Pilot 2006 Environmental Performance Index

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Pilot 2006 Environmental Performance Index

Appendix D: Policy Category Discussion

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This appendix serves as a supplement to Chapter 4 of the main report, which describes the major issues and results in each policy category. Here we provide additional information on the rationale for the specific indicators we chose in each policy category, background on the policy context for each policy category, a brief discussion of indicator-level results, and an assessment of prospects for future performance-based action. Detailed descriptions of the methods used for constructing the indicators are found at the end of Appendix F. There were several indicators that were determined to be essential measures of environmental performance that had to be left out of the report due to lack of data or difficulty in interpreting the data that does exist. Where appropriate, a discussion of these indicators is included.

Core Area:
Environmental Health

D.1. Environmental Health

Our Focus

A global study on the environmental burden of disease conducted by the World Health Organization (WHO) found that unsafe drinking water and poor sanitation accounted for the largest proportion of environmentally-related morbidity and mortality, followed by indoor air pollution, lead exposure and urban air pollution (WHO, 2002). Hence, these indicators were our focus in the EPI. We include the percent of population with access to an improved water source and the percent of population with adequate sanitation, both of which are also official indicators under MDG-7. The target for each of these measures is 100% coverage.

For indoor air pollution, the EPI utilizes the framework of the WHO, which quantifies indoor air pollution as a function of solid fuel consumed within the home, modified by the type of ventilation used. Over the long term the goal is to eliminate this sort of pollution exposure completely, therefore a level of zero has been set as the ultimate target. We also included the urban concentration of particulate matter in this policy category, which is described further in Section D.2 below. We calculated a measure of lead emissions per square kilometer based on data from Pacyna et al. (1995), but these data were from 1989 and therefore represented a snapshot of performance before most European countries had implemented stricter lead emission control policies. They have not been updated subsequently, and thus represent another globally important data gap.

Finally, the EPI sought to capture environmental health outcomes through the indicator of mortality in children ages one to four. The logic for this focus is strong, as children are environmental bellwethers. Research shows that they are more susceptible to environmental conditions than adults. Thus tracking their mortality is an important indicator of environmental conditions—but to do so, it is important to focus on mortality in the youngest non-infant age bracket, since infant mortality is heavily determined by many other non-environmental factors, key among which is access to health care. We set a target of zero, which reflects our belief that any level of child mortality is essentially undesirable and the fact that there are already a number of countries at or near this target.

The Policy Context

The provision of safe drinking water and adequate sanitation is fundamental to gains in environmental health. The goals of enhanced access to safe water and improved sanitation play a prominent role in the UN Millennium Development Goals, and in strategies to meet the established targets. MDG-7 and its Target 10 seek to reduce the proportion of humankind lacking sufficient access to clean drinking water and sanitation relative to a 1990 baseline by 2015.

The MDGs set a target for reducing under-five mortality by two thirds by 2015. There are, however, no corresponding targets for mortality in the one to four age group. Though the policy dialogue regarding this age group is limited and national statistics on this are spotty at best,[7] this age bracket is the most relevant from an environmental health perspective.

With regard to air pollutants, the depth of policy making is, in general, inversely related to the severity of the problem. Of the different types of air pollution, indoor air pollution poses by far the most severe threat, accounting for several million premature deaths per year. Yet there are no international targets or action plans, and there is very little regional or national activity. Regarding urban air pollution, policy targets, monitoring networks, and mitigation efforts are most advanced in regions where the problem is least severe. There are no international policy targets, though the WHO has set standards that some countries have adopted.

Assessment

The indicators for water and sanitation are closely correlated with income, with GDP per capita predicting approximately 60% of the variation in access to water and sanitation. In terms of results, there are few surprises for these indicators—sub-Saharan African countries score the worst, and developed countries consistently have close to 100% coverage.

There is a negative correlation between GDP per capita and mortality in the one to four age group (R^2 = .30, p<.001). Sub-Saharan African countries score particularly poorly owing to high levels of water-borne diseases and perhaps also to other factors, such as indoor air pollution and poor waste disposal and sanitation.

Indoor air pollution is also highly correlated with poverty. The 47 countries that are within five percent of the long-term target are predominantly high-income countries. There are 32 countries estimated to have 95% or more of the households burning solid fuel indoors without adequate ventilation. These are among the poorest countries of the world.

Prospects for Performance-Based Action

Clearly environmental health—and particularly water supply and sanitation—are high on the international policy making agenda as a result of the attention being given to them within the Millennium Development Goal framework. Indoor air pollution is not well tracked, and certainly is not gaining the international policy attention it deserves in light of its huge health impacts. The authors suggest increased reporting of mortality in the one to four age bracket as a metric of environmental health. In addition, air- and water-borne pollutant emissions and concentrations need to be tracked simultaneously to further develop these environmental health indicators.

As reported in the 2005 ESI (Esty, Levy et al., 2005), data coverage for key air and water pollutant concentrations is extremely poor. Iin the case of water the Global Environmental Monitoring System (GEMS/Water) network has expanded in the past few years, although the actual on-the-ground monitoring network has remained relatively stagnant.

7 Using data reported by countries in the UN Demographic Yearbook and on the WHO website, we were only able to compile statistics for 108 countries. Because of the poor reporting of mortality in this age bracket, we utilized estimates produced by the UN Population Division instead.

Core Area:
Ecosystem Vitality and Natural Resource Management

D.2. Air Quality

Our Focus

We rely on two indicators for Air Quality—Urban Particulates and Regional Ozone. As mentioned in Chapter 4, we ideally would have liked to use data on concentrations of sulfur oxides and nitrogen oxides—both acid rain precursors—but these data were not readily available on a global scale. Urban particulates is not a perfect substitute, but it does enable one to gauge the relative severity of urban air pollution problems across countries.

Although countries set targets that focus on different sizes of particulates (2.5 microns, 10 microns, or other sizes), the EPI focuses on 10 microns (PM10) as the most universally relevant measure. This is also the only urban pollutant for which quantitative measures have been estimated for a large number of cities. In the absence of an international target, the EPI proposes a target of 10 $\mu g/m^3$, which is essentially the natural background level of particulate matter in most regions of the world.[8]

Ground-level ozone provides another measure of long-range air pollution. Although acidification received greater attention in the 1970s and 1980s as a long-range air pollution transport problem, ground-level ozone has come to be recognized as a greater public health threat, and it also represents a threat to ecosystems in that it impairs photosynthesis. There are limited national targets and no international targets. In the absence of an authoritative source for a long-term target, a putative target of 15 parts per billion (ppb) was adopted based on recent epidemiological studies that suggest that there is not a "safe" level of exposure. This target is very low in view of existing conditions—only seven countries currently meet it.

Data on total carbon emissions from biomass burning were obtained, but we opted not to include them in the overall aggregation due to the focus that this would place on practices that are common largely in the developing world and the sense that this would represent double counting with the urban PM concentrations. Box D1 provides a summary of the findings on biomass burning.

The Policy Context

The Policy Context for urban particulates is discussed in Section D.1 above. In regards to regional ozone concentrations and long-range air pollution problems, these are dealt with most comprehensively in Europe, although the problems are most severe in Asia.

Understanding of the global extent of long-range air pollution dynamics has increased considerably in recent years, and there is a growing willingness to address the problem within international policy. For example, the Convention on Long-range Transboundary Air Pollution (CLRTAP) is an international policy mechanism, and its expansion over the years demonstrates countries' ability and willingness to cooperate in order to reduce the impacts of transboundary air pollution. However, developing countries are not yet represented in this convention (IUCN et al. 2005).

Assessment

Levels of urban particulates are lowest among wealthy countries and poor countries that have low levels of industrialization—Sweden and Uganda, for example, have similar PM10 levels. The levels are highest in very poor countries that burn very dirty fuels, have the oldest vehicle fleets, and suffer from high levels of natural

[8] The background level actually varies between 6 and 16 $\mu g/m^3$, but we chose a single target of $10 \mu g/m^3$.

Box D1: Biomass Burning

Biomass burning is one of the most important contributors to atmospheric pollution and CO_2 emissions. Results of an analysis of data developed by Randerson et al. (2005) on total carbon emissions from vegetation fires are provided here. Data were downloaded for the period 1997-2002 and the average annual emissions for this time period was computed. This average was then divided by the total land area for each country to determine emissions per square kilometer. These are reported in the table below for the twenty worst countries (highest emissions/km^2).

Country	Carbon Emissions (g/km2)	Country	Carbon Emissions (g/km^2)
Uruguay	840.4	Bolivia	568.2
South Africa	739.3	Argentina	558.4
Namibia	660.2	Zambia	550.2
Botswana	656.8	Lesotho	546.3
Paraguay	642.1	Angola	510.4
Zimbabwe	626.2	Swaziland	473.1
Rwanda	619.2	Papua New Guinea	436.6
Madagascar	614.3	Tanzania	428.2
Australia	585.5	Congo	425.5
Mozambique	585.5	Malawi	422.4

The countries with the greatest emissions of total carbon per land area are largely tropical countries with large grassland areas and/or in which a large percentage of the population is smallholder farmers who use fire for land clearing. Australia is the one non-developing country in the group, and burning there is related to rangeland management.

Biomass burning was also considered as a potential component of land degradation, but, while largely negative in terms of land conservation, it was determined that there may be instances in which biomass burning is relatively benign from a land management perspective.

particulates resulting from dust storms—Sudan, Mali, Niger, and Chad, for example, are among the worst performers.

Regional ozone levels are a function of multiple factors, including emissions within the country, emissions in countries downwind, and meteorological conditions that influence atmospheric chemistry. Emissions, transport dynamics, and meteorology are not evenly distributed geographically. The highest ozone concentrations are found in countries such as Mexico, Guatemala, China, Australia, and the United States. The lowest concentrations are in tropical countries with low emissions, such as Gabon, and Congo.

Prospects for Performance-Based Action

Air pollution concerns do not lend themselves well at present to coordinated international action organized around quantitative benchmarks and monitoring. Outcome measurement is limited, and the measurements we rely on here are derived from models. Of the many pollutants that should be tracked, only urban particulates are measured on an annual basis. Even with regard to urban particulates, monitoring is spotty, with ground-level monitoring observations available for only

62 countries (Esty, Levy et al., 2005). Better air pollution metrics, gathered on a worldwide basis, should be a priority for the global environmental policy community.

D.3. Water Resources

Our Focus

We use two indicators for this policy category, Nitrogen Loading and Water Consumption. Nitrogen load per average flow unit of a country's river basins is the indicator that was chosen to capture pollutant emissions. Changes to the global nitrogen cycle are emblematic of those in water quality more generally, as high concentrations of people or major landscape disturbances translate into a disruption of the basic character of natural inland water and coastal ecosystems.[9] Elevated levels of nitrogen are associated with air pollution deposition, industrial fertilizer application, natural and crop fixation (e.g. soybeans), and the subsequent fate of feed for livestock or food destined for direct human consumption. As nitrogen is highly reactive, there is a "self-cleansing" potential of land and aquatic-based ecosystems, accounting for about 80% of incident loads (Howarth et al., 1996).

The target for nitrogen concentrations was set at 1 mg/liter, which is at the border between oligotrophic and mesotrophic levels. Oligotrophic waters are nutrient poor, while mesotrophic waters have moderate amounts of nutrients (Smith and Smith, 2001). This is supported by environmental legislation in several countries—including South Africa and Australia—but it must be acknowledged that the actual nitrogen concentrations that are sustainable depend on the ecosystem type and the level of phosphorus in the water bodies, since eutrophication is often P-limited.

It must be added that the nitrogen loading is a modeled dataset on a globally consistent one-half degree grid. This was combined with modeled river flow data. Ideally we would have chosen direct measures of water pollutant concentrations such as nitrogen, phosphorus, and fecal coliform, but data are not available for many countries. Thus, we needed to rely on a modeled dataset to provide a useful but incomplete picture of water quality.

The second water indicator is the percentage of a country's territory affected by oversubscription of water resources. A growing world population with rising expectations for material well-being will place added and in some cases unsustainable pressure on the freshwater resource base. Water use is represented by local demands summed by domestic, industrial, and agricultural water withdrawals and then divided by available water supply to yield an index of local relative water use. A high degree of oversubscription is indicated when the water use is more than 40% of available supply (WMO, 1997). Countries can to some extent accommodate oversubscription in one region with inter-basin transfers, but these engender significant environmental impacts of their own. Thus, the ultimate target for each country is to have no area of their territory affected by oversubscription.

Colleagues at the University of New Hampshire Water Systems Analysis Group developed indicators on river fragmentation and impoundment of water supplies. However, these data are left out of the EPI aggregation at this time because of a lack of clear and globally consistent evidence demonstrating the negative ecosystem impacts of dams, and the potential offsetting environmental benefits of hydroelectric as a renewable energy resource. Box D2 presents the results of this assessment.

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[9] The contrast between pristine and contemporary states can be dramatic and potentially global in scope. Compared with the preindustrial condition, loading of reactive nitrogen to the landmass has doubled from 111 million to 223 million tons per year (Green et al. 2004) or possibly even higher (Galloway et al. 2004).

The Policy Context

Water is firmly established in the international dialogue on sustainable development. The Johannesburg World Summit on Sustainable Development (WSSD) was framed in part around the WEHAB initiative, with Water taking a prominent role among the other major development imperatives of Energy, Health, Agriculture, and Biodiversity (WEHAB, 2002). Follow-up activities of the United Nations Commission on Sustainable Development (CSD) consolidated during the 2-year "Water Cycle" that ended in 2005 emphasized the critical role of water in poverty alleviation. A 24-agency consortium of the United Nations is now engaged through the World Water Assessment Programme to issue triennial assessments on the state of the world's fresh water (e.g. UNESCO, 2003). Water is also the centerpiece of the United Nations International Decade for Action, "Water for Life" (2005-2015), which will help to set a world agenda on water issues for the 21st century.

Despite all of this policy attention, there are no internationally recognized targets for pollutant concentrations in water supplies designed to protect either human or ecosystem health. Nor are there targets for the unsustainable extraction of water resources from surface or ground water sources for economic activities or human needs. These two areas are in need of international policy attention.

Assessment

Results for nitrogen loading show no clear pattern in relation to GDP per capita. Arid and semi-arid countries perform poorly, largely owing to limited dilution potential.[10] After filtering out the arid countries, densely settled or agricultural exporting countries also show high levels of deposition due to high-input agriculture. These include Mexico, China, Australia, the United States, and Argentina.

10 The R-square between percent land area in arid and semi-arid climatic zones and nitrogen loading per available freshwater is 0.19 ($p<0.000$).

The percent of territory that is oversubscribed is affected by climatic factors and natural endowments, with many arid countries showing more than 50% of their territories oversubscribed. The percentage of a country's territory that is densely settled (>100 person per km^2) does not appear to affect this indicator, although Belgium and the Netherlands are two densely settled, temperate humid countries with significant portions (50% and 25% respectively) of their territories oversubscribed.[11] Water use for the agricultural sector is the most significant factor contributing to oversubscription.

Prospects for Performance-Based Action

Increased global demand for agricultural products and freshwater will make it difficult to meet targets for the two water indicators. Policy pressures can affect nitrogen loadings, though it will require significant effort to reign in agricultural nitrogen emissions. In light of population growth and the push for greater use of chemical fertilizers as part of the package for meeting MDG-1 on poverty and hunger, it seems unlikely that many countries will implement serious reforms regarding nitrogen emissions. The literature shows that the nitrogen cycle has accelerated dramatically in the past few decades, with few prospects in sight for slowing (Smil, 2004). The same basic problem faces the percentage of territory oversubscribed—global demands for freshwater rise unabated, and the push to meet the MDGs for hunger, water, and sanitation provision suggest that the target of zero percent oversubscribed territory will be difficult if not impossible to meet, yet continued over-abstraction (and particularly abstraction of fossil ground water) cannot be sustained indefinitely.

11 The R-square between percent land area in arid and semi-arid climatic zones and percent of territory affected by the oversubscription of water resources is 0.15 ($p<0.000$).

Box D2: Water Impoundment and Flow Fragmentation

Two additional indicators, storage of continental runoff behind modern dam systems and dams per million kilometers of stream length could have been included in the Pilot EPI. Because it was difficult to interpret a clear environmental performance signal or to identify what would be a target for sustainability, these measures were left out of the EPI aggregation. Nevertheless, the results and some suggestions for further work are reported here.

The demand for reliable sources of fresh water and flood control prompts a broad array of water engineering schemes to control the inherent variability of the hydrologic cycle and thus increase the reliability of water for human use. Dam-building has been prolific, with a year 2000 estimate of 45,000 large dams worldwide (WCD, 2000) and possibly 800,000 smaller ones (Hoeg, 2000). The facilities represent substantial investments in civilian infrastructure (US$2 trillion in capital) and serve as important instruments for development, with 80% of the global expenditure of $32–46 billion per year focused on the developing world (WCD, 2000).

Most of the beneficial effects and environmental impacts associated with water engineering have taken place over the last half-century, associated directly with the major flow stabilization of the global system of rivers (Figure D2). Positive effects include sufficient water for irrigation, industry, and drinking water; flood control; and hydroelectricity generation. Negative environmental effects include fragmentation and destruction of habitat, loss of species, health issues associated with stagnant water, and loss of sediments and nutrients destined to support downstream freshwater and coastal ecosystems and fisheries.

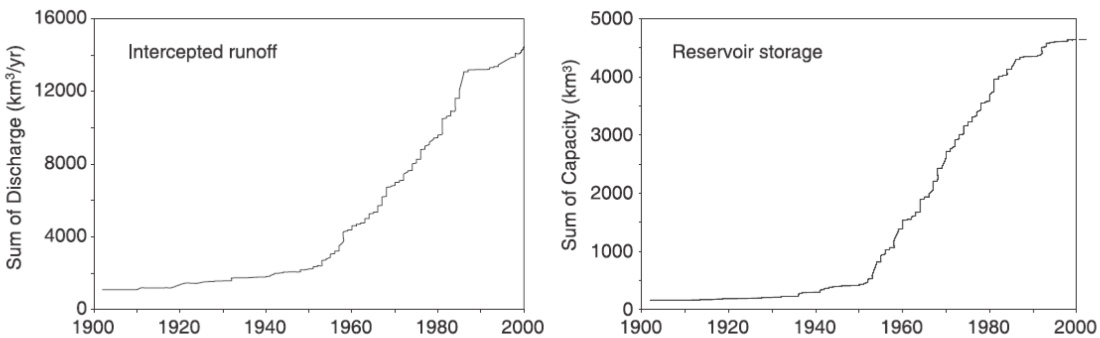

Figure D2. World's Largest Reservoirs

The time series here represent a subset of the world's largest reservoirs (>0.5 km^3 maximum storage each), representing about 70% of impounded volume globally (ICOLD and IWPDC archives).

Recent analysis shows the impact of these activities on the continental water cycle. Estimates place the volume of water trapped behind documented dams at 6,000–7,000 cubic kilometers (Shiklomanov and Rodda, 2003). In drainage basins regulated by large reservoirs (>0.5 cubic kilometers) alone, one third of the mean annual flow of 20,000 cubic kilometers is stored (Vörösmarty et al., 2003), or a volume sufficient to carry over an entire year's minimum flows.

While there are several shortcomings to their use in geospatial analysis, existing compendia of dams and reservoirs do provide several useful statistics for use in an EPI context. These are available as national inventories through the International Commission on Large Dams (ICOLD) and International Water Power and Dam Construction (IWPDC). From these data, indicators of the degree of flow storage relative to sustainable water supply can be calculated directly on a national basis. The resulting indicator is an aggregate measure of a society's capacity to store freshwater, with affiliated impacts assumed on the fragmentation of flow along the river continuum, disruption of migratory pathways, reservoir in-filling from siltation, loss of river sediment to nourish wetlands, etc.

Results of this impoundment measure are presented here for the top 20 countries. They are presented in terms of the residence time of water behind a country's dams. A value of one means that a country has water equivalent to one year's flow behind dams within its territory.

continued

Box D2: continued

The top 10 countries all have major dams that account for the majority of flow impoundment; in the case of Egypt the high residence time is almost entirely accounted for by the Aswan High Dam. Most of these countries have arid, semi-arid, or Mediterranean climates, with the exception of Ghana (which is semi-arid in the north only), Zambia (which is largely Savannah), North Korea, and Argentina.

The top 20 countries for the second measure, number of dams per million kilometers of stream length, are shown below. Many of the same countries show up here, but some small or island nations also make the list because of the relatively short length of their stream networks. Mountainous countries appear also to be disproportionately represented, which may be due to the relatively large numbers of small hydroelectric installations. From an ecosystem and aquatic habitat perspective, all things being equal the fewer the dams per kilometers of stream length the better, but this is a relatively under-studied area. From a renewable energy perspective, however, hydroelectric dams have the potential to provide a long-term sustainable energy supply. This underscores the difficulty of applying strict performance criteria. A longer-term strategy building on this indicator would consolidate the extant series of global georeferenced datasets, conjoin these with digital stream networks and flow estimates, and then make calculations across the full spectrum of river sizes. Statistical distributions of the indicator could then be assembled.

Country	Residence time all dams (in years)	Country	Residence time all dams (in years)
Egypt	31.0	Macedonia	1.4
Lesotho	10.6	Zambia	1.0
South Africa	7.2	Libya	1.0
Kyrgyzstan	4.3	Kazakhstan	0.6
Ghana	4.1	Tunisia	0.6
Morocco	4.1	North Korea	0.6
Tajikistan	3.2	Spain	0.6
Azerbaijan	2.9	Cyprus	0.6
Iraq	1.7	Albania	0.5
Turkey	1.7	Argentina	0.5
Country	**# dams per million km of stream**	**Country**	**# dams per million km of stream**
Albania	7827.8	Austria	1070.2
South Korea	5243.3	Slovenia	984.9
Cyprus	3385.3	Bulgaria	982.3
Mauritius	2461.6	India	864.6
Switzerland	2444.6	Portugal	777.0
Japan	1959.1	Slovakia	733.6
Spain	1578.1	France	709.8
United Kingdom	1351.0	Romania	686.4
Italy	1256.9	Germany	594.0
Czech Republic	1112.0	Turkey	583.1

Indicators with more direct links to environmental impacts (WCD, 2000) also need to be developed. For example, there would be good value in extending analysis from well-studied regions of the world (e.g. for the US), which have mapped stream reaches below regulated impoundments and then linked geophysical measures to ecosystem and biodiversity effects. Additional impacts arising from drainage of wetlands, river “training” and channelization, as well as levee construction should be considered.

– Charles Vörösmarty
University of New Hampshire Water Systems Analysis Group

D.4. Productive Natural Resources

Our Focus

In this policy category we include three indicators: Agricultural Subsidies, Overfishing, and the Timber Harvest Rate. Agricultural subsidies, according to a report by the OECD (2004), exacerbate environmental pressures through the intensification of chemical use and expansion of land use to sensitive areas (OECD, 2004). Based on this linkage between agricultural subsidies and environmental harm, an indicator that measures agricultural subsidies as a percent of agricultural GDP was chosen for inclusion in the index. Agricultural production occurs in countries at all levels of GDP, regardless of location. Thus removing subsidies is an action within the power of all governments. The authors recognize that this indicator is not flawless, especially in light of the implications of environmentally beneficial subsidies.[12] Where data were available we adjusted the aggregate subsidy measures by subtracting so-called "green-box" subsidies – those that are intended to promote environmentally sustainable farming practices. The resulting indicator, therefore, is a better approximation of environmentally harmful subsidies.

Box D3: Sustainable Agriculture – From Subsidies to Soil Conservation

The productivity and sustainability of land devoted to production of food and fiber is a critical issue in both the environment and development realms. The long-term goal is to conserve soil quality — structure, nutrients, organic content, etc. — and productive capacity through sustainable agricultural practices. No good measures of soil conservation exist today on a worldwide basis. The Pilot 2006 EPI therefore uses agricultural subsidies (net of payments for environmental services) as a proxy for sustainable agriculture.

While imperfect, the logic of the Agricultural Subsidies indicator derives from the many studies that show that farm subsidies, particularly price guarantees and commodity-related payments, distort planting decisions and encourage ecologically harmful practices such as intensive use of chemicals, farming in riparian zones, and monoculture. But this metric is deficient in a number of ways. First, subsidies are an input rather than an output variable. Second, the data on agricultural subsidies is imperfect and relies heavily on country self-reporting to the WTO. For many countries, no data exists. Third, unsubsidized agriculture is not necessarily sustainable agriculture. Many farming and forestry practices in countries without subsidies still degrade the productivity of the land and the quality of the soil.

Even if soil conservation measures do not emerge in the near future, better proxies for the sustainability of agriculture might be found. One possibility would be to track "agricultural land under controlled organic cultivation as a percentage of total agricultural land" with a target of 100% organic. While some observers might not like this focus and would argue that the developing world needs to expand its use of chemicals to increase yields, many agricultural experts (and consumers) see organic agriculture as the ultimate test of sustainability.

Practical issues limit the viability of an Organic Agriculture indicator today, but these obstacles are disappearing. Data availability on organic agriculture is quite good in developed countries, and differences among these nations in their definitions of "organic" are diminishing. In the developing world, the requisite data generally do not exist. So a focus on organic production as a metric would require some effort to expand worldwide tracking of farming on this basis. The growing emphasis on certification of products and the need for verification of supply chains should facilitate progress in this regard.

– R. Andreas Kraemer
Ecologic (Berlin, Germany)

[12] Comment taken from the EPI Expert Workshop held October 27-28, 2005.

For sustainable forest management, the EPI considers timber harvest relative to standing volume of forest, measuring countries' production of round wood as compared to wood volume.[13] Forest experts suggested that countries aim to harvest no more than three percent of their standing forest volume, ensuring a sustainable target for all countries given the varying growth rates of different forest types.[14]

There were also concerns about the data—with some countries appearing to harvest in excess of 30% of their standing forest volume annually. This appears to be an artifact of the data, since the two datasets on harvest and standing volume were produced for different purposes. It might also be representative of the fact that some countries have fuelwood plantations that account for their high rates of harvest relative to volume. However, the 95th percentile threshold for the worst performing countries is 24%, which means that no country is penalized for harvests in excess of this percentage.

We use a measure of "productivity overfishing" developed by the South Pacific Applied Geoscience Commission (SOPAC) in partnership with UNEP as part of their Environmental Vulnerability Index (SOPAC, 2004). Productivity overfishing is measured as the ratio of biological productivity, measured in tons of carbon per square kilometer of exclusive economic zone per year, to tons of fish catch per square kilometer of shelf per year. Higher ratios indicate better results. The target was set at 3.2 million tons of carbon per ton of fish catch. This indicator only reflects fishing within a country's exclusive economic zone (EEZ) under national responsibility, and not the behavior of many national fishing fleets ranging over the open ocean, for which flag nations should also be held responsible. A better measurement of overfishing would therefore examine proportional impacts on endangered fisheries by flag fishing fleet—yet data for this indicator are not readily available.

Three other potential indicators were explored—land degradation, subsistence crop yields, and urban sprawl—but ultimately could not be incorporated for reasons of data quality. Box D4 provides a current assessment of land degradation data. Unfortunately the only globally consistent dataset on this subject is woefully out of date and largely the product of expert judgment rather than on-the-ground measurement. We explored a measure of soil salinization due to irrigation, but there are a variety of biophysical reasons for which a country may be more likely to experience salinization that have little to do with the sustainability of irrigation.

Because declines in subsistence crop yields are a harbinger of poor soil fertility management, the authors explored a measure of trends in yields per hectare over time for maize, sorghum, and millet. However, data compiled by FAO for these crops show some suspicious patterns—such as consistent annual growth rates for certain crops over five year periods. This led to the conclusion that yield statistics for some countries are likely to be fabricated. Finally, we attempted to calculate a measure of land consumed due to urban growth (so called "urban sprawl") based on the average population density within urban areas (CIESIN, 2005).

This measure yielded some anomalous results. Some countries in Africa show very high-density urban areas because of under-estimates of their urbanized land area. As such, the sprawl indicator ultimately had to abandoned.

13 The FAO data do not appear to include estimates of subsistence-level forest cutting, but only commercial operations, and as such may seriously underestimate cutting in some countries where forests are cut for fuel wood. On the other hand, the data on standing volume may underestimate total wood volume in a country, particularly where crown cover is below 10-20%.

14 Suggestion taken from discussions with forest experts from the Yale School of Forestry and Environmental Studies on December 7-8, 2005.

Box D4: *Paucity of Soil Quality and Land Degradation Data*

The Global Assessment of Land Degradation (GLASOD) is the only comprehensive and uniform global assessment to date. It represents a consensus opinion of national and regional experts on the extent of land degradation in various categories of severity as of the early 1990s. According to Bot et al. (2000):

> *"The GLASOD data were derived from estimates by over 290 national collaborators, moderated by 23 regional collaborators. These estimates were based upon defined mapping units and a carefully structured set of definitions, but ultimately they were dependent on local knowledge rather than surveys. The results are thus to a degree subjective, and open to the criticism that local experts may have allowed perceived correlations with other factors, or even the vested interests of conservation institutions, to influence their judgment. Until methods are established for surveying and monitoring the status of land degradation, however, there is no better source of global data."*

Soil experts that were consulted had serious reservations about the reliability and validity of the GLASOD estimates. FAO has updated the numbers since the early 1990s, but there is no documentation on the methodology that was used.

A new global assessment, the Land Degradation Assessment in Drylands (LADA), will use improved methodologies with greater ground-truthing, but will be limited to dryland areas. Unless or until the Convention to Combat Desertification or some other international body provides the impetus to improve global measurements of soil degradation using some combination of satellite and *in situ* data, there is little prospect for improved data on soil conservation in this policy area.

The Policy Context

There are a number of international conventions in the area of ecosystems and natural resources, such as the Convention on Biological Diversity, the Ramsar Convention on Wetlands, and the Convention to Combat Desertification. Unfortunately, most of these agreements lack compliance mechanisms, and have only limited effectiveness in directing human actions onto a sustainable course.

For agricultural subsidies, the authors drew on the guidelines set forth by GATT and the WTO, which set an ultimate target of zero percent agricultural subsidies as a percent of agricultural GDP. Although the GATT and WTO guidelines are largely intended to promote free trade and remove barriers to developing country products, they can have an equally beneficial effect in the environmental arena. Establishing an ultimate target calling for the eradication of any agricultural subsidies underscores the necessity to remove incentives for unsustainable practices.

Despite the fact that forestry is an economic sector entirely dependent on natural resources, there have been few environmental successes in the international forestry policy arena. Policymaking for forest management differs from country to country based on the endowments and property rights regimes of individual nations. Countries have engaged in a forest policy dialogue for decades, recognizing that forest management is an important aspect of overall sustainable development. Understanding and implementing proposals resulting from these dialogues remains a challenge, and there have yet to be any global frameworks regarding sustainable forest management. As a result, forests continue to be subject to overcutting and degradation at a rapid rate.

The world's fisheries have seen mixed results in the international arena. The Law of the Sea includes Exclusive Economic Zones within the boundaries of the continental shelf, but high seas fishing regulations are much less defined and inadequate in many areas. Because of their open access nature, fisheries with a weak regulatory regime are at risk of overexploitation. This situation is exacerbated by government subsidies in a number of countries that provide incentives for expanding fishing beyond sustainable levels.

Environmental sustainability at the global scale would require that fish be caught at a rate that matches that of replenishment, hence the idea for maximum sustainable yield. Maximum economic benefit is actually reached before the maximum sustainable yield level and hence is even more desirable. Estimation of these quotas, however, depends on many factors. Several countries have successfully implemented property rights systems such as individually tradable quotas (ITQs) that are helping to protect the livelihoods of those who fish and the viability of the fisheries (e.g. New Zealand, Australia, and Canada). Achieving sustainable fisheries is a crucial issue in many parts of the world because seafood is an important source of protein in the diet. This issue deserves greater international policy attention.

Assessment

Agricultural subsidies are high across Europe. The worst performers—Switzerland, Norway, and Iceland—are all relatively small but affluent economies that are seeking to protect their farm sectors from international competition. Among other major agricultural producers, high subsidies are found in Japan, Korea, and the United States.

The measure of round wood volume harvests as a percent of standing forest volume show a different picture, with generally impoverished, arid and/or massively deforested countries showing up as the worst performers. Niger, Mauritania, Egypt, and Haiti all purportedly have more than 100% harvest of standing forests, but this is most likely an artifact of the data, with only forest plantations measured and large areas of very sparse vegetation not considered at all in the calculations. Although the percentages cannot be taken at face value, this indicator nevertheless reflects a reality that poor, subsistence countries are harvesting forests for fuel wood and charcoal production at unsustainable rates.

Regarding productivity overfishing, small island states perform quite well, perhaps because of their small or traditional fishing fleets. The worst performers are Chile, China, Iceland, Japan, Norway, Peru, Slovenia, and Thailand. With the exception of Slovenia, these are countries with large fishing fleets that consume large amounts of fish. Slovenia is among the worst performers because of an extremely small coastal zone (and hence small amounts of carbon production) relative to its fish catches.

Prospects for Performance-Based Action

The three core indicators are merely proxies for sustainable use of natural resources. Agricultural subsidies are a crude measure, and direct measures like soil erosion or marginal land under cultivation would be preferred. These measures could better indicate whether or not farmland is being appropriately managed.

Another as yet unavailable indicator of sustainably managed agricultural systems would measure yields per land area controlled for inputs such as labor, capital, and resources. With respect to forest management, it would be useful to include a measure of timber extraction as a fraction of regrowth in subsequent indices.

Regardless of how things are measured, there does not appear to be any impetus internationally to tackle the thorny issues of forest loss, unsustainable agriculture, and land degradation with anywhere near the levels of investment required.

For fisheries, there is increasing potential to obtain governmental data on the amount of fish that are being landed, and to allocate fishing allowances or property rights for fish that can protect the sustainability of the fishery in question. While at one time this seemed difficult because of data tracking issues, the increased capacity of remote-sensing and wireless communications makes it ever easier to imagine a regime that controls the number of fish landed by boat, by country, and by fishery. This would allow a move toward a regime that would keep fishing within sustainability limits.

D.5. Biodiversity & Habitat

Our Focus

Defining global indicators to monitor biodiversity conservation is a complex task. A recent publication proposed that over 100 individual indicators are needed to monitor the state of the ecosystems in the United States alone, and 14 indicators addressing different components of biodiversity are included in the Convention for Biological Diversity's framework (Balmford et al., 2005; Heinz Center, 2002; UNEP, 2004). In addition, a lack of global datasets precludes even the application of those 14 indicators at present.

The EPI focuses on two measures based on the national extent and location of protected area (PA) networks: a measure of the evenness of protected areas coverage by biome (Ecoregion Protection) and a measure of the degree to which the country's wildest areas are protected (Wilderness Protection). Protected areas are the cornerstone of conservation strategies and have been shown to effectively slow environmental alteration both within their borders and in surrounding areas, and to protect valuable goods and services. The extent and placement of PAs within a country can be used as an indicator of progress in biodiversity conservation (Chape et al., 2005).

Ideally, PA networks must contain a representative fraction of a region's biological diversity and separate it from possible threats. The degree to which a PA network is successful in achieving its intended goals depends on a series of interactions among selection, design, and management issues (Box D5). In general, two types of measurements can be used in evaluating PA success: effectiveness of management and effectiveness of coverage (Chape et al., 2005).

Clearly, the mere establishment of PA boundaries does not lead to biodiversity conservation if habitat destruction is allowed within the protected area. Although the significance of "paper parks" has been debated in the scientific literature, effectiveness in PA management is an important factor in evaluating a country's conservation efforts. The effectiveness of protected areas depends on several factors that are best measured at the site level (Ervin, 2003b; Hockings, 2003), but the overall effectiveness of conservation projects is correlated with budget and staffing levels (Dearden et al., 2005; Ervin, 2003a; James et al., 1999). However, current and internationally representative data are unavailable and it was not possible to monitor effectiveness of management here.

We chose the measure of the evenness of protected areas coverage by biome because some regions are under-represented at the global scale (Hazen & Anthamatten, 2004). This is despite an internationally agreed target of protection of 10% of the area in all major ecological regions. Consequently, the EPI evaluates the level of inclusion of a country's ecological regions in its PA network. Our target is protection of 10% of the area in every ecological region in a country. The focus is on terrestrial areas, as global targets for marine PA coverage have been suggested but are not yet universally accepted.

Box D5: Conservation of High Diversity Areas

Representation of a region's biodiversity is one of the main goals of protected area networks. Ideally, the selection of optimal areas to be set aside for conservation must be based on detailed knowledge about a region's biodiversity including species' identities, ranges, and threat levels. In reality, this is not the norm. For example, a recent study found that a significant fraction of species is not included in existing protected area networks (Rodrigues et al., 2004).

Although all major ecological regions regardless of their level of biodiversity should receive adequate protection, protecting areas of high biological value (e.g. high diversity, endemism or irreplaceability) is a sensible conservation strategy. Globally, several prioritization schemes are used to establish areas of high biological value that suffer from some level of threat (Olson and Dinerstein, 2002; Eken et al., 2004; Mittermeier et al., 1998). A global assessment of biodiversity conservation should include the level of protection afforded to biologically rich areas within each country, but global prioritization schemes emphasize conservation in tropical and sub-tropical countries. The data necessary to monitor the protection of high biodiversity areas in all countries are not currently available. Global biodiversity assessments are scarce, biased towards vertebrates, and the knowledge and the data required to estimate overall diversity at the global scale using surrogates are lacking. The lack of such fundamental data is a major hurdle in monitoring success in biodiversity conservation.

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The second measure—the Protected Wilderness Indicator (PWI)—focuses on the level of wilderness area protection. Protecting its last remaining wild areas may be a country's only or most cost effective conservation strategy. Each country's last wild areas are highlighted using an index of human environmental alteration based on human population density, land transformation, accessibility and electrical power infrastructure developed by Sanderson et al. (2002). The least disturbed areas within each ecological region in each country are identified and the total area protected is measured.[15]

Setting a global target for wilderness conservation is necessarily a subjective task, but since larger areas under formal protection are associated with greater success in achieving conservation goals, the EPI uses 90% as a target for remaining wild areas protection.

In addition to these two measures of protected area coverage, the timber harvest rate (described in Section D.4) and the oversubscription of water resources (described in Section D.3) were also included in this category. This is in recognition of the impact that deforestation has on habitat loss, and crucial role of water in sustaining aquatic ecosystems.

Ideally, we would have liked to include measures relating to habitat destruction and species conservation. Increasingly, biodiversity policymaking has shifted from species and protected areas to broader efforts to preserve habitat. Little in the way of data is available, however, on habitat conservation across the world. Species conservation measures, such as the percent of species threatened with extinction, are highly tied to natural endowments, with countries home to a large number of endemic species tending to score poorly.

[15] The least disturbed areas are defined as those that fall below one standard deviation below the mean for the human influence index in that ecoregion for that country.

Furthermore, in most cases it is impossible to attribute country responsibility for threatened species because species are listed as threatened on the basis of their global threat status. Thus, a country could be implementing extensive programs to protect a particular species, yet it would still appear to be doing poorly if that species happens to be threatened. In future work we would like to convey not only the extent of a country's protected area network, but also its success in targeting species rich areas, and the degree to which management of those protected areas is effective (as described above).

The Policy Context

Legal instruments concerned with biodiversity conservation exist at regional, national, and international levels. However, environmental policy is usually developed in isolation from other policy sectors resulting in conservation strategies that are not coherent with other development goals. Too often national environmental authorities lack institutional capacity to adequately design and enforce conservation policies, especially those with transboundary effects. In addition to the problems of coordination and capacity, we lack the knowledge to precisely link biodiversity to ecosystem functions and services and to define appropriate conservation strategies to protect large-scale and long-term ecological and evolutionary processes.

Despite the existence of legal instruments and international agreements, conservation policy generally lacks quantitative benchmarks, and action plans based on quantitative measures are rare. Even when benchmarks do exist, they are largely a product of political negotiations and are rarely grounded in conservation science; in some cases conservation science itself does not yet have the answers. For example, although the inclusion in protected areas of 10% of all major ecological regions is an internationally agreed upon target in the Convention on Biological Diversity, protection is not necessarily based on a sound scientific understanding of the territory required to preserve biodiversity and ecosystem functioning, nor is it based on quantitative measures already established.

Assessment

Five countries—Venezuela, Burkina Faso, Benin, Botswana, Jamaica and Panama—not only have completely representative protected area systems (protecting a minimum of 10% of each ecoregion) but also protect more than 60% of their wilderness areas. Thirty-seven countries currently achieve the target of 10% or greater protection of all their ecoregions. With the exception of Japan, these are all tropical countries. Many large countries, such as Russia, the United States, China, and Canada, are very near the target.

For the Protected Wilderness Indicator, it is harder to discern any particular pattern in the data. Although one might expect that Western European countries would score highly due to the fact that the only remaining lands that are relatively wild would by default be under protected status, in reality it is the developing countries that appear to have the highest percentages of their remaining wild lands under protected status. The Netherlands, Germany, and Belgium protect less than four percent of their wild lands, and France and Italy protect 6 and 11 percent, respectively. The United Kingdom, by contrast, protects 26%, which is very close to the United States total of 28%.

Prospects for Performance-Based Action

Currently, lack of appropriate databases and quantitative benchmarks make performance-based action difficult. Critical knowledge gaps about biodiversity itself, how it relates to ecosystem services, and how to effectively protect it from threats acting at different geographic scales need to be addressed before coordinated action can be implemented. The indicators produced here can be used to improve performance in PA selection and design; if properly managed, well-selected and representative PA networks are the basis of national biodiversity conservation strategies.

D.6. Sustainable Energy

Our Focus

Shifting toward non-polluting and sustainable energy sources has emerged as a central policy challenge. Present energy use, particularly electricity generation and fossil fuel combustion in the industrial transport, household, and commercial sectors, produces significant local air pollution and greenhouse gas emissions. To gauge progress toward sustainable energy, we include three indicators: Energy Efficiency, Renewable Energy, and Carbon Dioxide Emissions per unit GDP.

The Energy Efficiency indicator (energy consumption per unit GDP adjusted for PPP) reflects the degree of priority given to eco-efficiency in both the policy and business worlds, as well as its inclusion on the official indicator list under MDG-7. For a truly sustainable energy future, the world needs to decouple energy consumption from economic activity and GDP growth (IAEA, 2005). Although the world is a long way from achieving a complete decoupling, some countries are making progress through conservation, improved resource productivity, and shifts toward renewable energy sources such as wind, solar, and hydropower. In the absence of internationally agreed upon efficiency targets, the EPI establishes a target of efficient consumption equivalent to the 10th percentile of the most energy efficient countries currently.

We recognize that the use of renewable energy is partly a function of geography and natural endowments. All countries do not have access to hydropower, wind, or thermal energy. But all countries still have reasonable opportunities to replace non-renewable with renewable energy sources such as solar or biomass.

Renewable energy as a percent of total energy consumption is used as a proxy for clean and sustainable energy, for which no viable data exist.[15] The specific renewable sources tracked include hydroelectric, biomass, geothermal, solar, and wind electric power production.[16] The renewable energy indicator also measures energy diversification within a country, which provides both positive economic and environmental benefits (IAEA, 2005). The EPI target is set at 100% renewable energy, which by definition is the target that is sustainable in the long run. This target is crude, however, and a better one would track the percentage of energy from clean and sustainable sources.

In relation to climate change, it would be best for the EPI to report emissions of all six greenhouse gases tracked under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. However, given a lack of global data across several of these greenhouse gases, the best available option was a focus on carbon dioxide (CO_2) emissions per unit GDP. International benchmarks have been established for GHG emissions for industrialized countries through the Kyoto Protocol. Most of the countries that

[15] Clean and sustainable energy includes solar power, photovoltaic cells, tidal power, geothermal energy, hydropower, and wind power.
[16] Note that this indicator does not include non-commercial energy, such as biomass energy utilized by the rural poor or passive solar heaters utilized to heat water.

have taken on Kyoto obligations appear not to be on track to achieve these targets in the first budgeted period (2008-2012). Several other countries, most notably the United States and Australia, have declined to take on Kyoto emissions reduction targets. This makes the global response to climate change goals hard to achieve.

In the absence of both agreed-upon long-term total emissions targets or an allocation of permitted emissions, we have little guidance in establishing national GHG targets. From a planet-wide perspective, the absolute level of GHG emissions must be reduced. Indeed, to meet the Climate Change Convention's goal of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system," very substantial emissions reductions will be required. Absent consensus on a permitted level of emissions, we use a strict interpretation of the Convention goal and deploy a zero net emissions target. We recognize this goal might be relaxed slightly with more refined analysis.

It might be argued that including energy consumption per GDP and CO_2 per GDP in the same policy category is double counting. In fact, these two indicators are measuring different things. The overall R^2 for the two measures is .46 ($p<.001$), which suggests that energy efficiency only predicts 46% of the variation in CO_2 per GDP. The correlation is not higher because some countries have substituted renewable and nuclear energy for fossil fuel energy.

The Policy Context

While no definite policy goals have been set within the realm of sustainable energy use, the MDGs cite decreases in energy consumption per GDP among the indicators under Goal 7 (UNSTATS, 2005). Substantial international attention is focused on making economies more energy efficient. The Clean Development Mechanism (CDM) of the Kyoto Protocol seeks to reward high emitting countries for transferring technologies to promote energy efficiency among less efficient economies such as China and India.

There is currently no international agreement on clean or renewable energy, although these technologies constitute a key strategy for reducing global dependence on fossil fuels that emit greenhouse gases.

An argument might be made for tracking absolute levels of GHGs rather than GHGs/GDP as we do. Indeed as a matter of climate change policy, absolute levels of GHGs are of ultimate interest. Challenges to this include the estimation of the net carbon emissions permissible to avoid disruption or lasting changes in climatic conditions, and figuring out how to allocate those emissions to countries. The former constitutes a scientific problem while the latter is the subject of intense policy debates. Per capita quotas would favor population rich countries such as China and India and could counteract other policy goals such as demographic targets.

GHG emissions are an issue on which time series data would seem to be the most logical way to gauge current policy performance. We therefore provide, in table D1 below, changes in CO_2 emissions (1992-2000). Unfortunately, the most "successful" countries all achieved their emissions reductions by means of economic collapse rather than a focused GHG control policy.

The problem with looking at GHGs alone is that these levels today are largely a function of economic activity and population size. Moreover, almost all of the countries that have reduced their GHG emissions during this recent time period have done so not through policy design but as a by-product of economic collapse. We therefore focus instead on the critical measure of policy success in the short-run, the GHG efficiency of the economy.

Assessment

For energy efficiency, the best performing countries are also among the world's poorest—including Chad, Cambodia, Uganda, and Burkina Faso. There is a not a single industrialized country among the top 37 most energy efficient. Among industrialized countries, Ireland, ranked 38th, is followed by Italy (53), Switzerland (55), and Denmark (56). The worst performing countries are in the former Soviet Union and Arab States. There is no correlation between GDP per capita and energy efficiency.

For renewable energy, the top five countries are again developing countries, but ones with large hydro-power installations: Paraguay, Mozambique, Zambia, the Democratic Republic of Congo, and Laos. Among larger economies, Norway, Brazil, and Switzerland were the best performers. OPEC members and many African and Island nations had zero percent renewable energy.

Several industrialized countries perform surprisingly well on the measure of CO_2 emissions per GDP, including Switzerland, Sweden, France, Japan and Denmark, each with less than 60 metric tons of CO_2 emissions per million dollars GDP. This is no doubt partially due to the use of renewables in Switzerland and Sweden and the use of nuclear power in France and Japan. In general, the performance for this measure closely tracks the Sustainable Energy indicators—with the best performance from efficient countries, characterized by high degrees of renewables usage, and developing countries. Some of the worst performance is from the former Soviet republics and Arab States.

Prospects for Performance-Based Action

In the long term, decoupling energy use from GDP growth requires technological advances that make sustainable energy sources cost effective. In the short run, movement toward decoupling can be achieved by using energy more efficiently. Energy efficiency is also a function of the structure of the economy. Countries with large industrial sectors or agro-industries will, by their nature, consume more energy than countries that have large high technology or service sectors. Although manufacturing has become more efficient in the advanced industrialized countries, most of the efficiency gains have been due to adoption of information and communication technologies in all sectors and the progressive de-industrialization of their economies. The most important gains in energy efficiency need to be made in the industrial sector, particularly in countries such as China and India that are industrializing rapidly

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Table D1: Changes in Total Carbon Dioxide Emissions (1992-2000)

Rank	Country	% Change	Rank	Country	% Change	Rank	Country	% Change
1	Tajikistan	-81	46	United Arab Em.	11	91	Pakistan	44
2	Moldova	-69	47	Cambodia	12	92	Swaziland	44
3	Georgia	-59	48	Ecuador	12	93	Taiwan	45
4	Kyrgyzstan	-58	49	Finland	12	94	Costa Rica	45
5	Kazakhstan	-52	50	Burkina Faso	14	95	Angola	45
6	Nigeria	-44	51	Argentina	16	96	South Korea	47
7	Ukraine	-43	52	United States	16	97	Indonesia	49
8	Yemen	-39	53	South Africa	17	98	Laos	51
9	Azerbaijan	-38	54	Rwanda	17	99	Nicaragua	51
10	Mongolia	-32	55	Mozambique	18	100	Israel	51
11	Romania	-29	56	Slovenia	19	101	Turkey	51
12	Russia	-28	57	Malawi	19	102	Philippines	55
13	Zambia	-26	58	Iceland	19	103	Ghana	55
14	Slovakia	-21	59	Albania	20	104	Honduras	56
15	Congo	-18	60	Greece	22	105	Haiti	57
16	Dem. Rep. Congo	-18	61	Senegal	22	106	Thailand	57
17	Zimbabwe	-18	62	Guinea-Bissau	22	107	Panama	58
18	Bulgaria	-17	63	Tunisia	23	108	Chad	62
19	Denmark	-16	64	New Zealand	23	109	Venezuela	63
20	Czech Rep.	-14	65	Turkmenistan	23	110	Guatemala	64
21	Poland	-11	66	Burundi	25	111	Oman	64
22	Germany	-9.3	67	Central Afr. Rep.	25	112	Bolivia	68
23	Sweden	-8.7	68	Guinea	26	113	Chile	70
24	Switzerland	-8.6	69	Mali	26	114	Kenya	71
25	Armenia	-4.6	70	Spain	26	115	Egypt	76
26	Papua NG	-4.1	71	Trinidad & Tobago	26	116	Uganda	78
27	Hungary	-3.4	72	Cameroon	26	117	Benin	78
28	Norway	-1.7	73	Gabon	26	118	Bangladesh	81
29	Belgium	-1.6	74	Syria	26	119	Tanzania	85
30	Netherlands	-0.3	75	Australia	27	120	Myanmar	87
31	Cuba	0.1	76	Jordan	27	121	Ethiopia	92
32	France	0.2	77	Portugal	27	122	Malaysia	94
33	United Kingdom	0.3	78	Iran	28	123	Sudan	95
34	Suriname	0.3	79	Cyprus	29	124	El Salvador	95
35	Colombia	2.5	80	Jamaica	33	125	Saudi Arabia	101
36	Canada	4.4	81	Lebanon	34	126	Sri Lanka	102
37	Uzbekistan	4.7	82	Ireland	34	127	Togo	122
38	China	5.6	83	Gambia	37	128	Dominican Rep.	124
39	Italy	5.9	84	India	38	129	Madagascar	128
40	Mauritania	6.5	85	Sierra Leone	39	130	Côte d'Ivoire	141
41	Japan	7.2	86	Paraguay	40	131	Nepal	155
42	Mexico	7.2	87	Peru	40	132	Viet Nam	163
43	Austria	8.0	88	Morocco	41	133	Namibia	12000
44	Niger	9.9	89	Brazil	43			
45	Algeria	11	90	Liberia	43			

Source: Carbon Dioxide Information and Analysis Center (CDIAC).