We assign explicit weights to the indicators, policy categories, and objectives in order to create the aggregate EPI score (see Figure 2.1). The weightings we selected for the purposes of aggregation only represent one viewpoint, and we recognize there may be legitimate differences of opinion regarding the relative importance of policy categories.

We made some notable changes to our past weighting and aggregation methodology for the 2012 EPI. A 50-50 weighting for both the Environmental Health and Ecosystem Vitality objectives means that the overall composite EPI scores is too heavily influenced by the Environmental Health objective. This unevenness is the result of differences in the variance in the scores for the Environmental Health and Ecosystem Vitality objectives (standard deviations of 27.2 and 12.0, respectively). With 50-50 weights, the result is a much higher correlation between the overall EPI score and the Environmental Health objective score than for the Ecosystem Vitality objective score. In other words, countries that perform high in the Environmental Health objective are likely to perform better in the EPI overall, regardless of scores in the Ecosystem Vitality objective.

To correct this statistical imbalance between the two objectives, the Environmental Health objective for the 2012 EPI comprises 30 percent of the overall score while Ecosystem Vitality objective makes up the other 70 percent. These relative contributions do not reflect the prioritization of “nature” indicators over those of environmental health, but rather accomplish a balance between the contribution of these policy objectives to the overall EPI, and also recognize that humans require healthy ecosystems just as much as they require clean air and potable water. The change in weightings simply reflects a much-needed statistical correction to the aggregation method to produce EPI scores more balanced between the two objectives. Figure 2.3 demonstrates the balance achieved through these weights. Environmental Health (EH) and Ecosystem Vitality (EV) have statistical correlations of 0.57 and 0.64 with the overall EPI score, respectively.

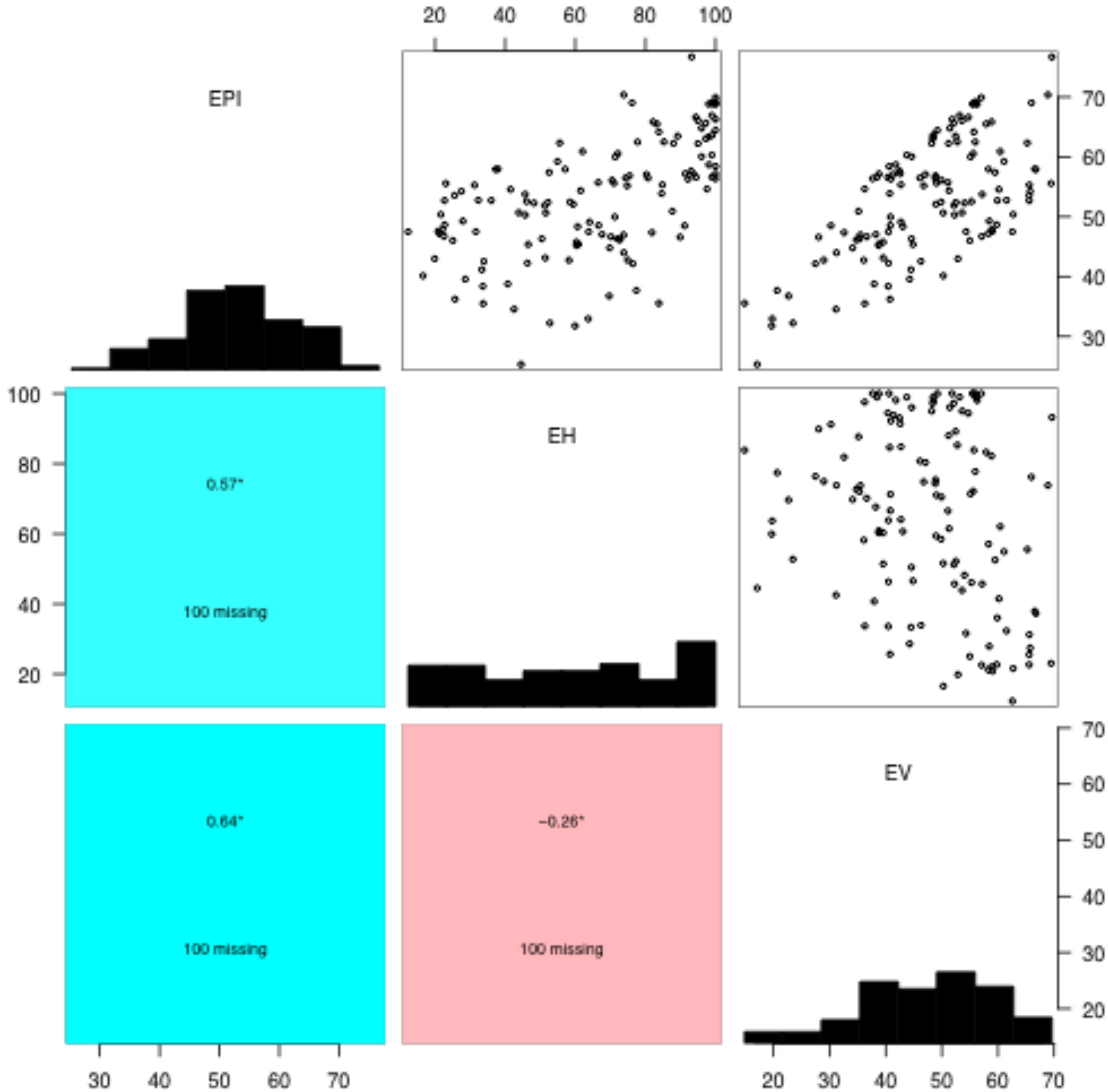


Figure 2.3 Relationship of the Ecosystem Health (EH) and Ecosystem Vitality (EV) objective scores to the overall EPI scores.

At the indicator level, weightings were determined based on expert judgments on the suitability of the data or the quality of the underlying data. For example, the forestry indicators were given lower weights for various reasons. Although we believe the satellite remote-sensing methodology used to construct the Forest Loss indicator to be sound, the method currently fails to account for reforestation as well as loss of forest. Therefore, as only a loss measure, it is not an ideal indicator to adequately assess performance in the forestry sector. To compensate for this inadequacy, we added the Forest Growing Stock and the Change in Forest Cover indicators, which have high uncertainty (see Section 4). The complete weightings used to construct the 2012 EPI are illustrated in Figure 2.1. It is important to note that these weights do not reflect the actual relative contribution (as measured by correlations) to the overall EPI because of differences in variances across indicators, policy categories, and objectives.

2.5 Materiality Thresholds

Recognizing that countries have varying natural resource endowments, physical characteristics, and geography, we applied the concept of materiality in the aggregation phase. If a country met the criteria for an indicator being "material" (i.e. relevant), the indicator was included in the EPI calculation. For countries that did not meet the materiality threshold, the indicator is "averaged around," meaning the other indicators in a particular category receive more weight.

The most obvious example of materiality is demonstrated through the Fisheries category. Some countries are landlocked and therefore cannot support a marine fishing industry or activities. Other cases of materiality are not as straightforward. For example, we set thresholds by which a policy category or indicator may be "immaterial" for a country. Desert countries that did not meet certain criteria for forest cover were exempted from the Forests policy category. A country that is considered in energy poverty (see Box 2.3 on Countries in Energy Poverty), i.e., below 130 KWH of annual electricity generation, likely does not need to concern itself with renewable electricity generation. Figure 2.4 details the materiality thresholds applied in the 2012 EPI.

Policy Category	Indicator	Materiality Filter
Biodiversity and Habitat	Marine protected areas	Coastal
	Critical habitat protection	Must have sites designated as ‘critical’ by the Alliance for Zero Extinction
Forests	Forest Loss	Must have minimum 100 sq. km of forested land
	Forest Growing Stock	Must have minimum 100 sq. km of forested land
	Change in Forest Cover	Must have minimum 100 sq. km of forested land
Fisheries	Coastal shelf fishing pressure	Coastal
	Fish stocks overexploited and collapsed	Coastal
Climate Change	Renewable electricity generation	Must generate above 130 KWH of electricity annually

Figure 2.4 Materiality filters applied to indicators in the 2012 EPI.

BOX 2.3 COUNTRIES IN ENERGY POVERTY

The United Nations has named 2012 the "International Year of Sustainable Energy for All," setting three goals: ensuring universal access to modern energy services, doubling the rate of improvement in energy efficiency, and doubling the share of renewable energy in the global energy mix. Possibly the greatest area of opportunity for achieving these goals is the developing world, where low electrification rates mean great potential for improving access, where efficiency gains from switching from widely used traditional fuels to modern energy can be significant, and where expanding populations and standards of living drive demand for new generation facilities that can take advantage of recent advances in renewable energy technology.

The aforementioned goals are driven not just by environmental sustainability targets, but also by recognition of the significant negative impact that energy poverty has on billions of lives. Many throughout the developing world experience energy poverty, lacking access to electricity. According to the IEA, 1.3 billion people lack access to electricity, and 2.7 billion to clean cooking facilities, mostly in rural areas in sub-Saharan Africa and developing Asia. For these populations, productive activity is limited by available energy sources. Electrification can improve lives and promote environmental sustainability here not just by providing light and power for a greater range of activities, but by encouraging a shift away from traditional energy sources that contribute to millions of deaths annually via indoor air pollution, and release significant amounts of greenhouse gases.

To provide modern energy, many countries have invested in large-scale primary generation facilities—hydroelectric dams, for example. But the infrastructure necessary to deliver electricity to the entire population is lacking, too expensive to build when the customer base is diffuse and much of the population served cannot afford to pay full price for electricity. In Tanzania, in 2009, just 13.9 percent of the population had access to electricity through the national grid. The country's wealthier unelectrified households use diesel generators for electricity production, and poorer households do without, relying on charcoal, fuelwood and kerosene for their energy needs. Tanzania's limited grid electricity comes primarily (60 percent) from hydropower, but overall energy consumption in the country is still 90 percent biomass, primarily fuelwood and charcoal. In 2005 Tanzania took steps towards alleviating energy poverty with the creation of the Rural Energy Agency, which is charged with identifying and supporting sustainable modern energy projects within the country. Via the efforts of this agency, Tanzania stands to meet both human development and environmental sustainability goals.

In the coming years, forward-thinking countries will explore strategies to increase renewable primary energy generation in order to provide modern energy access while protecting the shared environment for increasing populations with climbing standards of living. In addition, decentralized electricity generation and transmission—in the form of community mini-grids, for example—can help overcome cost issues in traditional grid expansion, and provide modern energy access to alleviate energy poverty. By developing strategies to increase electrification rates efficiently, expanding renewable energy, countries can both pursue reductions in energy poverty and work towards environmental performance goals.

2.6 Pilot Trend EPI

The Pilot Trend EPI (Trend EPI) is based on the same Indicator Framework as the 2012 EPI. The Trend EPI takes advantage of available historical data to measure performance changes from 2000 to 2010. In some cases no time series was available, as in the Water Resources policy category. In other cases, the indicators themselves are change variables (e.g. Forest Loss) and could be used directly. For each indicator having a meaningful time series, we use a simple linear regression model of the annual proximity-to-target scores to determine a rate of improvement or decline for each indicator. This number is then translated to a score from -50 to 50, where 0 represents no change. The extremes (50 is the “best” improvement and -50 represents a “biggest decline”) are based on the observed trend results, indicator by indicator. For the few indicators that are already change indicators and truncated at a value corresponding to “no change” (Forest Loss, Forest Growing Stock, Forest Cover, and Change in Water Quantity), the maximum possible trend value is 0.

Aggregation from the individual indicator to the policy categories and objectives proceeds using the same methodology and weights as the 2012 EPI. Aggregation of the policy objectives to create the Pilot Trend EPI uses different weights, however, to help maintain a balance between trend performances on Environmental Health and Ecosystem Vitality.

3. Results and Analysis

The 2012 EPI and Pilot Trend EPI provide a quantitative basis for comparing, analyzing, and understanding environmental performance for 132 countries. The two indexes rank these countries on their environmental performance using the most recent year of data available (the 2012 EPI) as well as performance over the last decade (the Trend EPI). Taken together, the 2012 EPI and Trend EPI reveal current standings on a core set of environmental issues, and, perhaps more meaningfully, identify where progress is or is not being made.

The full results of the 2012 EPI and Pilot Trend EPI, including country and indicator-level analysis, are available on the web at www.epi.yale.edu. We highlight some of the most important results and policy conclusions here in the report.

3.1 Main Results – Country Performance

Switzerland (with an EPI score of 76.69) leads the world in addressing pollution control and natural resource management challenges. Its top ranking on the 2012 EPI is in large part due to its high performance in air pollution control. Switzerland ranks first in the categories Air Pollution (effects on human health) and Air Pollution (ecosystem effects). It also has high marks for access to drinking water and the biodiversity and habitat indicators.

Latvia (70.37), Norway (69.92), Luxembourg (69.2), and Costa Rica (69.03) round out the top five positions in the 2012 EPI. These results show that it is possible for some middle-income countries, such as Latvia (per capita GDP $12,938) and Costa Rica (per capita GDP $10,238) to achieve impressive environmental outcomes. This suggests that income alone is not a sole determinant of environmental performance – policy choices and good governance also matter.

At the low end of the 2012 EPI rankings are South Africa (34.55), Kazakhstan (32.94), Uzbekistan (32.24), Turkmenistan (31.75), and Iraq (25.32). These countries are water scarce and face significant sustainability challenges; the last three are also known for weak governance.

Latvia stands at the top of the new Trend EPI followed by Azerbaijan, Romania, Albania, and Egypt. Improvements in air quality are driving much of the trend improvement results in Latvia. Upward trends in reduction of agricultural subsidies as well as lower rates of child mortality also contribute to Latvia's high trend results. Azerbaijan also demonstrates positive trends in lowering rates of child mortality and improving air quality. Romania has shown improvements in agricultural subsidies, fisheries (coastal fishing shelf pressure), and climate change. Albania's performance over the last decade in the climate change category is primarily responsible for high trend results. Egypt's position in the top five is largely due to substantial gains in the Environmental Health objective – in indoor air pollution, access to drinking water, and access to sanitation.

While many countries had generally positive environmental performance trends, some deteriorated over the 2000-2010 period. Estonia, Bosnia and Herzegovina, Saudi Arabia, Kuwait, and Russia were countries with the worst negative trends. Russia, at the very bottom of the Trend EPI ranking, has suffered a severe breakdown in environmental health as well as performance declines related to over-fishing and forest loss. It shows declines in every category except for slight improvements in sulfur dioxide emissions, though levels are still far below target.

For countries near the top of the EPI rankings, the Trend EPI results may not be particularly meaningful because many of the longtime leaders have limited room for improvement. Iceland, for example, ranks 13th in the EPI but 64th in the Trend EPI – reflecting its high ranking in the EPI over the past decade, which makes further gains hard to achieve. But some top-tier performers on this year's EPI do have strong Trend EPI rankings, reflecting improved performance over the past 10 years. The United Kingdom, for example, ranks ninth on the 2012 EPI list and 20th on the Trend EPI, which demonstrates that significant progress has been made over the last decade on a number of environmental issues.

3.2 Main Results – Global Trends

By comparing results at the level of the Environmental Health and Ecosystem Vitality Objectives, differences in global performance can be revealed through trends over the last decade. Figure 3.1 reveals an imbalance between how global policy-making is organized with respect to environmental matters that affect human health directly (labeled "Environmental Health Objective") and those that do not (labeled "Ecosystem Vitality Objective"). In 2000, we see that environmental health, averaged for the world, is significantly better than ecosystem vitality. And over the course of the next 11 years the gap widens – environmental health improves faster than ecosystem vitality. This imbalance reflects a failure to match policy-making capabilities to environmental objectives.

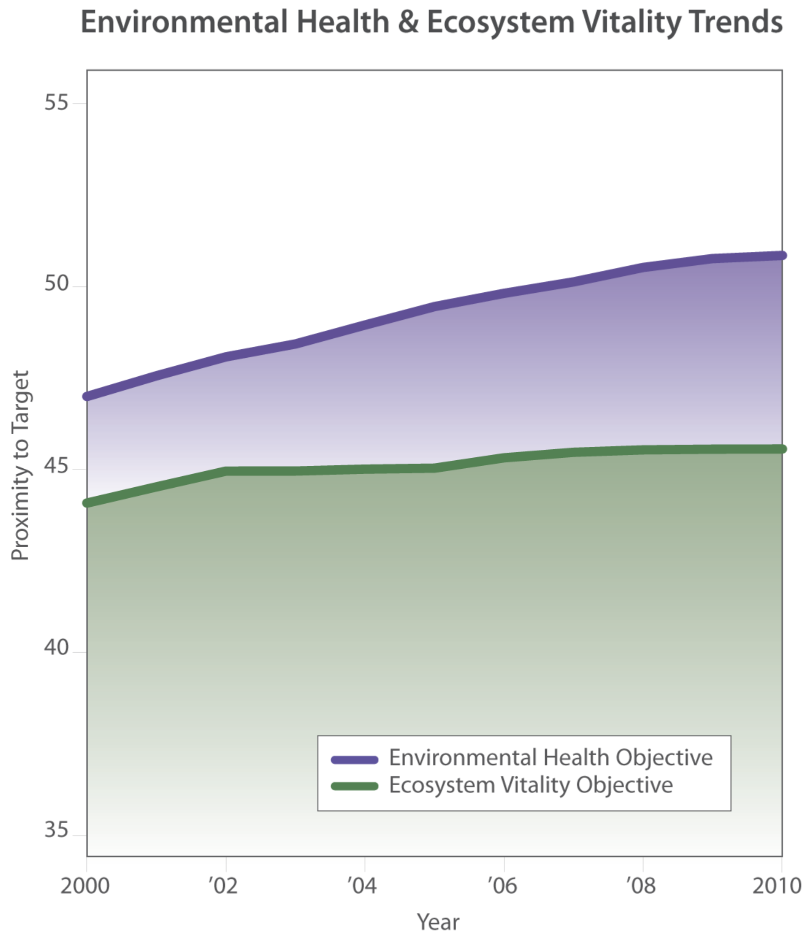
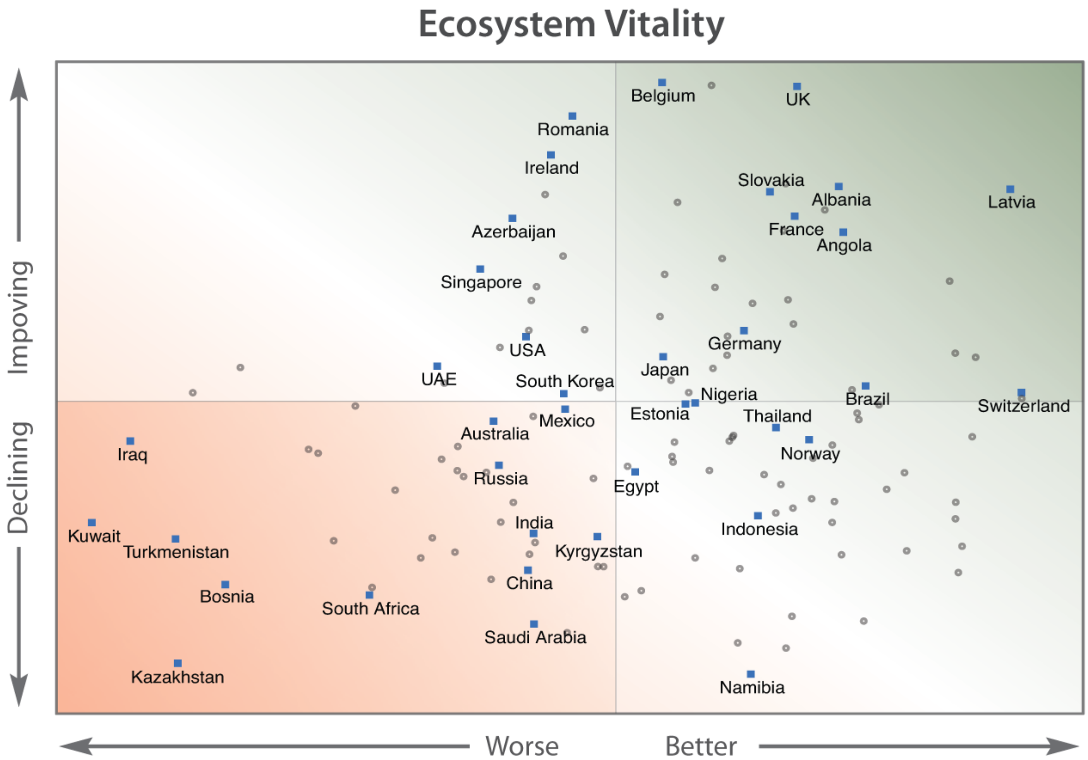


Figure 3.1 World average Environmental Health and Ecosystem Vitality objective scores, 2000-2010. The averages are population-weighted by country.

A closer examination of the 2012 EPI and Trend EPI results for a subset of countries also demonstrates distinct differences between trends in Environmental Health and Ecosystem Vitality performance in the last ten years. Figure 3.2 shows another core difference between Environmental Health and Ecosystem Vitality. For the Environmental Health measure, all countries but one (Iraq) that are currently doing worse than average have improved their scores significantly since 2000. This condition is an indication of positive policy responses. By contrast, for the ecosystem vitality measure, a majority of the countries doing poorly at present have been getting worse since 2000.



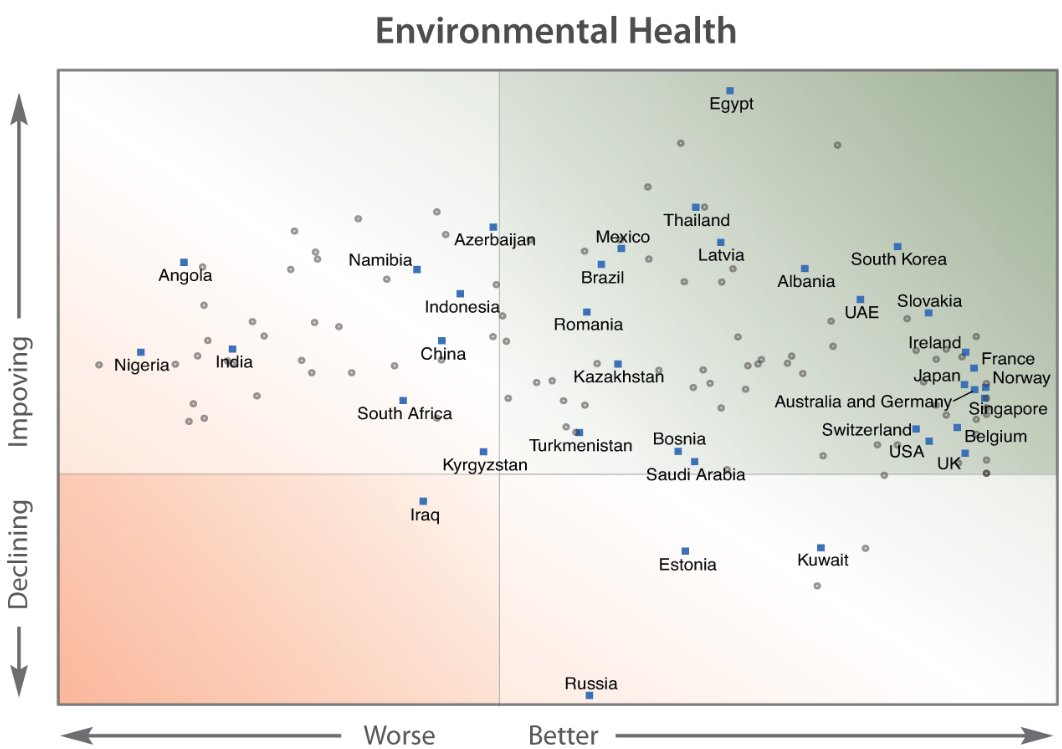
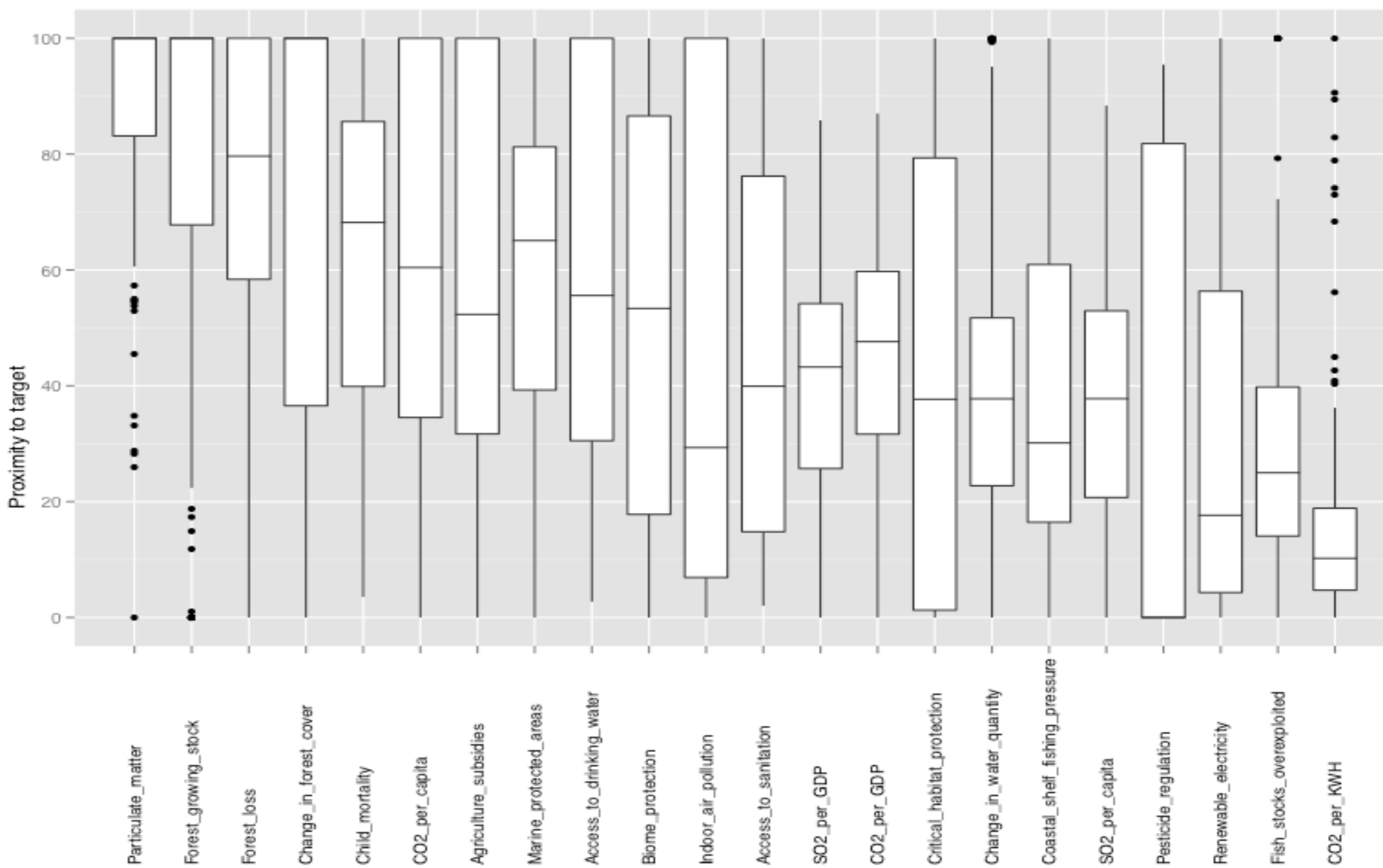


Figure 3.2 Comparison of current EPI values (x-axis) and recent trends (y-axis), by objective (Ecosystem Vitality and Environmental Health).

At the indicator level, the 2012 EPI reveals variability in performance and identifies issues in which global performance is headed in the right direction and others that are not. Figure 3.3 shows the distribution of country scores by indicator. These plots demonstrate that there is considerable differentiation among environmental issue areas in terms of their dominant policy dynamics. For fine particulate air pollution (PM 2.5) and forest growing stock, for example, most countries are performing well and more serious problems stem from anomalous values in outlier countries. Under these circumstances, policies need to be framed around reigning in these negative outliers, treating them as problem hotspots. For agricultural subsidies and access to drinking water, by contrast, the spread is much wider and there are many countries at 100 percent. For issues such as these, policies need to find ways to spread best practices already proven to work. Finally, there are issues such as renewable electricity generation and carbon emissions from electricity generation (CO2 per KWH), for which most countries have very poor scores. In these kinds of issue areas, there is a compelling need to find policy processes that are transformational and that permit movement into outcomes not currently prevalent.


Proximity to target
100
80
60
40
20
0
Particulate_matter
Forest_growing_stock
Forest_loss
Change_in_forest_cover
Child_mortality
CO2_per_capita
Agriculture_subsidies
Marine_protected_areas
Access_to_drinking_water
Biome_protection
Indoor_air_pollution
Access_to_sanitation
SO2_per_GDP
CO2_per_GDP
Critical_habitat_protection
Change_in_water_quantity
Coastal_shelf_fishing_pressure
SO2_per_capita
Pesticide_regulation
Renewable_electricity
Fish_stocks_overexploited
CO2_per_KWH

3.3 Policy Conclusions

- The latest EPI rankings reveal a wide range of environmental sustainability results. Many countries are making progress on at least some of the challenges they face. At the indicator level, our analysis suggests that some issues are being successfully addressed at a worldwide scale, although performance on some other challenges, notably climate change, has declined globally.

- Economic development matters. The Environmental Health scores, in particular, reveal a significant relationship with GDP per capita, although there is a diversity of performance within every level of economic development.

- The pattern of results make clear that environmental challenges come in several forms and vary with country-specific circumstances as well as the level of development. Some issues arise from the resource and pollution impacts of industrialization, such as air pollution and rising levels of waste. These impacts largely affect developed countries. Other challenges are commonly associated with poverty and underinvestment in basic environmental amenities, such as access to safe drinking water and basic sanitation. These problems primarily affect developing nations.

- A number of countries that lag on the overall EPI have impressive results on the Trend EPI. For countries that have been at the high end of the EPI ranking over the last decade, the trend results are less meaningful. We note that the overall EPI and Trend EPI rankings by themselves should be understood only as indicative. More insight will often be obtained by looking at the individual indicator level and policy category results.

- The Trend EPI reveals improvements for many countries on a significant number of issues. In the Environmental Health objective, global trends show decreasing child mortality as well as increasing access to sanitation and drinking water. However, persistent challenges remain in the Ecosystem Vitality objective. In particular, with respect to climate change, greenhouse gas emissions continue to rise globally with few countries on a sustainable emissions trajectory.

- A comparison of the 2012 EPI and Trend EPI exposes persistent gaps in environmental governance and management over time. In general, countries show gains on the Environmental Health objective across all levels of performance measured by the EPI. With regard to Ecosystem Vitality, however, the results are much more varied. Some countries are making gains, but many are not. And a worrisome number of countries are both low-ranked and declining.

- The 2012 EPI highlights an array of challenges constraining movement toward data-driven and analytically rigorous environmental policymaking. These issues include unreliable data sources, gaps in data coverage, limited time series metrics, persistent methodological weaknesses, and the lack of a systematic process for verifying the environmental data reported by governments. The more rigorous data standards used in the 2012 EPI resulted in the replacement or omission of some indicators used in previous indices. We are particularly distressed by the lack of global, accurate, and comparative data on waste management, recycling, toxic exposures, and several other critical policy concerns. Likewise, the low quality and limited availability of comparative data for issues such as agricultural sustainability and water quality as well as quantity is disappointing. Simply put, the world needs better data collection and monitoring, more consistent reporting and analysis, and mechanisms for independent data verification.

4. Policy Category Descriptions

4.1 Environmental Health

Policy Focus

Environmental conditions or factors have significant direct and indirect impacts on human health including many childhood diseases. Approximately 13 million deaths could be prevented every year by addressing environmental problems, such as air and water pollution, and through public health measures, such as improved access to water and sanitation and the use of cleaner fuels (WHO, 2008). It is estimated that about 25% of the diseases we face today are occurring due to prolonged exposure to environmental pollution (WHO, 1997)

Many environmental conditions lead to or exacerbate many childhood diseases and may cause death. These environmental conditions are directly linked to a lack of reliable and accessible safe drinking water, poor sanitation facilities, and environmental pollution (UNDP, 2005).

Indicator Selected

Child Mortality (CHMORT): This indicator measures the probability of dying between age 1 and 5 (4q1), which is highly correlated with mx(1-4). Because the causes of child mortality among 1–4 year olds are strongly influenced by environmental causes, this indicator is considered to be a useful proxy for underlying environmental conditions. Children are more vulnerable to environmental conditions because their immune systems are not yet fully developed and their metabolisms are faster than adults (UNDP, 2005). Environmental conditions are directly linked to many childhood diseases, such as malaria, cholera, tuberculosis, as well as respiratory, diarrheal, parasitic and skin diseases, acute respiratory infections, and cancer (UNDP, 2005).

Child Mortality is highly correlated with the Environmental Burden of Disease's Disability Adjusted Life Years (DALY) measure used in past EPIs. This indicator was chosen for the 2012 Core EPI because it meets all of our criteria. There is wide country coverage of child mortality, a historical time series is available, and data are updated regularly by the UN Population Division. Child mortality is measured in a globally consistent manner with established methods, therefore any change over time reflects a change in performance, and differences among countries reflect differences in performance.

Data Gaps & Deficiencies

The ideal indicator would be the Environmental Burden of Disease, but these data are not updated on a consistent basis and there is, as yet, no time series. EBD estimates also have limitations because they combine information on the capacity of the health care system and environmental risk factors in a given country. This is also true of the Child Mortality indicator, and we recognize that for the most developed countries the child mortality is largely non-environmental and driven by factors like accidents or congenital diseases.

Child mortality by cause would have been a useful indicator to include, but country coverage is poor and time series data are generally not yet available.

4.2 Air Quality – Effects on Human Health

Policy Focus

The WHO estimates that, of all diseases, lower respiratory tract infections are the second most attributable to environmental factors (WHO, 2006). Such infections are frequently caused by air pollution, which is estimated to cause approximately two million premature deaths worldwide per year. Particulate matter contributes to acute lower respiratory infections and other diseases such as cancer.

The 2012 EPI captures the health risks posed by particulate matter in two indicators: Outdoor Air Pollution and Indoor Air Pollution. These indicators represent environmental risks faced by countries at different positions on the economic spectrum. Three billion people in the poorest developing countries rely on biomass in the form of wood, charcoal, dung, and crop residue as their cooking fuel, which means indoor air pollution poses significant health risks in developing nations (Ezzati and Kammen, 2002). Meanwhile, outdoor air pollution tends to pose more severe risks in rapidly developing and developed nations with high levels of industrialization and urbanization. Thus, the air pollution indicators selected for use in the 2012 EPI identify the relevant environmental risks to countries at different development levels.

Indicators Selected

Indoor Air Pollution: Burning solid fuel indoors releases harmful chemicals and particles that present an acute health risk. These chemicals and particles can become lodged in the lungs when inhaled, leading to numerous respiratory problems, including acute lower respiratory tract infections. One recent study concluded that 4.6% of all deaths worldwide are attributable to acute lower respiratory tract infections caused by indoor fuel use (WHO, 2006).

This indicator is a measure of the percentage of a country's inhabitants using solid fuels indoors. The 2012 EPI uses data produced for the World Health

Organization's EBD study that capture exposure to indoor smoke risks (Smith et al., 2004). The data are adjusted to account for reported ventilation in each measured home to best estimate actual exposure. The target for Indoor Air is set by expert judgment at zero, which reflects the opinion that any amount of solid fuel used indoors pose a risk to human health and is therefore considered undesirable. Many developing countries have already achieved this target, indicating that elimination of indoor solid fuel usage is not an unrealistic expectation.

Particulate Matter: Suspended particulates contribute to acute lower respiratory infections and other diseases such as cardiovascular diseases and cancer. Finer particulates (such as $PM_{2.5}$) can be inhaled into the lungs, causing greater damage than coarser particulates. Annual average concentrations of greater than 10 micro-grams $PM_{2.5}$ per cubic meter are known to be injurious to human health.

This indicator was developed by scientists at Battelle in collaboration with CIESIN with funding from the NASA Applied Sciences Program. Using relationships between MODIS and MISR Aerosol Optical Depth (AOD) and surface $PM_{2.5}$ concentrations that were modeled by van Donkelaar et al. (2010), monthly MODIS and MISR AOD retrievals were used to estimate annual average surface $PM_{2.5}$ concentrations from 2001 to 2010. These were averaged into three year rolling averages from 2002 to 2009 to generate global grids of $PM_{2.5}$ concentrations. The grids were resampled to match CIESIN's Global Rural-Urban Mapping Project (GRUMP) 1km population grid. The population weighted average of the $PM_{2.5}$ values were used to calculate the country's annual average exposure to $PM_{2.5}$ in micrograms per cubic meter. The target is 10 micro-grams per cubic meter, per the WHO guidelines.

Data Gaps & Deficiencies

The use of satellite data to measure air pollution concentrations represents a major step forward in measurement, because of the ability to measure over large areas, and in areas without ground-based monitors, rather than just at the location of monitoring stations. Nevertheless, there are scientific uncertainties inherent in any conversion of a column measurement, such as AOD taken from the top of the atmosphere, to ground-level concentrations. The uncertainty of the underlying satellite-based dataset is fully quantified in van Donkelaar et al. (2010). In addition, the data only extend to 60^{o} north latitude, and hence the values for high latitude countries such as Norway and Russia only represent regions south of that parallel. Satellite retrievals of aerosol concentrations are not possible over highly reflective surfaces, such as snow-covered surfaces and deserts, so values were excluded in these regions.

Ideally other pollutants would be considered, especially tropospheric ozone. According to the US EPA (undated), "evidence from observational studies strongly indicates that higher daily ozone concentrations are associated with increased asthma attacks, increased hospital admissions, increased daily mortality, and other markers of morbidity."

4.3 Water – Effects on Human Health

Policy Focus

Human health is heavily dependent on clean water resources and adequate sanitation. According to the WHO, diarrhea is the disease most attributable to quality of the local environment. It is estimated that 88% of diarrhea cases result from the combination of unsafe drinking water, inadequate sanitation, and improper hygiene (WHO 2006, Pruss-Ustun 2004a).

Environmental factors account for an estimated 94% of the global disease burden for diarrhea (WHO 2006), which is a leading cause of death among children. One of the main sources of diarrheal disease is contamination by fecal-oral pathogens that are largely caused by a lack of safe drinking water and sanitation facilities. Additionally, inadequate sanitation poses threats to the environment from improper disposal and treatment of human waste. It is important for populations to have access to drinking water and adequate sanitation because these factors play large roles in human health.

Indicators Selected

Access to Water: Access to Water is an indicator that seeks to measure water quantities as a percentage of a country's population with access to an improved source of drinking water. An improved drinking water source is defined as piped water into dwelling, plot or yard; public tab/standpipe; tubewell/borehole; protected dug well; protected spring; and rainwater collection (UNICEF and WHO 2008). Improved drinking water sources allow access to non-contaminated water supplies, which will prevent the spread of diseases related to the quality of the environment, such as diarrhea.

Access to Sanitation: Access to Sanitation is an indicator that seeks to measure sanitation quantities as a percentage of a country's population with access to an improved source of sanitation. This metric is useful for estimating the environmental risk individuals face from exposure to poor sanitation. "Improved" sanitation technologies include: connection to a public sewer or septic system; non-public pour-flush or simple pit latrine and ventilated improved pit latrine. The excreta disposal system is also included if it is private or shared (not public) and separates human excreta from human contact. Adequate sanitation facilities reduce the chance of exposure to harmful bacteria and viruses that directly affect human health. Additionally, sanitation practices, such as waste collection and treatment, also reduce impacts to the environment.

There is excellent country coverage and globally consistent methodologies for these metrics. Additionally, both indicators are major long-term monitoring efforts that provide historical and future time series so changes over time reflect change in performance.

Data Gaps & Deficiencies

The water metric, Access to Water, does not capture the quality of water that individuals actually drink or use for food preparation. In some cases, “improved” water sources are not necessarily free of contaminants and may require additional treatment prior to consumption. There are no globally comparable data on the quality of tap water and well water used by many for drinking water.

4.4 Air Pollution (Effects on Ecosystems)

Policy Focus

Beyond its human health impacts, air pollution is also detrimental to ecosystems. Through direct exposure and accumulation, reactive compounds negatively impact plant growth and are primary contributors to acid rain, which can diminish fish stocks, decrease biological diversity in sensitive ecosystems, degrade forests and soils, and diminish agricultural productivity.

Indicator Selected

Sulfur Dioxide Emissions per capita and *Sulfur Dioxide Emissions per GDP*: Sulfur dioxide (SO_2) is the major cause of acid rain, which degrades trees, crops, water, and soil. SO_2 can also form hazardous aerosols under certain atmospheric conditions. The indicator is based on estimates of anthropogenic global sulfur dioxide emissions using a bottom-up mass balance method which was calibrated to country-level inventory data (Smith et al. 2010). The five steps in the calculation were: (1) development of an inventory by sector and fuel for three key years, (2) development of detailed estimates for smelting and international shipping, (3) calculation of a default set of emissions by interpolating emissions factors from the key years, (4) calculation of final annual emissions values by fuel that match inventory values, and (5) estimate sectoral emissions (Smith et al 2011, pg.1102).

The country totals were then divided by population and GDP. There are no internationally agreed upon targets for sulfur dioxide emissions. The 2012 EPI adopted the policy target of 0 emissions per capita and per GDP.

Data Gaps and Deficiencies

There is room for improvement in air pollution indicators. The 2010 EPI included indicators for additional reactive compounds such as Nitrogen Oxides and Non-Methane Volatile Organic Compound. There was also an indicator for Ozone Exceedences. However, issues with data reporting consistency and a lack of reliable time series data required that fewer air pollution indicators be included in the final 2012 EPI.

Existing data sources for air pollution concentrations and emissions are either incomplete or difficult to use in global comparisons. Air quality monitoring systems vary significantly between countries, often producing fundamentally dissimilar data. In addition, many countries have too few monitoring stations to produce representative samples. A complete air pollution index for the EPI would contain indicators for particulate matter, ozone, NO_2 and SO_2, carbon monoxide (CO), lead, methane, ammonia, mercury, black carbon, persistent organic compounds, VOCs, and benzene. We removed CO from this policy category because its effects are primarily on human health, and methane because it is mostly a greenhouse gas. Unfortunately, reliable data for the remainder of the pollutants listed are not available. An ideal performance measure for ecosystem vitality and air pollution would include time-specific emissions quantities, the mapping of pollutant movement, the ecological sensitivity to pollutants by area, and the level of clear policy commitments to emissions reductions. The European Union is a model in this regard because it meets all of these monitoring goals; however, there are no global datasets with all of these measures.

4.5 Water (effects on ecosystems)

Policy Focus

Pressure on global freshwater resources is growing due to factors such as population growth, air pollution deposition, climate change, land management, and economic development (Vorosmarty et al. 2010). This makes adequate water resource monitoring, management, and protection particularly urgent. Continued over-abstraction, and particularly abstraction of fossil ground water, cannot be sustained indefinitely. More effective monitoring of water quality and quantity on a country-by-country basis must occur in order to better inform policymaking and international efforts toward efficient and sustainable use while meeting the Millennium Development Goals.

Water issues are, by nature, interdisciplinary and multi-faceted. No single indicator can provide comprehensive information about water availability, use, quality, and access. The 2012 EPI contains a single indicator that measures the average change in river runoff from natural (pre-human) conditions, which relates to stress on aquatic ecosystems.

Indicators Selected

Change in Water Quantity: This indicator represents the percent change in river flow from a pre-industrial natural state owing to water use and impoundments. This indicator is included because water withdrawals and reservoir construction and management have negative impacts on river ecosystems, wetlands and floodplains, affecting the biodiversity of aquatic ecosystems (Döll et al. 2009). Water withdrawals and consumptive water use are estimated separately for the sectors irrigation, livestock, households and industry. Water impoundment is based on a beta version of the Global Reservoir and Dam data set (GRanD) (Lehner et al. 2011). The percent change in river flow owing to both factors was calculated on a 0.5 degree grid cell basis Döll et al. (2009). CIESIN used these data to calculate an area weighted average of the percent change by country. The target is 0% change.

Data Gaps and Deficiencies

Our ideal indicator would measure the total agricultural water withdrawals per available water by country as a time series. This is a policy mutable indicator with clear impacts on aquatic ecosystems. The problem is that neither the numerator nor the denominator is captured accurately or with sufficient country time series in the FAO AQUASTAT database. The Change in Water Quantity indicator has some significant strengths, in terms of providing an aggregate measure of the pressures of water abstraction on aquatic ecosystems. But it also has weaknesses that we recognize. It represents a one time-slice measure (circa 2000) based on modeled data parameterized by real estimates of water withdrawals (based on population distribution, irrigated areas, and reservoir locations). Thus it violates two of our selection criteria: time series data representing actual measures. But our sense was that it more accurately captures ecosystem impacts than the Water Stress and Water Scarcity measures used in the 2010 EPI, and, after consulting with many experts, we had few alternatives for such an important policy category. We felt we could not leave this category out.

Although it represented a major innovation in water quality measurement, we dropped the Water Quality Index (WQI), included in the 2008 and 2010 EPIs, largely because the station coverage for many countries was insufficient to develop a representative index. While the GEMS/Water database is a comprehensive global database comprising more than 3,000 monitoring stations, there are still major gaps in country coverage and many large countries are represented by only a handful of stations. This meant we needed to impute data for a number of countries (Srebotnjak et al. 2011). Another issue was the temporal coverage. In order to increase the number of countries covered by the

WQI we needed to use monitoring station data from as early as 1990. This hardly reflected the situation on the ground today.

4.6 Biodiversity & Habitat

Policy Focus

Human activities have altered the world's terrestrial, freshwater and marine ecosystems throughout history, but in the last 50 years the extent and pace of these changes has intensified, resulting in what the Millennium Ecosystem Assessment calls "a substantial and largely irreversible loss in the diversity of life on Earth" (Millennium Ecosystem Assessment, 2005). The sheer number of species at risk of extinction (16,306 species of plants and animals listed as threatened globally) clearly reflects the threat. Biodiversity – plants, animals, microorganisms and the ecological processes that interconnect them – forms the planet's natural productivity. Protecting biodiversity ensures that a wide range of "ecosystem services" like flood control and soil renewal, the production of commodities such as food and new medicines, and finally, spiritual and aesthetic fulfillment, will remain available for current and future generations.

Conventional management approaches have focused on individual resources, such as timber or fish production, rather than on ecosystems as a whole. Metrics to measure performance have similarly been limited to simple output quantities (e.g., metric tons of fish caught). Recently policy goals have shifted away from this sectoral approach to managing ecosystems, and moved towards an "ecosystem approach" that focuses on maintaining the health and integrity of entire ecosystems.

For want of accurate country-level data on species abundance or conservation efforts, and lacking consistent information on the management of habitats and the sustainable use of species, the 2012 EPI uses measures of protected area coverage by terrestrial biome and by area of coastline in addition to a measure of the protection of highly endangered species.

Indicators Selected

Biome Protection: This indicator measures the degree to which a country achieves the target of protecting at least 17% of each terrestrial biome within its borders, and represents a weighted average of protection by biome. The 17% target was established in 2010 at the 10^{th} Conference of the Parties (COP) of the Convention on Biological Diversity (CBD), and was increased from 10%, which was the earlier target set at the 7^{th} COP of the CBD. Weights are determined by the size of the biome (larger biomes receive greater weight in a country's score).

Coverage for each biome is capped at 17%, so that greater coverage for one biome cannot be used to compensate for deficient coverage of other biomes.

We treat protected status as a necessary but not sufficient condition for an ecological region to be classified as "effectively conserved." How well protected areas are managed, the strength of the legal protections extended to them, and the actual outcomes on the ground, are all vital elements of a comprehensive assessment of effective conservation. Such measures are not available on a widespread basis, though there are efforts underway through the World Commission on Protected Areas (WCPA) Science and Management Theme to compile data on protected area management effectiveness with a goal of eventually aggregating to national level measures.

Critical Habitat Protection: Comparable indicators of species conservation by country can be difficult to develop. This is partly due to the fact that for countries with larger natural endowments (e.g. more endemic species), there are greater conservation burdens. Moreover, species are assessed as threatened on the basis of their global conservation status. Even if a country takes extensive measures to protect a species in its own territory, it might still rank poorly on an index that looks at the number of endangered species within its borders. Thus, a country with few species, threatened or otherwise, could receive a high score, while a country with many endemics and threatened species that is working hard to conserve them could be penalized because a neighboring country is doing little by way of biodiversity conservation.

The Critical Habitat Protection indicator partly addresses these issues by assigning countries responsibility for the protection of endangered species found at Alliance for Zero Extinction (AZE) sites within their borders. The Alliance for Zero Extinction is a joint initiative of 52 biodiversity conservation organizations. It aims to prevent extinctions by identifying and safeguarding key sites selected as the remaining refuges of one or more Endangered or Critically Endangered species, as identified by the IUCN Red List criteria. The IUCN standard provides a consistent approach for AZE site designation across the world. Because of the rigorous criteria used to assign AZE sites, this indicator provides a good measure of how many gravely endangered species are receiving immediate conservation protection. Our target is the protection of 100% of sites, with the justification that there are a finite number of sites and the species in question are highly endangered. Countries with no AZE sites on their territories have total scores averaged around this indicator.

Unlike the 2010 EPI, which used points to designate the location of AZE sites and considered sites fully protected if the point fell within a protected area, the 2012 EPI uses spatial data on the AZE site extent, and measures the percentage of total AZE site area within each country that is protected.

Marine Protected Areas: Marine Protected Areas (MPAs) are the aquatic equivalent of terrestrial reserves. They are legally set aside for protection from human disturbances, such as fishing, industrial exploitation, and recreational activities (depending on the type of MPA). They help alleviate fishing mortality, reduce the harvesting of non-target species, and ensure fishing gear does not impact the marine environment. In addition to protecting biodiversity, MPAs aid in the restoration of commercially viable fish populations.

The Marine Protected Areas (MPA) indicator measures the percentage of a country's exclusive economic zone (EEZ) that is under protection. Protected area data were taken from the Marine Protected Areas Database managed by the UNEP World Conservation Monitoring Centre (WCMC). The indicator was calculated by comparing the area of MPA (in sq. km) to the country's total area of EEZ, as reported in the Global Maritime Boundaries database. The target, established by the 10^{th} COP of the CBD, is 10% of "marine and coastal areas", which we interpret to mean 10% of each country's EEZ.

Data Gaps and Deficiencies

The Biodiversity Information Partnership has made significant progress towards indicator development, including the development of Red List Index (RLI), an indicator of the changing state of global biodiversity by measuring trends in extinction risk over time. Yet the RLI does not yet provide a country-by-country assessment of the relative contribution of different countries to the threat status of different species.

One of the difficulties in developing comparative metrics is that much biodiversity information comes from field studies, whose data tend to be locally focused, inconsistently formatted, and dispersed across many scientific publications and databases. Many countries collect more detailed national-level data; however, it is generally unsuitable for the purposes of a global comparison. In response to this problem, some regions, such as the European Union, have begun establishing standards and protocols for biodiversity data collection. Yet even among countries participating in these efforts, significant information gaps remain. It is hoped that the Group on Earth Observations-Biodiversity Observation Network (GEO-BON) will soon be able to synthesize field data and satellite observations to come up with a global and regional assessment of the status of biodiversity, though it may be years before country-level assessments are possible.

4.7 Agriculture

Policy Focus

Agricultural practices are heavily dependent on natural resources, such as soil, water, and climate. As populations continue to grow, demands for adequate food supplies are increasing pressures on environmental systems. Agricultural demands have enormous impacts on global ecosystems accounting for approximately 40% of land use and 85% of water consumption (FAO, 2005). Inadequate policies in agriculture result in potentially negative influences on the environment, including deforestation, soil degradation, overuse of non-renewable water sources, production of greenhouse gases (especially in livestock production), pollution from agrochemicals, and destruction of natural habitat and biodiversity.

Indicators Selected

Agricultural Subsidies: According to a report by the OECD (2004), public subsidies for agricultural protection and agrochemical inputs exacerbate environmental pressures through the intensification of chemical use, the expansion of land into sensitive areas, and overexploitation of resources. Agricultural Subsidies measures the maginitude of subsidies, with a target of zero subsidies. Although this is an imperfect measure of environmental performance in the agricultural sector – it would be better to measure the actual impacts of subsidies on the environment through incentives that result in excessive chemical use, farming on marginal lands, and other ecologically damaging practices (Scherr, 2007) – this indicator is included in the 2012 EPI because it meets all of our requirements. There is wide country coverage and globally consistent methodologies for agricultural subsidies, which allow differences among countries to reflect difference in performance. This indicator is supported by a major long-term monitoring effort providing a historical and future time series so change over time reflects change in performance.

Pesticide Regulation: Pesticide Regulation is an indicator that measures policy commitment of pesticide use legislation. Pesticides are a significant source of pollution in the environment, affecting both human and ecosystem health. Pesticides damage ecosystems by killing beneficial insects, pollinators, and fauna they support. Human exposure to pesticides has been linked to increases in headaches, fatigue, insomnia, dizziness, hand tremors, and other neurological symptoms. Furthermore, many of the pesticides included in this index are persistent organic pollutants (POPs), endocrine disruptors, or carcinogens. Two major conventions, the Rotterdam and Stockholm Conventions, limit or prevent the use of certain toxic chemicals.

This indicator examines the legislative status of countries according the Stockholm Convention on persistent organic pollutants (POPs). It rates the degree to which these countries have followed through on the objectives of the conventions by limiting or outlawing the use of certain toxic chemicals. The target is to have legislation that bans the use of the entire list of "dirty dozen" pesticides.

Data Gaps & Deficiencies

There are a number of issues that we would like to address but could not. For example, land degradation, as defined by a loss of soil fertility and biological potential (Eswaran et al. 2001), has not been systematically assessed on a global basis. In the 2010 EPI report we reviewed work by the Global Land Degradation Assessment (GLADA), a partnership between the FAO and the World Soil Information System (ISRIC) to assess land degradation using satellite data (see Box 4.7 of Emerson et al. 2010). We re-examined this work but determined that there were still too many uncertainties in the data and methods to ensure an accurate representation of land degradation dynamics.

In the 2010 EPI we included an indicator of agricultural water intensity, which sought to measure agricultural pressure on the renewable water resources. This indicator measured agricultural water withdrawal for irrigation and livestock purposes. This indicator faced two issues that led to our decision not to include it in the 2012 EPI. The first issue has to do with the quality of the water abstraction data from FAO and the lack of consistent time series. FAO provides data on water abstraction based on country reporting, but it is widely recognized that country reports vary in quality. The second issue was the target of 10%, which was established based on expert opinion, but which may not be appropriate in all cases, especially for water abundant countries. Many countries use more than 10% of their water resources for agriculture with negligible impacts on the environment.

In 2008 we engaged in an expert review of indicators that would ideally measure the environmental performance of the agricultural sector (Scherr, 2007). The result was a long list:

- management of water for irrigation
- livestock concentration
- pesticide monitoring
- vegetative cover in agricultural landscapes
- biomass burning in agriculture
- agricultural subsidies
- nitrogen loads in water bodies
- biological health and productivity of agricultural soils
- wildlife in agricultural lands
- agricultural crop diversity
- area of eco-verified production
- conservation areas on private lands
- net greenhouse gas emissions from agriculture.

Apart from the agricultural subsidies and pesticide regulation indicators, we determined that none of these indicators could be measured with currently available data or in a way that would provide adequate guidance to decisionmakers concerning what they would need to do to improve performance and ultimately reduce agriculture sector impacts on the environment.

4.8 Forests

Policy Focus

Forests cover almost 30% of the Earth's terrestrial surface (FAO 2006). They harbor much of the world's biodiversity, provide invaluable ecosystem services (e.g., oxygen supply and flood control), and are a major source of traditional medicines, food products, biomass energy, wood for construction, and pulp for paper. Deforestation rates are particularly high in the tropical regions of Southeast Asia, South America, and Africa, though recent evidence suggests they may be declining (see Box 4.1). Forest planting, the natural expansion of forests, and landscape restoration are only partially offsetting these losses.

Because forests store carbon in their biomass and soils, deforestation is contributing somewhere between 8-20% of total annual global carbon emissions (van der Werf 2009). Through the climate change negotiations under the UN Framework Convention on Climate Change, it has been agreed that a mechanism for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (known as REDD) will be implemented. This could provide an important new source of funds to underwrite forest conservation, though its effects on the ground will vary.

One of the major barriers to establishing sustainable forest practices is the lack of long-term monitoring systems to regularly assess the condition of forests. Even when the scope is limited only to commercial wood production, experts have struggled to develop cost-effective and consistent methods for measuring forest resources and products. The forestry metrics included in the 2012 EPI are meant to be a starting point for measuring forest management on an international scale.

Indicators Selected

Forest Growing Stock: Growing stock is defined as the standing volume of the trees (in cubic meters) in a forest above a certain minimum size. Higher growing stock signifies more standing biomass, which often translates to better forest conditions. Our measure is represents the change in growing stock from one five year period to the next, based on data from the UN Food and Agriculture Organization's (FAO) *2010 Forest Resources Assessment* (FRA 2010) (FAO 2010). Growing stock change takes the total growing stock in a later period as a ratio of the growing stock in the prior period; a ratio of >=1 means that the growing stock has remained unchanged or is growing, and a ratio of <1 means that the growing stock is being depleted. The target is zero change. This is consistent with the logic that cutting forests faster than their rate of regrowth is an unsustainable and environmentally harmful policy.

It is important to note that standing tree volume alone is not a sufficient metric for detailed analysis of forest health. For example, the diversity and distribution of tree species and ages is important for future wood supply and biodiversity. In terms of carbon sequestration, soil carbon must also be examined, which may not be directly correlated to a forest's tree volume. Another specific objection to using growing stock as an indicator is that converting primary forests to forest plantations may increase tree volume, but degrade overall ecological conditions.

Forest Cover Change: Forest cover change (percent change per annum) is a metric frequently used in global assessments of deforestation. Similar to Forest Growing Stock, the 2012 EPI measures the change in area between each five-year time period and considers the target to be no change. Countries that are actively afforesting are not explicitly rewarded, but countries that are losing forest cover are penalized.

Forest Loss: In the 2010 EPI report we described a pilot effort to measure forest cover change using remote sensing data. For the 2012 EPI, working with scientists at the University of Maryland, we have adopted a measure of forest cover loss based on Moderate Resolution Imaging Spectroradiometer (MODIS) remote sensing data (Hansen et al. 2010). The basic approach adopted by the Maryland team was to identify locations of forest loss based on 500m MODIS data, and then measure the areas using higher resolution (30m) Landsat data. The target is 0 loss.

In a future effort, they will also be measuring areas of afforestation. But because the afforestation data are not yet ready, we decided that it is important to complement these data with the more complete picture of losses and gains provided by the FAO's FRA 2010.

Data Gaps and Deficiencies

There are many different potential variables that could go into an indicator measuring forest sustainability. The United Nations Forum on Forests has outlined seven principal areas of concern, which are also the key foci of the FAO's FRA. A comprehensive list of more than 400 sustainability variables, crafted as an extension of the Pan-European Criteria and Indicators for Sustainable Forest Management, is used as a foundation by the Ministerial Conference on the Protection of Forests in Europe (MCPFE, 2007). While capturing these metrics in a forest management indicator would be ideal, only a handful of countries have forest monitoring systems developed enough to produce meaningful reports on these criteria.

Though there are many areas of concern when measuring the sustainability of forest management, the core issue is whether forests are being cut at a faster rate than they are regrowing, which as mentioned above is measured as changes in growing stock. The only source of country-by-country data for growing stock is the FRA. Even though other sources of regional growing stock data exist, the advantage of the FRA is that it provides a consistent reporting format across countries and is recognized as the primary global reporting process.

On the other hand, within the FRA there are significant variations in data quality between countries due to differences in data collection methodology or differences in the frequency of measurements. One of the fundamental inconsistencies is that countries are allowed to choose what they consider to be a minimum tree size for inclusion in the growing stock measure. Countries also individually establish the height to which they calculate the volume and branch size they wish to include in this metric. Beyond these inconsistencies, some countries simply lack the resources to conduct regular forest surveys. Currently only 10% of the world's forested area has been assessed by field-based National Forest Inventories (NFIs), which is the primary source of national-level forest data (Holmgren 2007). Furthermore, only around 50 nations have field-based inventories; the rest use satellite data or expert estimates. The FAO generally accepts values reported by countries, and an analysis of the time series data showed that for any given time period between 15-20 countries repeat the same amount of growing stock from the prior time period. In the absence of an independent verification mechanism, there is little that can be done to validate the numbers. The same is true for the forest cover change data reported by the FRA.

In the past we considered data from on the percent of forest area certified as sustainably managed under schemes such as the Forest Stewardship Council (FSC) and the Pan-European Forest Certification (PEFC). Although there are compelling reasons to include a measurement of forest stewardship in the EPI, we nevertheless concluded that these schemes are not sufficiently representative because of inherent biases in which countries tend to adopt certification schemes and which do not. For example, countries where most forest lands are state owned do not tend to certify their forests, and many developing and former Eastern Bloc countries are also under-represented.

BOX 4.1 TRENDS IN TROPICAL DEFORESTATION

SDF Forest Monitoring for Action (FORMA), developed by the Center for Global Development, employs satellite data recorded by the Moderate Resolution Imaging Spectrometer (MODIS) to generate rapidly updated maps of deforested area in tropical regions. In the first FORMA data assessment (2011), David Wheeler, Robin Kraft, and Dan Hammer examine broad trends in recent tropical forest clearing derived from monthly data between December 2005 and August 2011. The report focuses on 27 tropical countries that accounted for 94 percent of global forest clearing between 2000 and 2005.

Analysis of FORMA data for these countries indicates that forest clearing has dropped 42.3 percent since 2005. The majority of this drop occurred during the period from September 2008 to September 2010 but divergent patterns at the country level imply that decreased demand for forest products during the economic downturn does not fully explain the decline in forest clearing. Instead, the data suggest that local and regional factors are more important when explaining deforestation dynamics. Reductions in forest clearing have occurred in twelve of the countries examined in this report (most significantly in Brazil, Indonesia, Paraguay, Bolivia, China) while increases have occurred in fourteen including Myanmar, Peru, Malaysia, and Venezuela.

It is important to note that the degree that each country contributes to the global forest clearing average has fluctuated significantly even over this time period. But when aggregated together, decreases in the global share of forest clearing by large countries like Brazil have more than offset increases in countries such Malaysia and Indonesia and resulted in significant decline in tropical forest clearing worldwide.

The authors note that additional analysis is required and FORMA coverage will be extended to include tropical countries that were not included in the 2011 analysis such as the Democratic Republic of Congo, Columbia, and Cameroon. However, even in this initial review, FORMA data collection is an admirable example of innovative environmental data collection and offers exiting prospects for consistent evaluation and temporal analysis of forest clearing moving forward.

4.9 Fisheries

Policy Focus

Few activities have a more direct impact on the marine ecosystem than fishing and aquaculture. Overfishing of species can be disastrous to marine biodiversity and ecosystem stability, and environmentally-destructive fishing equipment can devastate the habitat of marine creatures. Fisheries are also an important part of many countries' economies, especially in the developing world. Approximately half of global fish exports by value are attributable to developing countries, and fish accounts for nearly 20% of protein intake in those countries (excluding the fishmeal and fish oil used in livestock production). Approximately one billion people worldwide rely on fish as the most significant source of animal protein in their diets (WHO 2010). Demand for fresh seafood continues to rise with population growth and increasing affluence in developing countries, and seafood is increasingly seen as a healthy source of protein in developed countries. Unfortunately, many fish stocks reached full exploitation levels by the 1970s. Therefore, the management of fisheries will be increasingly critical if supplies are to be sustained.

The indicators for fisheries use the concept of Exclusive Economic Zones (EEZs), which are the areas up to 200 nautical miles from shore over which a country has political and economic control. We consider that fishing within this area is largely within countries' control, even if they permit foreign fishing vessels to fish in their waters. The EEZ is also where one could expect governments to be able to make relevant policy decisions to lessen the environmental harm done by fishing activities.

Indicators Selected

Both indicators were selected in close consultation with *Sea Around Us* project staff at the University of British Columbia, and are similar to indicators that will be used in the Ocean Health Index, which will be launched in 2012.

Fish Stocks Overexploited or Collapsed (FSOC): Fish Stocks Overexploited or Collapsed (FSOC) is based on the concept of overfishing. Overfishing occurs when fishing activity intensifies past a sustainable level, and the harvest of a species has reduced that species' capacity to replace its population through reproduction and growth (Ricker, 1975; Grainger, 1999). Fisheries can be categorized into one of several stages of development—developing, exploited, overfished, collapsed and rebuilding—based on a time series of fisheries landings (Froese and Kesner-Reyes, 2002; Kleisner and Pauly, 2011).

FSOC measures the percentage of fish stocks by species that are overexploited (catches are between 10% and 50% of the maximum catch over the time series) or collapsed (less than 10% of the maximum catch over the time series). The target level for FSOC for the 2012 EPI is effectively 0%, though the actual value for the calculation of the EPI is 0.13% owing to the statistical distribution of the country data.

Coastal Shelf Fishing Pressure (TCEEZ): This indicator is the closest that is currently available for measuring the extent of bottom trawling and dredging. It uses data on the volume of catch of species that are normally caught using these destructive fishing methods. Trawling is one of the most prevalent forms of fishing on the shelf globally, so this indicator is a proxy measure of the intensity of coastal trawling. Measuring the extent of trawling is important, because bottom trawling and dredging equipment are the most destructive fishing gears in use today (Watson, 2006). This fishing method relies on large weighted nets that are dragged along the bottom to collect fish and invertebrates in a non-selective manner. Trawling and dredging typically result in large amounts of bycatch and discards. Bottom habitat is adversely affected and damage can be long-lasting, especially in cases where continuous trawling and dredging occur. In some cases, biodiversity is significantly reduced.

Spatialized catch data are available from the global catch database of the *Sea Around Us* project (Watson et al., 2004). The database is derived from FAO global fisheries catch statistics, data from international and national fisheries agencies, and reconstructed catch datasets (Zeller and Pauly, 2007). The product of these sources of catch data was disaggregated spatially to a grid of 0.5° latitude by 0.5° longitude (259,200 grid cells globally) based on species distribution maps for over 1,500 commercially exploited fish and invertebrate taxa and data on fishing access agreements, which regulate foreign access to the Exclusive Economic Zones (EEZs) of maritime countries. Catch data are available by gear type, and a subset of catch in tonnes from trawling and dredging gears was obtained by EEZ.

TCEEZ measures the tons of catch in a country's EEZ that are associated with fish that typically are caught through trawling and dredging. The target level for TCEEZ for the 2012 EPI is 0 tons per square kilometer of EEZ.

Data Gaps and Deficiencies

Attributing country responsibility for overfishing and destruction of what is in essence a global commons is a difficult task. Many commercial fishing fleets fish well beyond their EEZs, and some countries under-report their fish catches. Poor countries often have difficulties monitoring and controlling the fishing going on within their EEZs. Another possible approach to measuring sustainability of fishing would be to measure fish consumption per capita, especially of the rarest and most economically valuable species. However, this would tend to penalize countries that have high proportions of fish protein in their diets and that may also have abundant fishing grounds relative to their populations.

For the 2010 EPI we included the Marine Trophic Index (MTI), which is the proportion of landed fish at a given trophic level as determined by its location in the food chain over time. The index declines as fishing depletes higher food chain species and is forced further down the food chain. As fish stocks become depleted, fishing activity is forced to focus on smaller and smaller fish. After further consultation with *Sea Around Us* staff, it was determined that there were problems with interpreting the MTI owing to the fact that geographic expansion of fisheries sometimes means that fishing down the chain may be masked by the ability to fish higher trophic level species in new regions, even though the pressures on fisheries are still significant.

A growing proportion of total fish consumption comes from aquaculture. Marine aquaculture (mariculture) has become a major industry in the Pacific Northwest, the North Atlantic, and off the coast of China and Chile, among other places. The Global Aquaculture Performance Index has produced some useful metrics using a species-country unit of analysis, but the indicators are not yet available on a time series basis, and though the country cover is complete for all countries involved in fish aquaculture, many countries are omitted because they do not practice fish aquaculture.

4.10 Climate Change & Energy

Policy Focus

The forecasted impacts of climate change – from sea level rise, coastal flooding, and extensive glacial deterioration to droughts, heat waves, and desertification – are already being felt globally and are projected to accelerate in severity (IPCC, 2007). The impacts of climate change will dramatically affect human health, water resources, agriculture, and ecosystems. While most anthropogenic greenhouse gas emissions (GHG) to-date have originated in developed nations, developing countries are experiencing, and will continue to experience, the most dramatic impacts from climate change (Stern, 2006). GHGs are emitted from a variety of human activities, including electricity generation, transportation, industrial agriculture, forestry, and waste management (IPCC 2007). Globally, the energy sector generates the largest share of anthropogenic GHG emissions, but individual countries' emissions profiles vary widely.

Because the focus of this study is performance, climate change sensitivity and vulnerability are not expressly considered, except in the selection of appropriate performance indicators.

Indicators Selected

Carbon Dioxide Emissions Per Capita and *Carbon Dioxide Emissions Per GDP:* In order to address country-level performance on fossil fuel-based energy sources, we denominate emissions by population and GDP. The CO_2 data come from the International Energy Agency's (IEA) sectoral approach, which includes emissions from electricity and heat production as well as energy extraction, manufacturing, construction, transportation, domestic, agriculture, forestry, and fishing.

The 2012 EPI sets a common target for all countries, reflecting a 50% global reduction below 2000 levels by 2050. Target per capita emissions are based on half of the total global emissions for the year 2000 emissions divided by the projected 2050 global population (UN *World Population Prospects*, median variant). This equals 1,262kg of CO_2-equivalent annual emissions per person. Target CO_2 per GDP emissions are based on half of 2000 emissions divided by the projected 2050 global GDP. This equals 0.07842 kg CO_2 per US dollar GDP PPP (in year 2000 constant US dollars).

CO2 Emissions Per kWh: Carbon dioxide emissions per kilowatt hour represents the ratio of CO_2 emissions to the electricity generated by thermal power plants separated into electricity plants and central heating plants (CHPs), as well as production by nuclear and hydro (excluding pumped storage production), and geothermal, among others (IEA documentation). The nominal policy target is 0 emissions per kWh.

Renewable Electricity: This indicator measures renewable electricity production as a percentage of total electricity production. Because the energy sector contributes the largest anthropogenic share of GHG emissions globally, the percent of all energy that comes from renewable sources indicates each country's performance in this critical sector. The renewable energy sources include electricity generators as well as liquid fuels used in transportation. This total renewable energy production is divided by the total electricity production, and the target is 100%.

Data Gaps and Deficiencies

Anthropogenic emissions of GHGs are the root of the climate change problem and are the core of the EPI indicators representing environmental performance for climate change. Emissions of GHGs have an impact on climate change regardless of where they are emitted, making emissions reductions in China as valuable as those in the United States. Because of the predicted severe and nearly ubiquitous impacts of GHGs, mitigation and monitoring of sectoral performances must occur at an international level with broad participation.

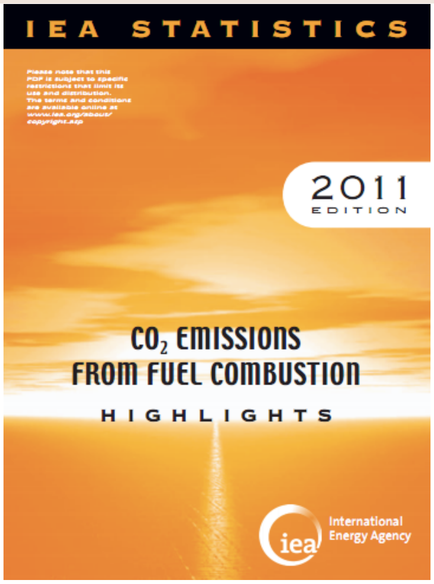
Despite the significant attention given to the issue of climate change, there are still major gaps in GHG inventories worldwide. Data availability varies by location and sector. Emissions data reporting from the industrial sector is widely available for most countries, although even these data contain notable gaps. Though data on carbon dioxide emissions from fossil fuel combustion are gathered annually by several international agencies, data on other GHGs are still minimal.

Fortunately, GHG emissions monitoring and reporting are improving. The International Energy Agency (IEA) produces annual data on carbon dioxide emissions from fossil fuel combustion within each country, which are considered to be among the most reliable data (see Box 4.2). Data on other GHGs are reported every five years and provided to the IEA by national statistical offices in OECD countries, and collected from various sources in government and industry in non-OECD countries. Members of the UNFCCC self report annual GHG emissions, but the accuracy depends upon the monitoring capacity of individual countries. In general, more countries and agencies are monitoring and compiling GHG emissions data, but the international body of data is far from sufficient to deconstruct the real drivers of climate change emissions within each country.

In the future we would like to divide total GHG emissions into sectors in order to provide better insight into the performance of the economy. A particularly glaring example is transportation emissions, which make up 23% of global emissions from fossil fuels (OECD/ITF 2008). While total CO_2 emissions from transportation are estimated, there is no international data on which to ground these numbers. More detail about which sectors are emitting what – including non-commercial energy consumption, transportation, agriculture, forestry, and waste disposal – would provide a better assessment of where and how climate change is being addressed in each country.

A major source of uncertainty is emissions from deforestation and changing land use. Emissions from this source were estimated to be 20-25% of the total annual GHG emissions worldwide (IPCC 2007 WGI), yet the data that exist are problematic. Attention through the UNFCCC reporting requirements and international programs like REDD have bolstered these measurements in recent years, but international calculations are too often unreliable.

BOX 4.2 THE FUTURE OF CO2 EMISSIONS



The recent events at the 2011 UN Climate Change Conference in Durban shed light on the importance of providing data on climate change trends around the world. It is necessary for policymakers and other stakeholders to be aware of emissions data to make judgments on current policies and future action plans. The 2012 EPI includes the most recent emissions data available, which currently extend through 2009. However, the latest preliminary estimates of CO2 emissions for 2010-11 provide vital information to stakeholders regarding the future direction of global climate change.

Globally, CO2 emissions decreased in 2009, as developed (Annex I) countries reduced their emissions overall by 6.5% (IEA 2011). Although this overall decrease seemed hopeful, lowered CO2 emissions were short-lived. In 2010, global carbon emissions from fossil-fuel combustion and cement production increased by 5.9% (Peters et al. 2011). This significant increase marks the highest total annual growth of CO2 emissions to date, and in combination with emissions from land-use change reached a record high of 10.0 +/- 0.9 petagrams (Pg) of carbon in 2010 (Peters et al. 2011). This growth is the result of emerging economies, such as China and India, and economic improvements in dominating countries following the 2008 financial crisis. Although developed (Annex B) countries decreased their CO2 emissions again in 2010 by 3.4%, developing (non-Annex B) countries have offset this decline with an alarming 7.6% increase in CO2 emissions (Peters et al. 2011, Global Carbon Project 2011) following continuous growths in 2008 and 2009 (IEA 2011).

CO2 emissions correspond strongly to GDP. However, in 2010, CO2 emissions grew faster than real GDP. The Global Carbon Project (2011) estimates additional growth in CO2 emissions during 2011, with the potential to reach 9.4 Pg. In regards to consumption-based emissions, developing countries surpassed developed countries with higher consumption-based emissions for the first time in 2009. This trend continued through 2010 and is expected to persistently increase as economies continue to grow and changes occur with regards to international trade.

By 2035, the World Energy Outlook 2010 (IEA 2010) projects demands for electricity will be approximately three-quarters higher than current levels, and demands for transport fuel may grow by approximately 40% (IEA 2011). These increased estimates will be driven by rapid growth in population and income in developing countries and the delay to implement better fuel-efficient technologies worldwide. As a result, there will be increased CO2 emissions from coal and fuel and also from oil and gas, which are other major contributors in primary energy supplies. Meanwhile, renewable electricity generation is expected to continue growing over the next 25 years, benefiting from government support, declining investment costs and rising fossil-fuel prices.

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Appendix I: Indicator Profiles

The following indicator profiles provide metadata on data sources, methods, transformations, and targets. The profiles are organized alphabetically by indicator code as follows:

Objective	Policy Category	Indicator	Indicator code
Environmental Health	Air (effects on human health)	Indoor air pollution	INDOOR
		Particulate matter	PM25
	Water (effects on human health)	Access to drinking water	WATSUP
		Access to sanitation	ACSAT
	Environmental Health	Child mortality	CHMORT
Ecosystem Vitality	Air pollution	SO2 emissions per capita	SO2CAP
		SO2 emissions per $ GDP	SO2GDP
	Water	Change in Water Quantity	WATUSE
	Biodiversity and habitat	Biome protection	PACOV
		Marine protected areas	MPAEEZ
		Critical habitat protection	AZE
	Forests	Forest loss	FORLOSS
		Change in forest cover	FORCOV
		Forest growing stock	FORGROW
	Fisheries	Coastal shelf fishing pressure	TCEEZ
		Fish stocks overexploited	FSOC
	Agriculture	Agricultural subsidies	AGSUB
		Pesticide regulation	POPs
	Climate change	CO2 emissions per capita	CO2CAP
		CO2 emissions per $ GDP	CO2GDP
		Electricity emissions per KWH	CO2KWH
		Percent of energy production from renewables	RENEW

Indicator: Access to Sanitation

Objective / Policy: **Environmental Health - Water**

Code: *ACSAT*

Description: Access to adequate sanitation measures the percentage of a country's population that has access to an improved source of sanitation. "Improved" sanitation technologies are: connection to a public sewer, connection to septic system, pour-flush latrine, simple pit latrine, ventilated improved pit latrine. The excreta disposal system is considered adequate if it is private or shared (but not public) and if hygienically separates human excreta from human contact. "Not improved" are: service or bucket latrines (where excreta are manually removed), public latrines, latrines with an open pit. The total population of a country may comprise either all usual residents of the country (de jure population) or all persons present in the country (de facto population) at the time of the census. For purposes of international comparisons, the de facto definition is recommended. Source: United Nations. Multilingual Demographic Dictionary, English Section. Department of Economic and Social Affairs, Population Studies, No. 29 (United Nations publication, Sales No. E.58.XIII.4).

Rationale: Access to adequate sanitation is not only a public health concern, but also a threat to the environment in countries where human waste is not adequately disposed of or treated.

SOURCE(S)

Variable: Access to sanitation
Citation: WHO / UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation
Year of publication: 2011
Covered time: 1990-2005 (5 year values), 2008
URL: http://www.wssinfo.org/data-estimates/table/
Date data obtained: 40778
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

The indicator is computed as the number of people using improved sanitation facilities in relation to the total population, expressed as a percentage. Estimates are based on data from nationally representative household surveys and national censuses, which in some cases are adjusted by the Joint Monitoring Program to improve comparability among data over time.

Additional notes:

0 values are not actually 0 according to our evaluation of the data; so all 0 cells are treated as missing data and displayed with -8888. The countries not included in WHO / UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation list are coded with -9999. Taiwan's data are provided from Taiwan's Ministry of Environment. For countries with at least 2 data points, the data were imputed based on linear interpolation (between the first and last data point). All other missing are coded as following: -8888 for countries with published data, and -9999 for countries not included in WHO/UNICEF data. Data for Lithuania were imputed based on regional averages.

Transformation needed for aggregation: Inverse, logarithmic

Nominal Policy Target: 100
Top Performance Benchmark: 100
Poor Performance Benchmark: 13
Source: Millennium Development Goals. The poor performance benchmark is based on the 5th percentile of the data time series.

Indicator: Agricultural Subsidies

Objective / Policy: **Ecosystem Vitality - Agriculture and Land Management**

Code: *AGSUB*

Description: This indicator seeks to evaluate the magnitude of subsidies in order to assess the degree of environmental pressure they exert. The NRA is defined as the price of their product in the domestic market (plus any direct output subsidy) less its price at the border, expressed as a percentage of the border price (adjusting for transport costs and quality differences) (WDR 2009).

Rationale: According to a report by the OECD (2004), public subsidies for agricultural protection and agrochemical inputs exacerbate environmental pressures through the intensification of chemical use, the expansion of land into sensitive areas, and overexploitation of resources.

SOURCE(S)

Variable: Nominal Rate of Assistance (NRA)
Citation: Anderson, K. (ed.), Distortions to Agricultural Incentives: A Global Perspective, 1955 to 2007, London: Palgrave Macmillan and Washington DC: World Bank, October 2009.
Year of publication: 2009
Covered time: 1955-2007
URL: www.worldbank.org/agdistortions
Date data obtained: 8/24/2011
Data type: tabular

Variable: Producer Support Estimates(PSE) and Producer Nominal Assistance Coefficient (NAC)
Citation: OECD (2011), Agricultural Policy Monitoring and Evaluation 2011: OECD Countries and Emerging Economies, OECD Publishing. http://dx.doi.org/10.1787/agr_pol-2011-en
Year of publication: 2011
Covered time: 1986-2010
URL: http://stats.oecd.org/Index.aspx?DataSetCode=MON20113_1
Date data obtained: 11/22/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Nominal Rate of Assistance (NRA)

Indicator creation method:

Where available, we used data on the Nominal Rate of Assistance (NRA) from the World Development Report, 2008.

Additional notes:

The source of these data is a product database from World Bank's research project "Distortions to Agricultural Incentives", led by Kym Anderson. The values for variable “nratott” represent nominal rates of assistance (NRA) in all primary agriculture, total for covered and non-covered products, and non-product-specific assistance (NPSA), value of production-weighted average. If 'nra_tott' was not available, we used one of the following variables: 'nra_totp' (NRA in all primary agriculture, total excluding NPSA), 'nra_totm' (NRA in all primary agriculture, value of production-weighted average, importables), 'nra_totx' (NRA in all primary agriculture, value of production-weighted average, exportables), or 'nra_toth' (NRA in all primary agriculture, value of production-weighted average, nontradables). NRA to covered products can be decomposed into: (a) NRA to output conferred by border market price support, value of production-weighted average of covered products; (b) NRA to output conferred by domestic market price support, value of production-weighted average of covered products; and (c) NRA to inputs, value of production-weighted average of covered products. For OECD countries, we converted their Producer Nominal Assistance Coefficient (NAC) values to NRA by subtracting a unit from the NAC values (Anderson, 2008). The Producer Nominal Assistance Coefficient (NAC) is the ratio of gross farm receipts including support, to farm receipts measured at border prices. The NAC for European Union countries was assigned to missing EU27 countries. The negative subsidies were set to 0. For missing countries, we conducted research to determine evidence of whether a country has subsidies for agriculture. If we found evidence of subsidies, we used a model based on GDP per capita and the regional average NRA to impute a value. All others were imputed as 0.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0
Top Performance Benchmark: 0
Poor Performance Benchmark: 1.4094699
Source: Expert opinion. The poor performance benchmark is based on the 95th percentile of the 2000-2010 data.

Indicator: Critical Habitat Protection

Objective / Policy: **Ecosystem Vitality - Biodiversity and Habitat**

Code: *AZE*

Description: Percentage of the total AZE site area that is within protected areas.

Rationale: The Alliance for Zero Extinction (AZE) has identified 587 sites that each represents the last refuge of one or more of the world's most highly threatened 920 species. From the perspective of biodiversity conservation, protection of these sites is of the highest priority.

SOURCE(S)

Variable: AZE sites
Citation: Alliance for Zero Extinction
Year of publication: 2011
Covered time: 2011
URL: http://www.zeroextinction.org/
Date data obtained: 10/6/2011
Data type: GIS polygon shapefile obtained from the American Bird Conservancy.

Variable: World Database of Protected Areas (WDPA)
Citation: UNEP-World Conservation Monitoring Centre
Year of publication: 2011
Covered time: 1990-2011
URL: http://www.wdpa.org/
Date data obtained: 10/6/2011
Data type: GIS polygon shapefile

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

A time series version of the World Database of Protected Areas (WDPA) from 1990-2011 was obtained from the World Conservaiton Monitoring Centre. For each country, the percentage area of AZE site(s) that fell within protected areas was calculated.

Additional notes:

The delineation of AZE sites may have uncertainties. Countries with no AZE sites were averaged around for EPI calculations, and are coded -7777.

Transformation needed for aggregation: none

Nominal Policy Target: 100
Top Performance Benchmark: 100
Poor Performance Benchmark: 0
Source: Expert opinion

Indicator: Child Mortality

Objective / Policy: **Environmental Health - Health**

Code: *CHMORT*

Description: Probability of dying between a child's first and fifth birthdays per 1,000 children aged 1.

Rationale: Because the causes of child mortality among 1–4 year olds are strongly influenced by environmental causes, this indicator is considered to be a useful proxy for underlying environmental conditions. The target was set in such a way as to give the best performing countries a score of 100, since at the higher levels of development the causes of child mortality are least likely to be environmental.

SOURCE(S)

Variable: Probability of dying by age (qx) - Medium variant

Citation: United Nations, Department of Economic and Social Affairs, Population Division: World Population Prospects DEMOBASE, 2010 revision

Year of publication: 2010

Covered time: 1990-2011

URL: http://esa.un.org/unpd/wpp

Date data obtained: 8/1/2011

Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: probability of dying between age 1 and 5

Indicator creation method:

The probablility is obtained by using probability data for a child alive at his/her first birthday of dying before reaching his/her fifth birthday. The formula is used from UN Population Divisions data: 4q1 = (1-((1-5q0)/(1-1q0))). 1q0 is the infant mortality rate (interpolated 1q0), Medium Variant; 5q0 is the under five mortality (interpolated 5q0), Medium variant; and 4q1 is the child mortality (interpolated 4q1), medium variant. Data are divided by 1,000 to estimate the probability of a child dying between his/her first and fifth birthdays.

Additional notes:

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0

Top performance benchmark: 0.001

Poor performance benchmark: 0.1133

Source: Expert opinion. The poor performance benchmark respresents the 95th percentile of 2000-2010 EPI data; the top performance benchmark is based on expert judgment and owing to natural background rates of child mortality not necessarily the result of environmental factors.

Indicator: CO2 Emissions Per Capita

Objective / Policy: Ecosystem Vitality - Climate Change

Code: *CO2CAP*

Description: The ratio has been calculated using the Sectoral Approach CO2 emissions and population data from the IEA.

Rationale: Carbon dioxide emissions contribute to climate change. We use three denominators - population, GDP, and electricity generation - in order to assess the relative carbon efficiency of economies in these three aspects.

SOURCE(S)

Variable: Carbon Dioxide Emissions
Citation: International Energy Agency (IEA)
Year of publication: 2011
Covered time: 1960-2009
URL: http://data.iea.org
Date data obtained: 10/27/2011
Data type: tabular

Variable: Population
Citation: International Energy Agency (IEA)
Year of publication: 2011
Covered time: 1960-2009
URL: http://data.iea.org
Date data obtained: 10/27/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: kg CO2 per person

Indicator creation method:

The sectoral Approach contains total CO2 emissions from fuel combustion as calculated using the IPCC Tier 1 Sectoral Approach and corresponds to IPCC Source/Sink Category 1 A. Emissions calculated using a Sectoral Approach include emissions only when the fuel is actually combusted.

Additional notes:

According to IEA documentation, "The main source of the 1970 to 2007 population data for the OECD member countries is National Accounts of OECD Countries, Volume 1, OECD, Paris, 2009. Data for 1960 to 1969 have been estimated using the growth rates from the population series published in the OECD Economic Outlook No. 76. For the Czech Republic, Hungary and Poland (1960 to 1969) and Mexico (1960 to 1962), the data are estimated using the growth rates from the population series from the World Bank published in the World Development Indicators CD-ROM. For the Slovak Republic, population data for 1960 to 1989 are from the Demographic Research Centre, Infostat, Slovak Republic. The main source of the population data for the OECD non-member countries is World Development Indicators, World Bank, Washington D.C., 2009. Population data for Chinese Taipei, Gibraltar, Iraq and a few countries within the regions Other Africa, Other Latin America and Other Asia are based on the CHELEM-CEPII online database, 2009. Due to lack of complete time series, figures for population of Other Latin America do not include British Virgin Islands, Cayman Islands, Falkland Islands, Martinique, Montserrat, Saint Pierre and Miquelon, and Turks and Caicos Islands; and figures for population and GDP of Other Asia do not include Cook Islands". For countries with at least 2 data points, the data were imputed based on linear interpolation (between the first and last data point) and constant values outside this time frame. All other missing are coded as following: -8888 for countries with data from the source, and -9999 for countries not included in source country list.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 1262
Top Performance Benchmark: 1262
Poor Performance Benchmark: 19,617.538
Source: The IPCC indicates that emissions would need to be cut by one-half of year 2000 levels by 2050; target per capita emissions are based on half of 2000 emissions divided by the projected 2050 population. The poor performance benchmark is based on the 95th percentile of the distribution of the data over the time series from 2000-2010.

Indicator: CO2 Emissions Per GDP

Objective / Policy: **Ecosystem Vitality - Climate Change**

Code: *CO2GDP*

Description: This ratio has been calculated using the Sectoral Approach CO2 emissions and the GDP using purchasing power parities data from the IEA.

Rationale: Carbon dioxide emissions contribute to climate change. CO2 per unit GDP is a common metric employed in countries to assess the intensity in the output of carbon dioxide emissions. The IPCC indicates that emissions need to be cut by 50 percent from 2000 levels by 2050 to contain global temperature rise within 2 degrees Celsius.

SOURCE(S)

Variable: Carbon Dioxide Emissions
Citation: International Energy Agency (IEA)
Year of publication: 2011
Covered time: 1960-2009
URL: http://data.iea.org
Date data obtained: 10/27/2011
Data type: tabular

Variable: GDP PPP (2000 US dollars)
Citation: International Energy Agency (IEA)
Year of publication: 2011
Covered time: 1960-2009
URL: http://data.iea.org
Date data obtained: 10/31/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: kg CO2 per US dollar GDP PPP (in year 2000 constant US dollars)

Indicator creation method:

Sectoral Approach contains total CO2 emissions from fuel combustion as calculated using the IPCC Tier 1 Sectoral Approach and corresponds to IPCC Source/Sink Category 1 A. Emissions calculated using a Sectoral Approach include emissions only when the fuel is actually combusted.

Additional notes:

As per IEA documentation, "The main source of the 1970 to 2007 GDP series for the OECD member countries is National Accounts of OECD Countries, Volume 1, 2009. GDP data for 1960 to 1969 have been estimated using the growth rates from the series in the OECD Economic Outlook No 76 and data previously published by the OECD Secretariat. Data prior to 1990 for the Czech Republic and Poland, prior to 1991 for Hungary, and prior to 1992 for the Slovak Republic are IEA Secretariat estimates based on GDP growth rates from the World Bank. The main source of the GDP series for the non-OECD member countries is World Development Indicators, World Bank, Washington D.C., 2009. GDP figures for Bosnia and Herzegovina, Brunei Darussalam, Chinese Taipei, Cuba, Gibraltar, Iraq, Democratic People's Republic of Korea, Libyan Arab Jamahiriya, Myanmar, Namibia (1971-1979), Netherlands Antilles (available from 1980), Qatar, Turkmenistan, Former Soviet Union (before 1990), Former Yugoslavia (before 1990) and a few countries within the regions Other Africa, Other Latin America and Other Asia are from the CHELEM-CEPII online databases 2008, 2009. GDP figures for Albania (1971-1979), Angola (1971-1984), Bahrain (1971-1979, 2006-2007), Bulgaria (1971-1979), Ethiopia (1971-1980), Jordan (1971-1974), Kuwait (1990-1991, 2006-2007), Lebanon (1971- 1987), Malta (2007), Mozambique (1971-1979), Oman (2006-2007), Romania (1971-1979), Serbia (1990-1998), United Republic of Tanzania (1971-1987), the United Arab Emirates (1971-1972 and 2006-2007), Vietnam (1971-1983), Yemen (1971-1989) and Zimbabwe (2006-2007) have been estimated based on the growth rates of the CHELEM-CEPII online database, 2009. The GDP data have been compiled for individual countries at market prices in local currency and annual rates. These data have been scaled up/down to the price levels of 2000 and then converted to US dollars using purchasing power parities (PPPs). Purchasing power parities are the rates of currency conversion that equalise the purchasing power of different currencies. A given sum of money, when converted into different currencies at the PPP rates, buys the same basket of goods and services in all countries. In other words, PPPs are the rates of currency conversion which eliminate the differences in price levels between different countries. Due to lack of complete time series, figures for GDP of Other Latin America do not include British Virgin Islands, Cayman Islands,Falkland Islands, Martinique, Montserrat, Saint Pierre and Miquelon, and Turks and Caicos Islands; and figures for population and GDP of Other Asia do not include Cook Islands. Data for GDP for Serbia include Montenegro until 2004.". For countries with at least 2 data points, the data were imputed based on linear interpolation (between the first and last data point) and constant values outside this time frame.All other missing are coded as following: -8888 for countries with data from the source, and -9999 for countries not included in source country list.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0.07842
Top performance benchmark: 0.07842
Poor performance benchmark: 1.5843834
Source: The IPCC indicates that emissions would need to be cut by one-half of year 2000 levels by 2050; target per GDP emissions are based on half of 2000 emissions divided by the projected 2050 GDP. The poor performance benchmark is based on the 95th percentile of the distribution of the data over the time series.

Indicator: CO2 Emissions Per kWh

Objective / Policy: **Ecosystem Vitality - Climate Change**

Code: *CO2KWH*

Description: Carbon dioxide emissions per kilowatt hour represents the ratio of CO2 emissions to the electricity generated by thermal power plants separated into electricity plants and CHP plants, as well as production by nuclear and hydro (excluding pumped storage production), geothermal, etc. (IEA documentation).

Rationale: Carbon dioxide emissions contribute to climate change. We use three denominators - population, GDP, and electricity generation - in order to assess the relative carbon efficiency of economies in these three aspects.

SOURCE(S)

Variable: Carbon Dioxide Emissions from electricity and heat
Citation: International Energy Agency (IEA)
Year of publication: 2011
Covered time: 1960-2009
URL: http://data.iea.org
Date data obtained: 11/1/2011
Data type: tabular

Variable: Total electricity output
Citation: International Energy Agency (IEA)
Year of publication: 2011
Covered time: 1960-2009
URL: http://data.iea.org
Date data obtained: 11/1/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: grammes of CO2 per kWh

Indicator creation method:

According to IEA documentation, the indicator has been calculated using CO2 emissions from electricity and heat ("Main Activity Producer" and "Autoproducer"). The CO2 emissions include emissions from fossil fuels, industrial waste and non-renewable municipal waste that are consumed for electricity and heat generation in the transformation sector and the output includes electricity and heat generated from fossil fuels, nuclear, hydro (excluding pumped storage), geothermal, solar, biomass, etc. In the ratios of CO2 emissions per kWh by fuel, coal includes primary and secondary coal, peat and manufactured gases (excluding gas works gas);oil includes petroleum products (and small amounts of crude oil for some countries) and gas includes natural gas and gas works gas.

Additional notes:

Emissions per kWh should be used with caution due to data quality problems relating to electricity efficiencies for some countries (IEA documentation). For countries with at least 2 data points, the data were imputed based on linear interpolation (between the first and last data point) and constant values outside this time frame. All other missing are coded as following: -8888 for countries with data from the source, and -9999 for countries not included in source country list.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0

Top performance benchmark: 0.503529744
Poor performance benchmark: 845.8325
Source: Expert opinion. The poor performance benchmark was based on the 95th percentile of the 2000-2010 data and adjusted based on expert judgment.

Indicator: Change in Forest Cover

Objective / Policy: **Ecosystem Vitality - Forest**

Code: *FORCOV*

Description: The 2012 EPI measures the change in area between time periods (2005 to 2010 for the most recent time period), and considers the target to be no change. Thus, countries that are actively afforesting are not explicitly rewarded, but countries that are losing forest cover are penalized.

Rationale: Forest cover change is an important and widely used measure of the change in forest extent, which has important implications for ecosystem services and habitat protection. Reduction in extent of forests can be related to agricultural and urban expansion, and is generally considered negative for forest ecosystem health.

SOURCE(S)

Variable: Trends in Extent of Forest 1990-2010
Citation: FAO, Global Forest Resources Assessment 2010
Year of publication: 2011
Covered time: 1990, 2000, 2005 and 2010
URL: http://www.fao.org/forestry/fra/fra2010/en/
Date data obtained: 12/13/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Percent change from period 1 to period 2

Indicator creation method:

This measure represents the percent change in forest area, applying a 10% crown cover as the definition of forested areas, between time periods. We used total forest extent, rather than the extent of primary forest only. The change measure is calculated from forest area data in 1995, 2000, 2005, and 2010. The data are reported by national governments, and therefore methods and data sources may vary from contry to country. Positive values indicate aforestation or reforestation, and negative values represent deforestation.

Additional notes:

Countries with less than 100 sq. km in forest area in the year 2000 as defined by the forest cover component of FORLOSS were averaged around.

Transformation needed for aggregation: Inverse

Nominal Policy Target: 0

Top performance benchmark: 1.1
Poor performance benchmark: 0.88
Source: Expert opinion. The top and poor performance benchmarks are based on the 95th and 55th percentiles of the 2000-2010 data.

Indicator: Forest Loss

Objective / Policy: **Ecosystem Vitality - Forest**

Code: *FORLOSS*

Description: The indicator represents the loss of forest area owing to deforestation from either human or natural causes, such as forest fires.

Rationale: Forest cover loss is a measure that reflects the decline of forest biodiversity, forest ecosystem services, and forest carbon emissions within a country. Although it would be desirable to measure forest health and species composition, or alternatively forest management, comparable data on these parameters are not available consistently across countries.

SOURCE(S)

Variable: Forest cover loss
Citation: University of Maryland
Year of publication: 2011
Covered time: 2000-2005, 2005-2010
URL:
Date data obtained: 12/13/2011
Data type: GIS grids

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

The University of Maryland researchers used MODIS 500-meter resolution satellite data to identify areas of forest disturbance, then used Landsat data to quantify the area of forest loss. This indicator uses a baseline forest cover layer (forest cover fraction with a 30% forest cover threshold) to measure the area under forest cover in the year 2000. It then combines forest loss estimates from Landsat for the periods 2000-2005 and 2005-2010 to arrive at a total forest cover change amount for the decade. This total is then divided by the forest area estimate for 2000 to come up with a percent change in forest cover over the decade. Further details on the methods used are found in the following publication: Hansen, M., et al. 2010. Quantification of global gross forest cover loss. *Proceedings of the National Academies of Science*. Available at www.pnas.org/cgi/doi/10.1073/pnas.0912668107.

Additional notes:

This indicator is derived from satellite data and therefore may have inaccuracies in forest delineation in the two time periods. In addition, no credit is given to countries for aforestation during the two time periods. Countries with less than 100 sq.km of forest area were averaged around in the calculation of the EPI.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0

Top performance benchmark: 0.02
Poor performance benchmark: 1.075
Source: Expert opinion. The poor performance benchmark was based on the 95th percentile 2000-2010 data and adjusted based on expert judgment.

Indicator: Forest Growing Stock

Objective / Policy: **Ecosystem Vitality - Forest**

Code: *FORGRO*

Description: Growing stock is a volumetric measure that measures the cubic meters of wood over bark of all living trees more than X cm in diameter at breast height. The definition of X may vary by country.

Rationale: Growing stock is defined as the standing tree volume of the forest resources. An increase in growing stock usually means higher quality forests, whereas a decrease in growing stock generally indicates degrading forest conditions.

SOURCE(S)

Variable: Growing stock in forest
Citation: FAO, Global Forest Resources Assessment 2010
Year of publication: 2011
Covered time: 1990, 2000, 2005 and 2010
URL: http://www.fao.org/forestry/fra/fra2010/en/
Date data obtained: 12/13/2011
Data type: tabular

Variable: Forest area
Citation: FAO, Global Forest Resources Assessment 2010
Year of publication: 2011
Covered time: 2000, 2005
URL: http://www.fao.org/forestry/fra/fra2010/en/
Date data obtained: 12/13/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Ratio of period 2 to period 1

Indicator creation method:

Growing stock includes the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches to a minimum diameter of W cm. Countries indicate the three thresholds (X, Y, W in cm) and the parts of the tree that are not included in the volume. Countries must also indicate whether the reported figures refer to volume above ground or above stump. The diameter is measured at 30 cm above the end of the buttresses if these are higher than 1 meter. Growing stock includes windfallen living trees but excludes smaller branches, twigs, foliage, flowers, seeds, and roots.

Additional notes:

Approximately 15-17% of countries for any given reporting period show no change in total growing stock. It is not possible to ascertain which countries really had no change as measured on the ground and which countries may simply repeat values from one period to the next. Countries with less than 100 sq. km in forest area in the year 2000 as defined by the forest cover component of FORLOSS were averaged around. The 1990-2000 growth was split into two time periods: 1990-1995 and 1995-2000. The original data included the total growing stock for Serbia and Montenegro for years 1990, 2000 and 2005 the growing stock was split between the two countries based on the FAO forest area.

Transformation needed for aggregation: Inverse

Nominal Policy Target: 1

Top performance target: 1.32
Poor performance target: 0.86
Source: Expert opinion. The top and poor performance benchmarks are based on the 95th and 5th percentiles of the 2000-2010 data.

Indicator: Fish Stocks Overexploited

Objective / Policy: **Ecosystem Vitality - Fisheries**

Code: *FSOC*

Description: This is the fraction of species that are fished in each country's exclusive economic zone (EEZ) that are overexploited or collapsed. The definition of overexploited is catches that are less than 50% and greater than 10% of the maximum catch over the time series and the definition of collapsed is catches less than 10% of the maximum catch over the time series.

Rationale: Overfishing is harmful to marine life. Overfishing occurs in fisheries that have been exploited at levels that exceed the capacity for replacement by reproduction and growth of the exploited species (Ricker 1975, Grainger 1999).

SOURCE(S)

Variable: Fraction of EEZ with overexploited and collapsed stocks
Citation: Sea Around Us Project, University of British Columbia Fisheries Centre
Year of publication: 2010
Covered time: 1950-2006
URL: http://seaaroundus.org/
Date data obtained: 9/20/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Fraction

Indicator creation method:

Species that are being overfished are producing catches that are below the level that could be sustainably derived. As a result of intense exploitation, most fisheries generally follow sequential stages of development: undeveloped, developing, fully exploited, overfished, and collapsed. Grainger and Garcia (1996) conceived the first version of the Stock Status Plots (SSP) by defining development phases of marine fisheries landings as part of a trend analysis of global marine fisheries landings (Figure 2). Their analysis used curves fitted to the time series of landings and classified the slopes of the curves as:

1. flat slope at a minimum: undeveloped;
2. increasing slopes: developing fisheries;
3. flat slope at a maximum: fully exploited;
4. decreasing slopes: senescent fishery (collapsed).

To simplify the approach of Grainger and Garcia (1996), Froese and Kesner-Reyes (2002) used designations for stock status that were based on the level of catch relative to the maximum catch during the time that the stock had been exploited. As this approach did not involve fitting polynomials to the catch time series, many more species could be evaluated. They defined the status of over 900 stocks as undeveloped, developing, fully exploited, overfished, or collapsed. The SSPs presented here and on the Sea Around Us (SAU) website build on the work of Grainger and Garcia (1999) and Froese and Kesner-Reyes (2002), but address several criticisms of the original approaches. First, the original plots did not account for the fact that newly exploited stocks might be considered developing if their landings have not reached a peak by the most recent year of exploitation. Therefore, SAU counts all stocks that have a peak in catch (maximum catch) in the final year of the time series as developing. Secondly, SAU merges the undeveloped and developing categories, as we assume that any fishery undergoing even low exploitation as being developed. Finally, we account for stock recovery which has occurred in well-managed fisheries, through an additional category called rebuilding.

The SAU SSPs are created in four steps (Kleisner and Pauly, 2011). The first step is the definition of a stock. SAU defines a stock to be a taxon (either at species, genus or family level of taxonomic assignment) that occurs in the catch records for at least 5 consecutive years, over a minimum of 10 years time span, and which has a total catch in an area of at least 1000 tonnes over the time span. Secondly, SAU assesses the status of the stock for every year, relative to the peak catch. SAU defines five states of stock status for a catch time series. This definition is assigned to every taxon meeting the definition of a stock for a particular spatial area considered (e.g., EEZ, LME).

1. Developing - before the year of peak catch and less than 50% of the peak catch;
2. Exploited - before or after the year of peak catch and more than 50% of the peak catch;
3. Overexploited - after the year of peak catch and less than 50% but more than 10% of the peak catch;
4. Collapsed - after the year of peak catch and less than 10% of the peak catch;
5. Rebuilding - occurs after the year of peak catch and after the stock has collapsed (after the post-maximum minimum catch, Figure 3), when catch has recovered to between 10% and 50% of the peak.

Thirdly, SAU creates the graph of number of stocks by status by tallying the number of stocks in a particular state in a given year, and presenting these as percentages. Finally, the cumulative catch of stock by status in a given year is summed over all stocks and presented as a percentage in the catch by stock status graph. The combination of these two figures represents the complete Stock Status Plot. The numbers for this indicator are taken from the overexploited and collapsed numbers of stocks over total numbers of stocks per EEZ.

Additional notes:

The FSOC indicator is based on global catch data, which may not accurately track declines in abundance in certain cases. For example, changes in the price of fish, consumer preferences, or management strategies can all result in catches that decline while biomass does not. Small island states were aggregated to the countries under administration. Landlocked countries are averaged around in calculation of the EPI.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0

Top performance benchmark: 0.13

Poor performance benchmark: 1.0714285

Source: Expert opinion. The poor performance benchmark was based on the 95th percentile 2000-2010 data and adjusted based on expert judgment.

Indicator: Indoor Air Pollution

Objective / Policy: **Environmental Health - Air Quality**

Code: *INDOOR*

Description: Solid fuels include biomass fuels, such as wood, charcoal, crops or other agricultural waste, dung, shrubs and straw, and coal. The use of solid fuels in households is associated with increased mortality from pneumonia and other acute lower respiratory diseases among children as well as increased mortality from chronic obstructive pulmonary disease and lung cancer (where coal is used) among adults (WHO 2007).

Rationale: The use of solid fuels in households is associated with increased mortality from pneumonia and other acute lower respiratory diseases among children, as well as increased mortality from chronic obstructive pulmonary disease and lung cancer (where coal is used) among adults (WHO 2011).

SOURCE(S)

Variable: Percentage of population using solid fuel as the primary cooking fuel
Citation: World Health Organization's Indicator and Measurement Registry, version 1.6.0
Year of publication: 2011
Covered time: 1974-2008
URL: http://apps.who.int/gho/indicatorregistry/App_Main/view_indicator.aspx?iid=2267
Date data obtained: 12/5/2011
Data type: tabular

Variable: Proportion of population using solid fuels
Citation: Millennium Development Goals, Indicator 29 (non-MDG)
Year of publication: 2010
Covered time: 1990-2007
URL: http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=712
Date data obtained: 12/5/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

These data were collected from nation-wide household surveys in 52 countries. The rest of the data are generated from models predicting solid fuel use. The model used solid fuel use values from the household fuel use database, and assumed that as countries develop economically, people gradually shift up an energy ladder from solid fuels to cleaner fuels. The final exposed population is calculated as: Household equivalent solid fuel exposed population = population using solid fuel × ventilation factor. Information of the main type of fuel used for cooking are collected at the national and sub national levels in most countries using censuses and surveys.
According to WHO, the household surveys used include: DHS survey, MICS survey, WHS survey and other reliable and nationally representative country surveys.

Additional notes:

WHO notes that there may be discrepancies between the various internationally reported and nationally reported figures for the same year because of the following factors: (1) use of different definitions of solid fuel (wood only or wood and any other biomass, e.g. dung residues), (2) use of different total population estimates, and (3) different denominators (estimates are expressed as percentage of population using solid fuels (as per MDG indicator) as compared to percentage of household using solid fuels (as assessed by surveys such as DHS or MICS)). Taiwan's data are provided from Taiwan's Ministry of Environment. Where data were missing from WHO, we used MDG data, mostly for years 2003 and 2007. The minimum value of 5 from MDG dataset was set to the minimum value for WHO dataset, which is 0.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0
Top performance benchmark: 0.1
Poor performance benchmar: 100
Source: Expert opinion. The poor performance benchmark was based on the 95th percentile 2000-2010 data and adjusted based on expert judgment.

Indicator: Marine Protected Areas

Objective / Policy: **Ecosystem Vitality - Biodiversity and Habitat**

Code: *MPAEEZ*

Description: The percentage of each country's exclusive economic zone (EEZ, 0-200 nautical miles) that is under protection by a marine protected area (MPA).

Rationale: Marine Protected Areas (MPAs) are an essential insurance policy for the future of both marine life and local people. They safeguard the ocean's rich diversity of life and provide safe havens for endangered species, as well as commercial fish populations. Well-designed networks of ecologically representative MPAs can also allow better security against environmental change, such as global warming.

SOURCE(S)

Variable: Percentage of EEZ area protected
Citation: IUCN and UNEP-WCMC (2011) The World Database on Protected Areas (WDPA): January 2011. Cambridge, UK: UNEP-WCMC.
Year of publication: 2011
Covered time: 1990-2010
URL: http://www.unep-wcmc.org/
Date data obtained: 9/20/2011
Data type: tabular

Variable: World EEZ Shapefile, v.6.0
Citation: VLIZ Maritime Boundaries Geodatabase
Year of publication: 0
Covered time: 2011
URL: http://www.vliz.be/vmdcdata/marbound/
Date data obtained: 12:00:00 AM
Data type: Shapefile

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

The January 2011 version of the World Database on Protected Areas was used by the UNEP World Conservation Monitoring Centre for a spatial time series analysis of protected area coverage from 1990 to 2010. WCMC considered all nationally designated protected areas whose location and extent is known. They used polygons where available, otherwise they used buffered points. WCMC removed all overlaps between different designations and categories, buffered points and polygons, and dissolved the boundaries so as to create a protected areas mask. The time series was generated based on the date of gazetting of the protected areas. Dated and undated protected areas were used; protected areas with unknown year of establishment were assumed to have been established before 1990.

Additional notes:

Landlocked countries are averaged around in calculation of the EPI.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 10
Top performance benchmark: 10
Poor performance benchmark: 0.0003
Source: Convention on Biological Diversity; The low performance benchmark of 0.0003 is established the 5th percentile of the distribution of the data, years 2000-2010.

Indicator: Biome Protection

Objective / Policy: **Ecosystem Vitality - Biodiversity and Habitat**

Code: *PACOV*

Description: The weighted percentage of biomes under protected status, where the weight is determined by the relative size of biomes within a country. Countries are not rewarded for protecting beyond 17% of any given biome (i.e., scores are capped at 17% per biome) so that higher levels of protection of some biomes cannot be used to offset lower levels of protection of other biomes.

Rationale: This indicator measures the degree to which a country achieves the target of protecting 17% of each terrestrial biome within its borders. The Convention on Biological Diversity (CBD) established the 17% target at its 10th Conference of the Parties in Nagoya, Japan (2010). We treat protected status as a necessary but not sufficient condition for an ecological region to be "effectively conserved." How well protected areas are managed, the strength of the legal protections extended to them, and the actual outcomes on the ground, are all vital elements of a comprehensive assessment of effective conservation. Such measures are not available on a widespread basis, though there are efforts underway to fill critical gaps.

SOURCE(S)

Variable: World Database of Protected Areas
Citation: UNEP World Conservation Monitoring Centre
Year of publication: 2011
Covered time: 1990-2010
URL: http://www.protectedplanet.net
Date data obtained: 10/1/2011
Data type: ESRI file geodatabase

Variable: WWF Ecoregions of the World
Citation: World Wildlife Fund USA
Year of publication: 0
Covered time: circa 2000
URL: http://www.worldwildlife.org/science/ecoregions/delineation.html
Date data obtained: 12:00:00 AM
Data type: ESRI Shapefile

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

CIESIN used a time series version of the World Database on Protected Areas (WDPA) developed by UNEP World Conservation Monitoring Centre in 2011, which provides a spatial time series of protected area (PA) coverage from 1990 to 2010. WCMC considered all nationally designated protected areas whose location and extent is known. Boundaries were defined by polygons where available, and where they were not available protected area centroids were buffered to create a circle in accordance with the the PA size. WCMC removed all overlaps between different protected areas by dissolving the boundaries so as to create a protected areas mask. The time series was generated based on the date of gazetting of the protected areas. Dated and undated protected areas were used; protected areas with unknown year of establishment were assumed to have been established before 1990. To calculate this indicator CIESIN overlayed the protected area mask on biome data developed by WWF's Terrestrial Ecoregions of the World (Olson et al. 2001) for each country. Because we are measuring the extent of terrestrial protected areas, biome 98 (water) was excluded. The area and percentage of each biome under protected status was calculated, and the weighted percentage, based on size of biome, was used to calculate the ecoregion protection indicator. All biome protection percentages were capped at 17% so that higher protection in one biome cannot be used to offset lower protection in another. Details on the methodology can be obtained by reading the document "Eco-Region Protection Indicator for the 2011 release of the Natural Resources Management Index of the Millennium Challenge Corporation: Data and Methodology", available at http://sedac.ciesin.columbia.edu/es/papers/ecoregion_protection_methodology_2011.pdf

Additional notes: Protected Areas Boundary data may have inaccuracies, and for many countries no boundary data may exist for certain protected areas and bufferred points were used instead. In overlaying two global data sets with different scales and resolutions, there will inevitably be a certain degree of spatial error in the analysis. To reduce the spatial error, however, CIESIN took precautions to improve the biome data set from Olsen et al. (2001) with better coastline delineations.
Transformation needed for aggregation: none
Nominal Policy Target: 17 Top performance benchmark: 17 Poor performance benchmark: 0 **Source:** Convention on Biological Diversity

Indicator: Particulate Matter

Objective / Policy: **Environmental Health - Air Quality**

Code: *PM25*

Description: These data are derived from a model that was parameterized by MODIS Aerosol Optical Depth (AOD) data. The model covered all areas sounth of 60 degree North latitude.

Rationale: Particles suspended in outdoor air contribute to acute lower respiratory infections and other diseases such as cancer.

SOURCE(S)

Variable: Population-weighted exposure to PM2.5 in micro-grams per cubic meter

Citation: van Donkelaar, A., R. V. Martin, M. Brauer, R. Kahn, R. Levy, C. Verduzco, and P. J. Villeneuve, 2010. Global Estimates of Exposure to Fine Particulate Matter Concentrations from Satellite-based Aerosol Optical Depth, Environ. Health Perspect., 118(6): 8

Year of publication: 2010

Covered time: 2003-2010 (terminal years for three-year rolling means)

URL:

Date data obtained: 10/27/2011

Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: micrograms per cubic meter

Indicator creation method:

PM2.5 concentrations were averaged over the period 2001-2005 and the grid was resampled to match the Global Rural-Urban Mapping Project 1km population grid. The weighted average of the values in each grid cell was used to come up with a country total exposure to PM2.5 in micrograms per cubic meter.

Additional notes:

For countries with at least 2 data points, the data were imputed based on linear interpolation (between the first and last data point) and constant values outside this time frame.All other missing are coded as following: -8888 for countries with data from the source, and -9999 for countries not included in source country list.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 10

Top performance benchmark: 10

Poor performance benchmark: 49.13929

Source: World Health Organization recommendation for PM 2.5 concentrations. The low performance benchmark was based on the 95th percentile of the of distribution of the available time series data from approximately 2000-2010.

Indicator: Pesticide Regulation

Objective / Policy: **Ecosystem Vitality - Agriculture and Land Management**

Code: *POPs*

Description: The POPs indicator examines the legislative status of countries on one of the landmark agreements on POPs usage, the Stockholm Convention, and also rates the degree to which these countries have followed through on the objectives of the conventions by limiting or outlawing the use of certain toxic chemicals.

Rationale: Pesticides are a significant source of pollution in the environment, affecting both human and ecosystem health. Pesticides damage ecosystem health by killing beneficial insects, pollinators, and fauna they support. Human exposure to pesticides has been linked to increases in headaches, fatigue, insomnia, dizziness, hand tremors, and other neurological symptoms. The pesticides included in this inicator are persistent organic pollutants (POPs), which are endocrine disruptors, or carcinogens.

SOURCE(S)

Variable: POPs regulation

Citation: UNEP Chemicals, "Master List of Actions on the Reduction and/or Elimination of the Releases of Persistent Organic Pollutants, Fifth edition", June 2003

Year of publication: 2003

Covered time: 1960-2006

URL: http://www.chem.unep.ch/pops/; and http://www.pops.int/documents/meetings/inc7/mastlist5/ml5.pdf, page 243 onward

Date data obtained: 12/6//2011

Data type: pdf

INDICATOR SUMMARY

Unit of Measurement: 22 Point Scale

Indicator creation method:

The criteria for indicator calculation is the number of the "dirty dozen" pesticide banned, restricted and allowed in the country, by year. For each of the following POPs: Aldrin, Chlordane, DDT, Dieldrin, Dioxin_Furan, Endrin, Heptachlor, Hexachlorobenzene, Mirex, PCB, Toxaphene, we assign 2 points in the year that were banned, 1 point when they are restricted. See http://www.pops.int/documents/meetings/inc7/mastlist5/ml5.pdf, page 243 onward.

Additional notes:

Taiwan's data were provided by Taiwan's Environmental Protection Agency. For countries with at least 2 data points, the data were imputed based on linear interpolation (between the first and last data point) and constant values outside this time frame. All other missing are coded as following: -8888 for countries with data from the source, and -9999 for countries not included in source country list.

Transformation needed for aggregation: none

Nominal Policy Target: 22

Top performance benchmark: 22

Poor performance benchmark: 0

Source: Stockholm Convention

Indicator: Renewable Electricity

Objective / Policy: **Ecosystem Vitality - Climate Change**

Code: *RENEW*

Description: The percentage of the total renewable electricity net generation in total electricity net generation.

Rationale: Renewable electricity production reduces reliance on fossil fuels, which produce greenhouse gases and pollute the atmosphere.

SOURCE(S)

Variable: Renewable electricity production as a percentage of total electricity production
Citation: International Energy Agency (IEA)
Year of publication: 2011
Covered time: 1980-2009
URL: http://data.iea.org
Date data obtained: 12/23/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

This indicator was calculated by dividing the renewable electricity production by total electricity production. The renewable electricity production includes biodiesel, biogasoline, other biogas, charcoal, geothermal, hydro, other liquid biofuels, sludge gas, solarphotovoltaics, solar thermal, tide wave & ocean, and wind.

Additional notes:

Transformation needed for aggregation: none

Nominal Policy Target: 100

Top performance benchmark: 100
Poor performance benchmark: 0
Source: Expert opinion

Indicator: SO2 Emissions Per $ GDP

Objective / Policy: **Ecosystem Vitality - Air Quality**

Code: *SO2GDP*

Description: Sulfur dioxide emissions per GDP represents the ratio of SO2 emissions to GDP in 2005 constant international prices PPP.

Rationale: Sulfur dioxide (SO2) deposition has detrimental impacts on aquatic and terrestrial ecosystems, and it is also harmful to human health. SO2 is produced by the energy sector, industry, transportation, and agricultural waste burning (Smith et al, 2011).

SOURCE(S)

Variable: Sulfur Dioxide Emissions
Citation: Smith, S.J., J. van Aardenne, Z. Klimont, R.J. Andres4, A. Volke, and S. Delgado Arias. (2011). Anthropogenic sulfur dioxide emissions: 1850–2005, Atmos. Chem. Phys., 11, 1101–1116.
Year of publication: 2011
Covered time: 1850-2005
URL: http://dx.doi.org/10.5194/acp-11-1101-2011
Date data obtained: 10/27/2011
Data type: tabular

Variable: GDP, PPP (constant 2005 international $)
Citation: World Development Indicators, The World Bank
Year of publication: 2011
Covered time: 1980-2010
URL: http://databank.worldbank.org/ddp/home.do
Date data obtained: 4/11/2011
Data type: tabular

Variable: GDP, PPP (constant international $)
Citation: CIESIN calculations based on Per capita GDP (WDI and CIA Factbook) and Population (WDI and CIA Factook)
Year of publication: varies
Covered time: 1995-2009
URL: http://databank.worldbank.org/ddp/home.do; https://www.cia.gov/library/publications/the-world-factbook/
Date data obtained: 4/11/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: grammes SO2 per US dollar PPP (in 2005 constant US dollars)

Indicator creation method:

The full method for this variable is described in Smith et al. 2011. In summary, estimates of anthropogenic global sulfur dioxide emissions were calculated using a bottom-up mass balance method which was calibrated to country-level inventory data. The 5 steps in the calculation are: (1) development of an inventory by sector and fuel for three key years, (2) development of detailed estimates for smelting and international shipping, (3) calculation of a default set of emissions by interpolating emissions factors from the key years, (4) calculation of final annual emissions values by fuel that match inventory values, and (5) estimate sectoral emissions (Smith et al 2011,pag.1102). The country totals are then divided by GDP in constant 2005 US dollars.

Additional notes:

A systemic uncertainty component was added to account for uncertainty assumptions in different regions. Petroleum products are often quantified in ranges of sulfur content, which inherently includes some uncertainty. Where there are emission controls, how well the controls are monitored will also impact measurements. The original data included the total SO2 for Serbia and Montenegro, thus the SO2 was split between the two countries based on the denominator.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0

Top performance benchmark: 0.075

Poor performance benchmark: 11.46125

Source: Expert opinion. The poor and top performance benchmarks are based on the 5th and 95th percentiles of the 2000-2010 data.

Indicator: SO2 Emissions Per Capita

Objective / Policy: **Ecosystem Vitality - Air Quality**

Code: *SO2CAP*

Description: Sulfur dioxide emissions per capita represents the ratio of SO2 emissions to population.

Rationale: Sulfur dioxide (SO2) deposition has detrimental impacts on aquatic and terrestrial ecosystems, and it is also harmful to human health. SO2 is produced by energy sector, industry, transportation, domestic and AWB (Smith et al, 2011).

SOURCE(S)

Variable: Sulfur Dioxide Emissions
Citation: Smith, S.J., J. van Aardenne, Z. Klimont, R.J. Andres4, A. Volke, and S. Delgado Arias. (2011). Anthropogenic sulfur dioxide emissions: 1850–2005, Atmos. Chem. Phys., 11, 1101–1116.
Year of publication: 2011
Covered time: 1850-2005
URL: http://dx.doi.org/10.5194/acp-11-1101-2011
Date data obtained: 10/27/2011
Data type: tabular

Variable: Population
Citation: World Development Indicators, The World Bank
Year of publication: 2011
Covered time: 1960-2010
URL: http://databank.worldbank.org/ddp/home.do
Date data obtained: 4/11/2011
Data type: tabular

Variable: Population
Citation: CIA Factbook
Year of publication: varies
Covered time: 2000-2010
URL: https://www.cia.gov/library/publications/the-world-factbook/
Date data obtained: 4/11/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: kg SO2/person

Indicator creation method:

The full method for this variable is described in Smith et al. 2011. In summary, estimates of anthropogenic global sulfur dioxide emissions were calculated using a bottom-up mass balance method which was calibrated to country-level inventory data. The 5 steps in the calculation are: (1) development of an inventory by sector and fuel for three key years, (2) development of detailed estimates for smelting and international shipping, (3) calculation of a default set of emissions by interpolating emissions factors from the key years, (4) calculation of final annual emissions values by fuel that match inventory values, and (5) estimate sectoral emissions (Smith et al 2011,pag.1102). The country totals are then divided by population.

Additional notes:

A systemic uncertainty component was added to account for uncertainty assumptions in different regions. Petroleum products are often quantified in ranges of sulfur content, which inherently includes some uncertainty. Where there are emission controls, how well the controls are monitored will also impact measurements. The original data included the total SO2 for Serbia and Montenegro, thus the SO2 was split between the two countries based on the denominator.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0
Top performance benchmark: 0.272485252
Poor performance benchmark: 105.90408
Source: Expert opinion. The poor and top performance benchmarks are based on the 5th and 95th percentiles of the 2000-2010 data.

Indicator: Coastal Shelf Fishing Pressure

Objective / Policy: **Ecosystem Vitality - Fisheries**

Code: *TCEEZ*

Description: This is the catch from trawling and dredging gears divided by the EEZ area by country and year.

Rationale: Benthic trawling is a fishing method that targets fish and invertebrates that inhabit ocean floor (or benthic) ecosystems. These include cod, scallops, shrimp, and flounder. This type of trawling comes at a heavy environmental cost. Bottom trawling and dredging equipment have been described as the most destructive fishing gear in use today (Watson, 2004 and 2006). Benthic trawls are boats equipped with large heavy nets that are dragged across the living seafloor. The nets are held open at the front by a metal beam or by large "doors," which can weigh several tons, and which are designed to scour the bottom as the trawl is dragged along, forcing the fish and invertebrates up into the net. This process exerts a heavy toll on the natural habitats of the sea floor, breaking off brittle bottom flora and fauna such as sponges and corals. Marine species such as turtles that try to escape the gear suffer stress, injury, and quite frequently, death (FAO, 2005). This indicator is an attempt to measure the intensity of gears such as trawlers that operate on the coastal shelf.

SOURCE(S)

Variable: Catch from trawling and dredging gears (mostly bottom trawls) (Tonnes)
Citation: Sea Around Us Project, University of British Columbia Fisheries Centre
Year of publication: 2011
Covered time: 1950-2006
URL: http://seaaroundus.org/
Date data obtained: 8/31/2011
Data type: tabular

Variable: EEZ area
Citation: Sea Around Us Project, University of British Columbia Fisheries Centre based on FAO data
Year of publication: 2011
Covered time: 1950-2006
URL: http://seaaroundus.org/
Date data obtained: 8/31/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Tonnes per square km

Indicator creation method:

The Sea Around Us spatial database is based on several major data sources such as the FAO capture fisheries and its regional bodies, the International Council for the Exploration of the Seas (ICES) STATLANT database (www.ices.int/fish/statlant.htm), the Northwest Atlantic Fisheries Organization (NAFO; www.nafo.ca/), as well as data provided from the Canadian, United States, and other governments. The catches in each spatial cell is associate with the appropriate fishing gear code to determine the catch from trawling and dredging gears. This total metric tonnes of catch is divided to the area of EEZ.

Additional notes:

Small island states were aggregated to the countries under administration. Landlocked countries are averaged around in calculation of the EPI.

Transformation needed for aggregation: logarithmic

Nominal Policy Target: 0
Top performance benchmark: 0.00001665
Poor performance benchmark: 1.000
Source: Expert opinion. The poor performance benchmark is based on the 95th percentile of the 2000-2010 data and adjusted based on expert judgment.

Indicator: Access to Drinking Water

Objective / Policy: **Environmental Health - Water quantity**

Code: *WATSUP*

Description: The percentage of a country's population that has access to an improved source of drinking water.

Rationale: Diarrheal disease is a leading causes of death among children and is contracted through contaminated water sources.

SOURCE(S)

Variable: Access to drinking water
Citation: WHO / UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation
Year of publication: 2011
Covered time: 1990-2005 (5 year values), 2008
URL: http://www.wssinfo.org/data-estimates/table/
Date data obtained: 8/23/2011
Data type: tabular

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

The WHO defines an improved drinking water source as piped water into dwelling, plot or yard; public tap/standpipe; tubewell/borehole; protected dug well; protected spring; and rainwater collection (UNICEF and WHO 2008).

Additional notes:

Some of the countries exceed the 100 percent target. We set these values to 100. Countries reported as having 0% coverage are not actually 0 according to our evaluation of the data; so all 0 cells are treated as missing data. The countries not included in WHO / UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation list are coded with "-9999." Taiwan's data are provided from Taiwan's Ministry of Environment. Data for Lithuania were imputed based on regional averages.

Transformation needed for aggregation: none

Nominal Policy Target: 100
Top performance benchmark: 100
Poor performance benchmark: 36
Source: Millennium Development Goals. The low performance benchmark was based on the 5th percentile of the 2000-2010 data.

Indicator: Change in Water Quantity

Objective / Policy: **Ecosystem Vitality - Water resources**

Code: *WATUSE*

Description: Area-weighted percent reduction of mean annual river flow from "natural" state owing to water withdrawals and reservoirs.

Rationale: Water withdrawals and reservoir construction and management have negative impact on river ecosystems, wetlands and floodplains, affecting the biodiversity of aquatic ecosystems (Döll et al. 2009).

SOURCE(S)

Variable: Water use

Citation: Döll, P., K. Fiedler, and J. Zhang. Global-scale analysis of river flow alterations due to water withdrawals and reservoirs, Hydrol. Earth Syst. Sci., 13, 2413–2432, 2009

Year of publication: 2009

Covered time: 2005

URL:

Date data obtained: 11/10/2011

Data type:

INDICATOR SUMMARY

Unit of Measurement: Percentage

Indicator creation method:

Water withdrawals and consumptive water use is estimated separately for the irrigation, livestock, household and industrial sectors. Water impoundment is based on the Global Reservoir and Dam version 1.1 data set (GRanD). The percent change in river flow owing to both factors was calculated on a 0.5 degree grid cell basis. CIESIN used the data developd by Döll et al. (2009) to calculate an area weighted average of the percent change by country.

Additional notes:

These data represent a relatively conserative estimate of human impacts on natural water flows. The impact of reservoirs is probably underestimated by the study as small reservoirs are not taken into account. Data for Brunei were imputed based on regional averages.

Transformation needed for aggregation: inverse, logarithmic

Nominal Policy Target: 0

Top performance benchmark: 0.00773015215

Poor performance benchmark: 44.384146048

Source: Expert opinion. The poor performance benchmark was based on the 95th percentile of the 2000-2010 data.

Appendix II. Preliminary Sensitivity Analysis

Michaela Saisana & Andrea Saltelli
European Commission – Joint Research Centre – IPSC, ITALY

The main advantage and added value of the Environmental Performance Index (EPI) is that an aggregated index, with a set of environmental indicators measuring different aspects of sustainability, is more reliable than looking at each indicator separately. The Pilot Trend EPI, with information on the trends of nations' sustainability levels over the last eleven years (2000-2010), is a particularly valuable addition to the 2012 EPI. There are, however, practical challenges in the EPI related to the quality of available data and the aggregation of these into a single number.

Assessing the conceptual and statistical coherence of the EPI and estimating the impact of modelling assumptions on a nation's sustainability level serves a two-fold purpose: (a) it ensures the transparency and reliability of the EPI, and (b) it enables policymakers to derive more accurate and meaningful conclusions. Yale and Columbia Universities have invited the European Commission Joint Research Centre (JRC) in Ispra-Italy to assess each EPI report since its launch in 2006. The JRC researched extensively the quality of composite indicators and ranking systems that classify countries' performances along policy lines (OECD, 2008; Saisana *et al*., 2005; 2011; Saltelli *et al.* 2008, Paruolo *et al*., 2012).[i]

The statistical assessment of the 2012 EPI was done along three main avenues: an evaluation of conceptual/statistical coherence of its structure, an interpretation of the rankings based on significance tests, and an evaluation of the impact of key modelling assumptions (e.g., weighting and aggregation) on nations' EPI scores and ranks. This short note summarises the main findings from the first analysis on the conceptual/statistical coherence of the EPI structure. Detailed findings on all three types of analysis will be available online at www.epi.yale.edu by mid-March 2012.

Conceptual and statistical coherence in the EPI

As described in the main text of the EPI report, the EPI scores for nations worldwide are computed as the simple (or weighted) averages within and across ten policy categories and two objectives (*Ecosystem Vitality* and *Environmental Health*) for a total of 22 indicators. Each of those indicators offers a partial picture of a nation's sustainability level. The intention of the EPI is to provide a more reliable overall picture of sustainability levels around the world than any single indicator would provide taken independently.

The data delivered to the JRC at the time of writing represented normalized values (target-driven min-max method) of 22 treated variables (e.g., logarithmic transformation) together with the country scores on ten policy categories, two objectives and the overall EPI on an annual basis between 2000-2010. These normalized indicators are not affected by outliers or skewed distributions,[ii] except for *outdoor air pollution* (described by $PM_{2.5}$) and *CO2 emissions per kWh*. However, the skewed distributions of those variables do not bias significantly the results of the respective EPI objective (i.e. Environmental Health in the first case or Ecosystem Vitality in the second case). The 2000-2010 dataset is characterized by excellent data coverage (93 percent data availability in a matrix of 22 variables × 132 countries × 11 years). Data coverage per EPI objective, country, or year is also very good or excellent.

Researchers used principal component analysis (PCA) on the 2000-2010 dataset to assess the extent to which the conceptual framework is confirmed by statistical approaches and to identify eventual pitfalls. The analysis confirms, in part, the EPI structure: for Environmental Health, the first latent factor of the three policy categories captures 83 percent of the variance; for Ecosystem Vitality, the first latent factor of the seven policy categories describes only 31 percent of the total variance. These results suggest the use of arithmetic average across the policy categories is statistically justified for Environmental Health but questionable for Ecosystem Vitality.

Next, tests focused on identifying whether the EPI and the two EPI objectives are statistically well-balanced in the underlying components. Unlike past releases of the EPI where the two objectives received equal weights, the 2012 weights them at 3/10 and 7/10, respectively. The EPI team was aiming for scores that were not dominated by one of the two objectives, but the weights also reflect the number of policy categories included in each objective. The same goal guided the choice of the weights at the policy category level. Hence, in the present context, our analysis answers the question: 'is the EPI country classification dominated by just one of the two EPI objectives (or just one or two policy categories)?' We have used a non-linear 'importance measure' (henceforth S_i), known as correlation ratio or first order sensitivity measure (Saltelli *et al.*, 2008). The S_i describes 'the expected reduction in the variance of EPI scores that would be obtained if a given objective (or policy category) could be fixed'. As discussed in Paruolo *et al.*, 2012, we can take this as a measure of importance; thus, if the two EPI objectives or the ten EPI policy categories are all expected to contribute significantly to determining the EPI country classification, their S_i values should not differ too much. A more detailed discussion of this non-linear analysis will be available by March 2012 on the EPI website.

Results are reassuring for the overall EPI. The EPI objectives are both important in classifying countries on an annual basis in the overall EPI, (S_i values between 0.2 and 0.5 over the years; see Table 1 for results in the latest year, second column), although Ecosystem Vitality appears to have a greater impact. For simplicity, one may look at the linear approximation to S_i (i.e. the squared Pearson product moment correlation coefficients; see Table 1, third and sixth column) with the caveat that these are more suitable for linear relations.

When looking at the impact of the ten policy categories on the overall EPI, there is no dominance issue, though Child Mortality and Water (ecosystem) appear to be slightly more important, while Air Pollution (ecosystem) and Forestry have the least impact on the variance of the EPI scores.

Environmental Health is balanced with respect to Water & Sanitation and Child Mortality (S_i values close to 0.9; see fifth column), but Air Pollution has less impact than expected (S_i~0.4).

Ecosystem Vitality appears to be less balanced. Although there is no particular dominance issue in the four policy categories – Air, Water, Biodiversity and Climate Change – all have the same impact on the Ecosystem Vitality score, but the remaining three policy categories – Forestry, Marine & Fisheries and Agriculture – have practically "no saying" on the *Ecosystem Vitality* classification.

Table 1. Importance measures for the EPI 2012 components

EPI component	**Importance measures for EPI**		**Weights within EPI**	**Importance measures for the two EPI Objectives**		**Weights within objectives**
	S_i non linear(1)	**S_i linear(2)**		**S_i non linear(1)**	**S_i linear(2)**	
Environmental Health	0.231 (0.057)	0.329	30%			
Ecosystem Vitality	0.489 (0.076)	0.415	70%			
				Environmental Health		
Air Pollution (health)	0.165 (0.092)	0.267	8%	0.455 (0.100)	0.661	25%
Water & Sanitation (health)	0.279 (0.122)	0.289	8%	0.925 (0.045)	0.886	25%
Child Mortality	0.415 (0.078)	0.300	15%	0.938 (0.022)	0.918	50%
			9%	**Ecosystem Vitality 2012**		
Air pollution (ecosystem)	0.108 (0.051)	0.135	9%	0.410 (0.081)	0.363	13%
Water (ecosystem)	0.074 (0.059)	0.166	18%	0.342 (0.066)	0.388	13%
Biodiversity & Habitat	0.438 (0.080)	0.448	6%	0.484 (0.091)	0.444	25%
Forestry	0.121 (0.063)	0.000	6%	0.076 (0.038)	0.081	8%
Marine & Fisheries	0.041 (0.032)	0.015	6%	0.021 (0.026)	0.001	8%

Agriculture	0.166 (0.067)	0.005	18%	0.051 (0.055)	0.022	8%
Climate change	0.116 (0.042)	0.008	8%	0.461 (0.081)	0.446	25%

Source: European Commission Joint Research Centre

Notes: (1) Numbers represent the average kernel estimates of the Pearson correlation ratio ( ) calculated by bootstrap (1000 samples). (2) Numbers represent the Pearson correlation coefficient (squared). (3) Bootstrap standard deviations for the correlation ratio are given in parenthesis. (4) Results are based on the data reported for 2010.

he same type of analysis across the five variables underlying *Environmental Health* shows that outdoor air pollution ($PM_{2.5}$) seems to have a much lower impact with respect to the other four variables in the Environmental Health country classification. For Ecosystem Vitality, seven out of 17 variables are randomly associated to Ecosystem Vitality, which suggests that even if countries make an effort to improve in those variables, this will not necessarily be translated into an improvement in their Ecosystem Vitality classification.

The negative association between the two EPI objectives (ranging between -0.5 and -0.2 over the years 2000-2010) strongly suggests that Environmental Health and Ecosystem Vitality should not be aggregated linearly into a single number but rather presented separately or treated with a different, less compensatory aggregation strategy.

To understand this point, consider whether countries with similar overall EPI scores but very different performance on the two objectives should actually be placed on the same level of sustainability. Take, for example, Congo and Armenia:

Congo - Environmental Health =12, Ecosystem Vitality = 62, EPI=47.5
Armenia - Environmental Health =63, Ecosystem Vitality =40, EPI=47.5

Armenia is relatively more balanced in performance across the two EPI objectives, while one may argue that Congo should somehow be penalised for very low performance on Environmental Health.

This is the kind of consideration that led the authors of the Human Development Index to switch from linear to geometric aggregation between the 2009 and 2010 release of the index (see Paruolo et al., 2012 for a discussion). In the case discussed above, Congo would get 37.8 and Armenia 45.8 (using the 30-70 weights of the EPI). Again such important differences associated to the aggregation formula suggest caution – if the two objectives were positively correlated with one another this issue would be less critical, i.e. there would be less countries for which this would be an issue.

Linear aggregation is a simple and easy to communicate, but it is very demanding in terms of the type of data that can be confidently aggregated. Where the data are more complex and with unavoidable trade-offs, as is the case with the rich structure of the EPI data set, linear aggregation does not favour coherence, as discussed for the two countries above.

If that is the case, perhaps future releases of EPI should reflect the compensation issue and switch to a less compensatory aggregation than the linear weighted average. The weighted geometric average of the objectives and/or the policy categories presented above by way of illustration is just one of the possibilities. The consideration of logarithms for most variables in the 2012 EPI methodology is already a step in this direction, and the 2012 EPI, overall, appears a decisive improvement over the 2010 EPI (see the 2010 EPI validation report in Saisana and Saltelli, 2010).

Conclusion

The JRC analysis suggests that the 2012 EPI structure (tested on an eleven year period over 2000-2010) appears a decisive improvement over the 2010 EPI. The 2012 EPI is statistically coherent and balanced with respect to the two objectives on Environmental Health and Ecosystem Vitality and also within Environmental Health. Yet, some reflection is still needed on the construction of the Ecosystem Vitality objective where the use of arithmetic average in combining the information appears problematic due to the negative or random associations between the policy categories. These trade-offs within Ecosystem Vitality are a reminder of the danger of compensating between policy categories while also identifying the areas where more work is needed to achieve a coherent framework – particularly regarding the relative importance of the indicators that compose the EPI framework. Finally, the negative association between the two EPI objectives (ranging between -0.5 and -0.2 over 2000-2010) might be seen as a warning that Environmental Health and Ecosystem Vitality should not be aggregated into a single number but rather presented separately, e.g. with countries displayed on a simple plot (bi-dimensional radar plot) where the Euclidean distance from the origin illustrates the sustainability of the country.

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ENDNOTES

[i] JRC auditing studies of composite indicators are available at http://composite-indicators.jrc.ec.europa.eu/. JRC has co-authored, with the Organisation for Economic Co-operation and Development (OECD), a Handbook on Constructing Composite Indicators: Methodology and User Guide, whose methodology has largely been used for the present analysis.

[ii] Groeneveld and Meeden (1984) set the criteria for absolute skewness above 1 and kurtosis above 3.5. The skewness criterion was relaxed to 'above 2' to account for the small sample (132 countries).