Environmental Performance Index

2014 ENVIRONMENTAL PERFORMANCE INDEX

Full Report and Analysis

Yale Center for Environmental Law & Policy, Yale University
Center for International Earth Science Information Network, Columbia University

In collaboration with
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The 2014 Environmental Performance Index is a joint project between the Yale Center for Environmental Law & Policy (YCELP) and the Center for International Earth Science Information Network (CIESIN) at Columbia University, in collaboration with the Samuel Family Foundation and the World Economic Forum.

About YCELP

The Yale Center for Environmental Law & Policy, a joint research institute between the Yale School of Forestry & Environmental Studies and Yale Law School, seeks to incorporate fresh thinking, ethical awareness, and analytically rigorous decisionmaking tools into environmental law and policy.

About CIESIN

The Center for International Earth Science Information Network's mission is to provide access to and enhance the use of information worldwide, advance the understanding of human interactions in the environment, and serve the needs of science and public and private decisionmaking.

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The Samuel Family Foundation has a long history of supporting the arts, healthcare and education. In recent years, it has broadened its mandate internationally, to engage in such partnerships as the Clinton Global Initiative, and participate in programs aimed at global poverty alleviation, disability rights and human rights advocacy, environmental sustainability, education and youth programs.

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The World Economic Forum is an independent international organization committed to improving the state of the world by engaging business, political, academic and other leaders of society to shape global, regional and industry agendas.

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COMMONLY USED ABBREVIATIONS AND ACRONYMS

Alliance for Zero Extinction (AZE)
Asian Institute for Energy, Environment & Sustainability (AIEES)
Biochemical Oxygen Demand (BOD)
Center for Disease Control (CDC)
Center for International Earth Science Information Network (CIESIN)
Climate Analysis Indicators Tool (CAIT)
Climate Change Performance Index (CCPI)
Community of Latin American and Caribbean States (CELAC)
Convention on Biological Diversity (CBD)
Council of Agriculture (COA)
Environmental Performance Index (EPI)
Exclusive Economic Zone (EEZ)
European Union (EU)
Food and Agriculture Organization (FAO)
Forest Resource Assessment (FRA)
Forest Stewardship Council (FSC)
Global Burden of Disease 2010 (GBD 2010)
Global Domestic Product (GDP)
Global Environment Monitoring System (GEMS)
Global Forest Watch (GFW)
Gravity Recovery and Climate Experiment (GRACE)
Greenhouse Gases (GHGs)
Gross National Income (GNI)
International Council for the Exploration of the Seas (ICES)
International Energy Agency (IEA)
International Union for Conservation of Nature (IUCN)
Joint Monitoring Programme (JMP)
Joint Research Centre (JRC)
Least Developed Countries (LDCs)
Millennium Development Goals (MDGs)
National Aeronautics and Space Administration (NASA)
Northwest Atlantic Fisheries Organization (NAFO)
Organisation for Economic Co-operation and Development (OECD)
Organization of the Petroleum Exporting Countries (OPEC)
Particulate Matter (PM)
Persistent Organic Pollutants (POPs)
Reducing Emissions from Deforestation and Forest Degradation (REDD)
Small Island Developing States (SIDS)
Sustainable Development Goals (SDGs)
United Nations (UN)
United Nations Children's Fund (UNICEF)
United Nations Educational, Scientific and Cultural Organization (UNESCO)
United Nations Environment Programme (UNEP)
United Nations Framework on the Cov-ention of Climate Change (UNFCCC)
United Nations Statistical Division (UNSD)
Volatile Organic Compounds (VOCs)
World Conservation Monitoring Centre (WCMC)
World Database on Protected Areas (WDPA)
World Health Organization (WHO)
World Trade Organization (WTO)
World Wildlife Fund (WWF)
Yale Center for Environmental Law & Policy (YCELP)

What is the EPI?

The Environmental Performance Index (EPI) ranks how well countries perform on high-priority environmental issues in two broad policy areas: protection of human health from environmental harm and protection of ecosystems. Within these two policy objectives the EPI scores country performance in nine issue areas comprised of 20 indicators. Indicators in the EPI measure how close countries are to meeting internationally established targets or, in the absence of agreed-upon targets, how they compare to the range of observed countries.

WHY THE EPI?

The EPI gives decisionmakers access to important environmental data organized in a way that is easy to understand, useful, and drives productive competition. The EPI allows countries to compare their performance to neighbors and peers. With the inclusion of time series data, countries can also see how their own performance has changed over time.

2014 Innovations

This 2014 EPI report and the accompanying website offer several innovations and improvements over past versions of the Index. Readers will notice that this report moves away from a denser and more technical style in favor of a more narrative and exploratory approach.

Technical details are available on the 2014 EPI website at www.epi.yale.edu and will be available in a forthcoming academic article.

The website itself is likewise redesigned. The new website will give users unparalleled access to the EPI scores, rankings, and data, allowing users to create their own peer group comparisons, explore individual environmental issues in depth, download all the data that underlie the 2014 EPI, and access real-world stories that add nuance to the EPI.

The data and indicators have also undergone improvements for the 2014 EPI. This iteration presents new Climate and Energy indicators that account for differing economic and development status across the world's countries. The Air Quality and Forest issue areas include new indicators for Air Pollution and Change in Forest Cover that make use of cutting-edge satellite data for results that are more reflective of the actual state of the environment. For the first time anywhere, the 2014 EPI introduces a new indicator of Wastewater Treatment. Using new data collected by the Yale Center for Environmental Law & Policy, the Wastewater Treatment indicator measures the amount of collected wastewater that a country treats before releasing it back into the environment.

Each of these data innovations drives continued improvement to the strength and quality of the EPI. In addition, the 2014 EPI ranks 178 countries - more than ever before - and includes more countries from sub-Saharan Africa and Small Island Developing States (SIDS) such as Palau and Kiribati. Together, better data and more inclusion makes the results and stories included in this report important lessons for global environmental management.

RESULTS & CONCLUSIONS

Switzerland has again landed in the top spot of the 2014 EPI. The remainder of the top five are, in order, Luxembourg Australia, Singapore, and the Czech Republic. Singapore's presence in the fourth spot is particularly notable, demonstrating that predominantly urban nations can capitalize on population density to achieve strong environmental performance. Every country in the top five is not only performing well on the 2014 EPI, but time series data also show that these countries have improved their environmental performance over the past decade. Among countries with the largest economies, Germany ranks the highest in the sixth spot followed by the United Kingdom in 12th, Canada in 24th, Japan in 26th, France in 27th, and the United States in 33rd. The fastest growing economies show diversity in their performance although they tend to fare worse than more established economies. Russia ranks 73rd, Brazil 77th, China 118th, and India 155th.

The poorest performers in the 2014 EPI are those with significant political or economic strife, suggesting again that other pressing issues can sideline effective environmental policy. Somalia is in last place (178th) with other turbulent countries from around the globe in the bottom ten, including Haiti at 176th, Afghanistan at 174th, and Bangladesh at 169th.

In addition to the headline rankings, the 2014 EPI includes a pilot effort to generate a global environment scorecard. A close look at both the pilot global scorecard and the country ranking highlights reveals a number of lessons:

Dramatic progress is possible when measurement and management practices align, but when measurement is poor or out of alignment with management, natural and human systems suffer. Since 1990 more than two billion people have gained access to improved drinking water and proper sanitation, exceeding Millennium Development Goal (MDG) targets and improving global well-being. There has been similar success in the protection of natural habitats. Well-organized data systems and clearly established targets have led to widespread increase in protected areas. What these results demonstrate is that targeted, data-driven investments do deliver progress.

On the other hand, the EPI documents that weak measurement systems give rise to poor outcomes. For instance, marine fisheries are badly monitored, many fleets deliberately misreport or fail to report catch data, and international policy targets are ad hoc and incomplete. It is no surprise that fish stocks around the world are in stark decline. Air quality measurement capabilities are also weak and poorly coordinated with management despite all the media attention it gets. International policy targets are largely absent, and the world has observed policy stagnation and alarming air pollution crises in a growing number of cities.

Countries of varying economic development have divergent climate emissions trajectories; these warrant different policy priorities. Wealthy countries produce the highest levels of climate emissions, but have for the most part been successful in reducing the carbon intensity of economic growth over the last decade. Emerging economies, such as Brazil, India, and China, are growing quickly and see the steepest increase in emissions over the last decade. For the poorest countries, such as Nepal, emissions are comparatively low. The EPI demonstrates a range in countries' abilities to meet these targets that are not necessarily tied to wealth, as other indicators are, such as those in the Environmental Health objective.

In addition to these issue-specific lessons, there are also some important cross-cutting conclusions:

Cities offer opportunities and challenges when it comes to environmental sustainability. Some elements of sustainability, such as wastewater treatment, benefit from denser urban populations. Others, including air pollution, are harder to address under crowded conditions. Singapore, for example, is a highly dense, urbanized nation that ranks in the top five of the 2014 EPI. The city-state's high performance on Wastewater Treatment, Access to Drinking Water, and Improved Sanitation speaks to the potential of urban infrastructure to secure some elements of environmental health.

For some priority indicators, measurement capabilities remain distressingly weak. The sustainability of agricultural practices and freshwater resource management, for example, have virtually no reliable metrics by which to identify priority needs, set policy targets, or evaluate national performance. Other key areas lacking adequate measurement include exposure to toxic chemicals, solid waste management, recycling, and wetlands protection. Issue areas that are fundamentally ecological and systems-oriented tend to be measured least effectively. Failing to manage such systems poses increasing risks, and the need to step up to the measurement challenge is dire.

To meet the growing demand for environmental performance indicators, the world will need to build on existing strengths and invest in innovative approaches. The EPI team remains committed to working with interested partners, as it already has with Air Quality and Water Resources, to develop new measurements and indicator systems. Such innovation will require tighter partnership between governments, corporations, scientists, and civil society. The EPI documents the tangible benefits that arise where such efforts are pursued and the shameful damage that manifests where they are not.

Overall, there is always room for improvement. One major international effort to drive that improvement is the United Nations' (UN) establishment of the Sustainable Development Goals (SDGs), which will set targets for global environmental, economic, and social sustainability that are universal, easily communicated, and quantifiable. The EPI results are released at a time when they can inform the SDG development process, the success of which will be dependent upon better data, clear targets, and strong monitoring. As the international community pursues the SDGs, the EPI indicators are benchmarks by which the world can measure progress toward sustainable development.

Global Scorecard

The world lags on some environmental issues, while demonstrating progress in others. A "global scorecard" provides first-time insight as to collective policy impacts on the major environmental issues of our time. Overall, improvements have been made in many of the categories of the Environmental Health objective, including Access to Drinking Water, Child Mortality, and Access to Sanitation. Declines and overall low scores are found in Air Quality, Fisheries, and Wastewater Treatment.

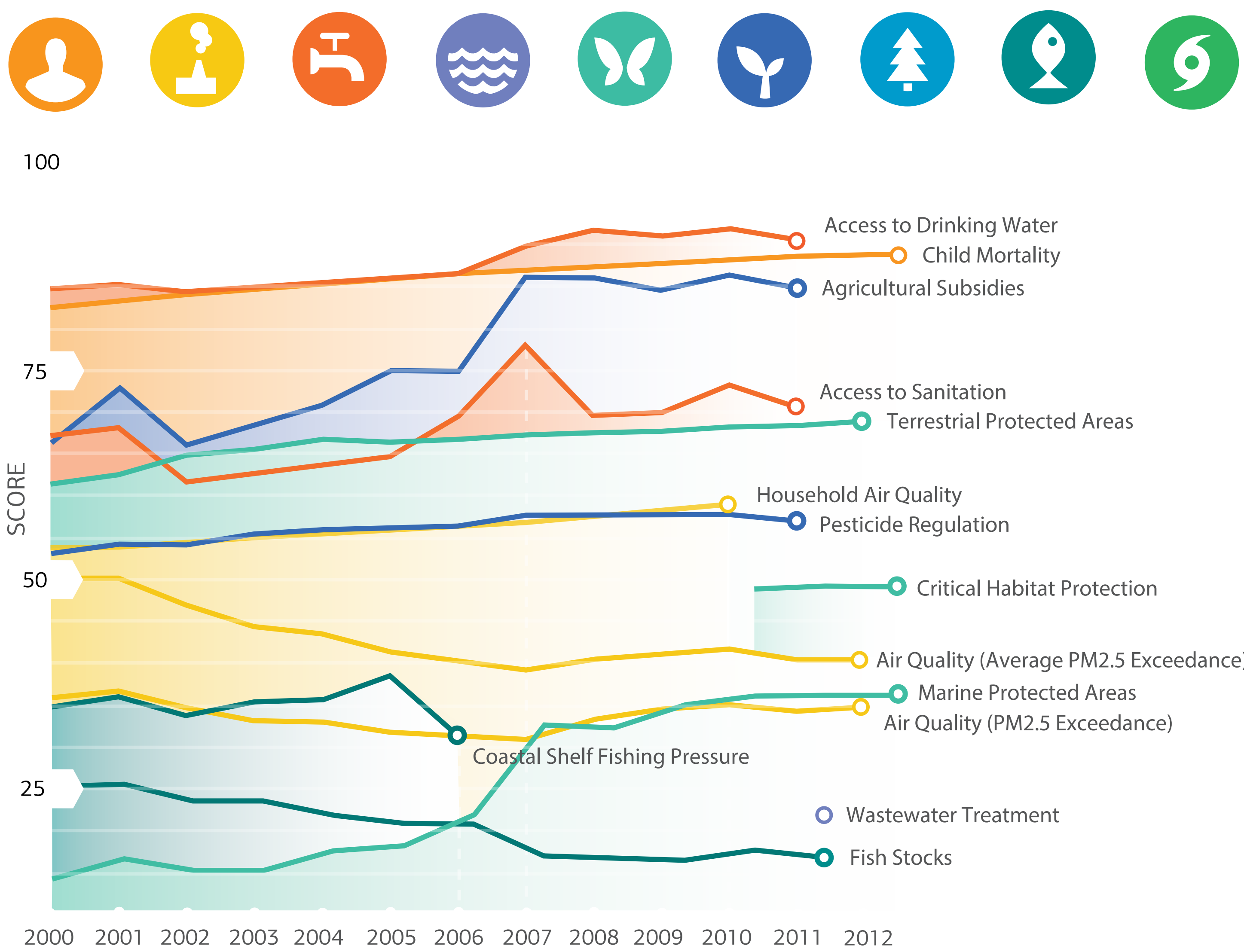

Figure 1. Global indicators for most of the policy issues assessed by the EPI. Note: Wastewater Treatment only has one data point and no available time series. Similarly, relevant global indicators were not possible for the Climate and Energy or Forest indicators, which already represent 10-year trends.

INDICATOR SPECIFIC HIGHLIGHTS

01. Dramatic progress is possible when measurement and management practices align. Since 1990 more than two billion people have gained access to improved drinking water and proper sanitation, exceeding MDG targets and improving global well-being. In Afghanistan alone, the percentage of households with access to clean drinking water went from 5 percent in 1991 to 61 percent in 2011. Ethiopia has also been able to connect more of its villages to safe drinking water through investments from the national government and international aid organizations. These great successes resulted from a well-organized measurement system that allowed policymakers to track their performance, identify priority needs, and create mechanisms to maintain accountability.

There has been similar success in the protection of natural habitats. Well-organized data systems and clearly established targets have led to widespread increases in protected areas, like Mount Cameroon National Park in Cameroon. Cameroon's government established the park in 2009 because data showed the area is home to some of the most threatened mammal species in the world. Likewise, Peru is one of the few countries to carefully analyze its territory to identify areas where critically threatened or endangered species exist and to specifically protect these areas. These results demonstrate that targeted, data-driven investments do deliver progress.

02. When measurement is poor or not aligned with proper management, natural and human systems suffer. The EPI documents that weak measurement systems give rise to poor outcomes. For instance, marine fisheries are badly monitored, many fleets deliberately misreport or fail to report catch data, and international policy targets are ad hoc and incomplete. It is no surprise that fish stocks around the world are in stark decline.

Despite all the media attention it gets, air quality measurement capabilities are weak and poorly coordinated with management. International policy targets are largely absent, and the world has observed policy stagnation and alarming air pollution crises in a growing number of cities. With the expansion of industry, fossil fuel-based transportation sectors, and increasing urbanization in the developing world, the number of people breathing unsafe air has risen by 606 million since 2000, now totaling 1.78 billion. On the other hand, the number of people lacking access to clean drinking water has decreased from 1.04 billion in 2000 to 759 million in 2011.

Perhaps unsurprisingly, given high urbanization, industrialization, and population growth, populations in China and India have the highest average exposure to fine particulate matter ($PM_{2.5}$) in the world.

03. Countries of varying economic development have divergent climate emissions trajectories; these warrant different policy priorities. Wealthy countries produce the highest levels of climate emissions, but have, for the most part, been successful in reducing the carbon intensity of economic growth over the last decade. Denmark, for example, has made strong policy commitments to reduce emissions through increasing efficiency and renewable energy. Middle-income countries, such as Brazil, India, and China, are still growing economically

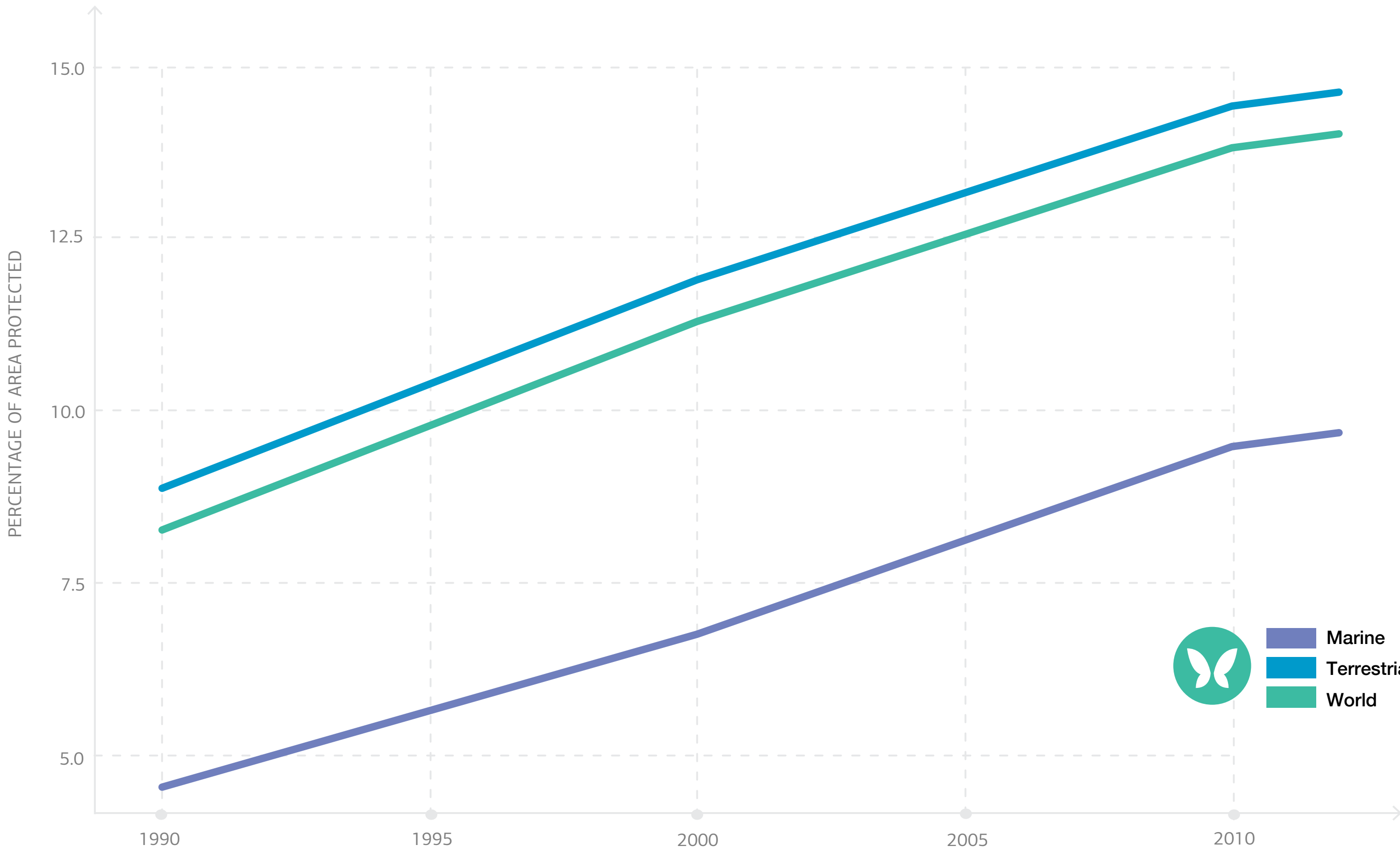

Figure 2. Time series of percentage of marine and terrestrial protected areas and the percentage of protected areas throughout the world. (Source: IUCN and UNEP-WCMC, 2012.)

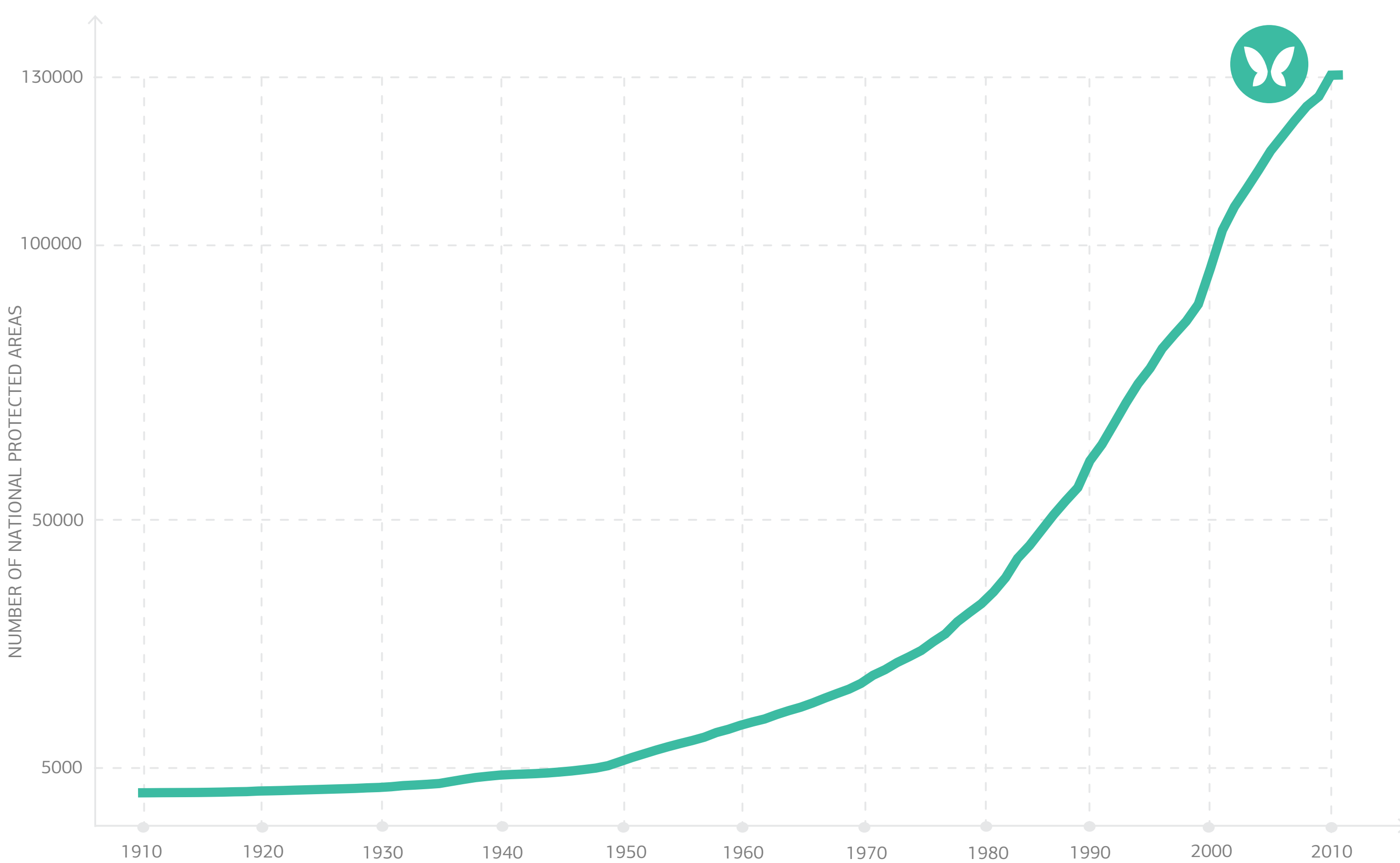

Figure 3. Trend in number of national protected areas from 1910 to 2011. (Source: IUCN and UNEP-WCMC, 2012)

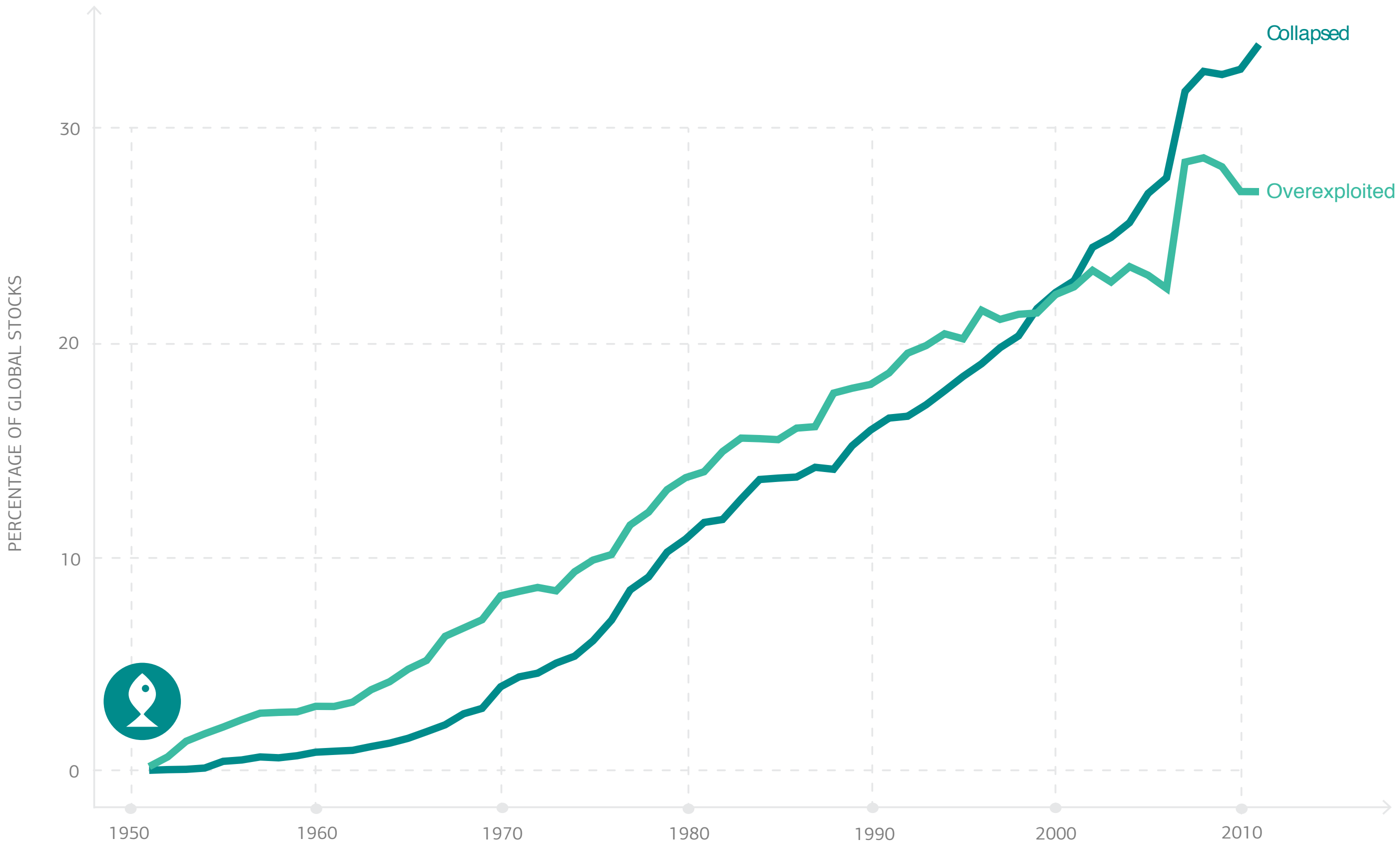

Figure 4. Percentage of global fish stocks that are overexploited or collapsed. (Data source: Kristin Kleisner, Sea Around Us Project.)

INDICATOR SPECIFIC HIGHLIGHTS

and see the steepest increase in emissions over the last decade. The 2014 EPI gauges their performance on their ability to reduce the rate at which carbon intensity increases. For the poorest countries, such as Nepal, emissions are comparatively low, therefore rendering climate mitigation less of a policy priority. The EPI demonstrates a range in countries' abilities to meet these targets that are not necessarily tied to wealth, as other indicators are, such as those in the Environmental Health category.

04. Data from novel sources and cutting-edge technologies help improve the accuracy and importance of the 2014 EPI. A much wider array of tools for filling key measurement gaps is available now, compared to the 1980s and 1990s when environmental indicators first entered the international spotlight. New technologies such as remote sensing and institutions in the form of third-party organizations have emerged, and the EPI makes use of these cutting-edge innovations. Fisheries measures, for example, do not come from traditional sources such as international organizations that aggregate national reports. Instead, fisheries data come from an independent academic watchdog group, the Sea Around Us Project, which uses diverse information streams to generate much more complete and accurate portrayals of fleet behavior than any single source. Air quality and forestry measures make use of satellite data to generate metrics that are far more comparable and comprehensive than what emerged from previous modeling efforts and national reports.

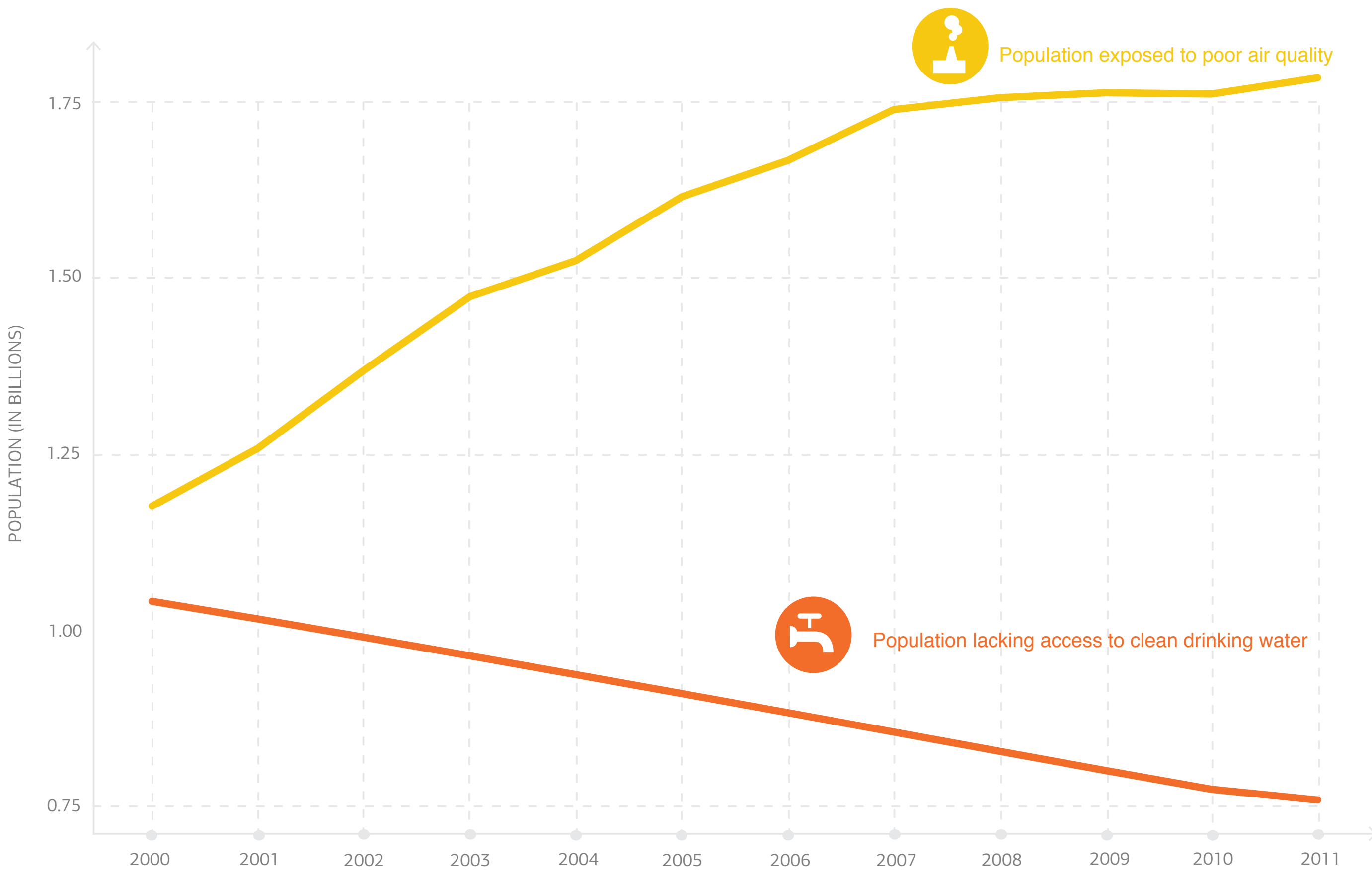

Figure 5. Comparison of trends in number of people lacking access to clean air ("bad air") and lacking access to improved water ("bad water"). Bad air is defined as 25 micrograms per cubic meter, more than twice the WHO standard for clean air of 10 micrograms per cubic meter. Source: 2014 EPI.

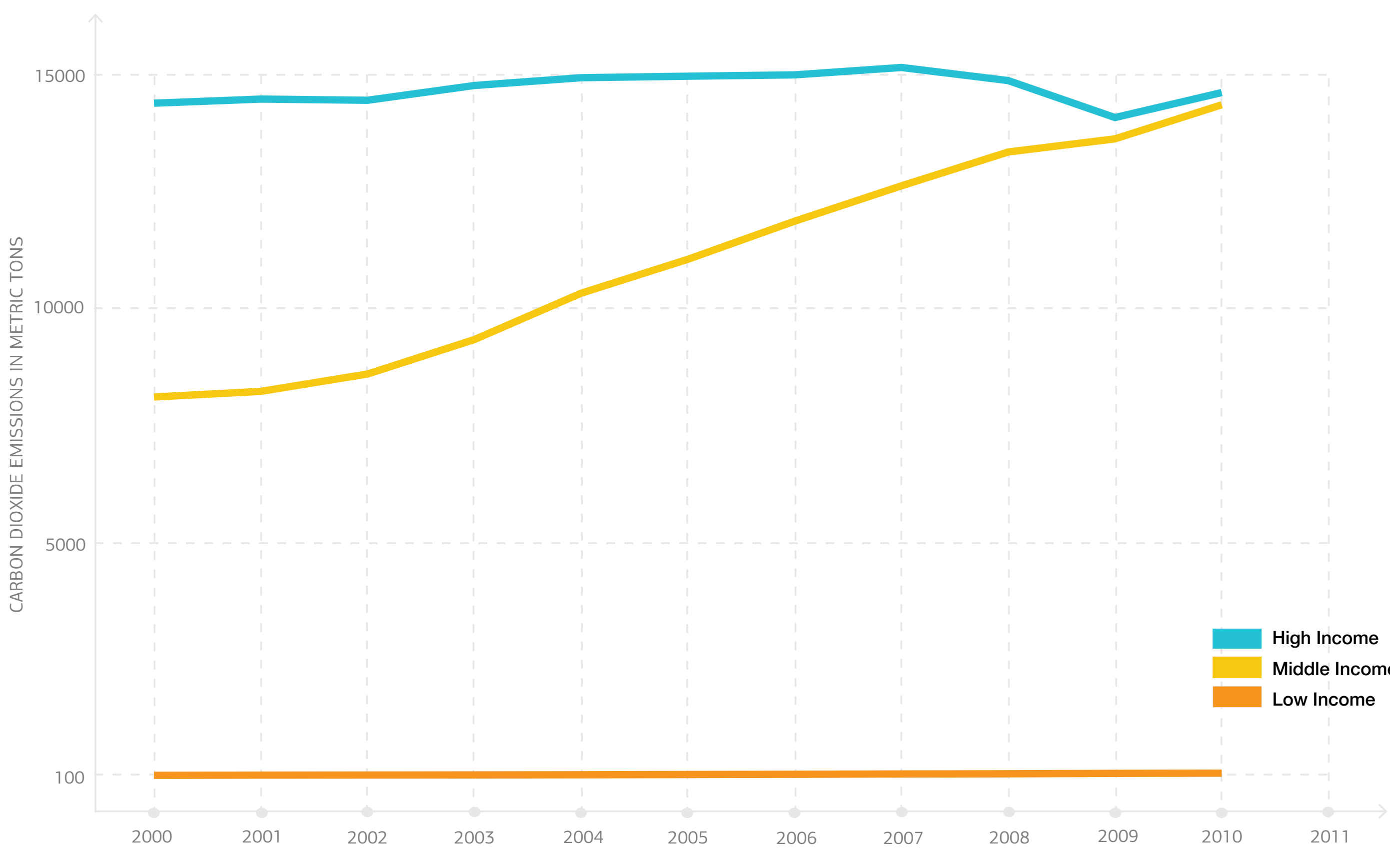

Figure 6. Carbon dioxide emissions organized by income groups. High = Gross National Income (GNI) per capita of US$12,616 or greater; Middle income = GNI per capita between US$1,086 and US$12,615; Low income = GNI per capita of US$1,085 or less. (Source: International Energy Agency, 2013.)

OTHER CONCLUSIONS

01. The EPI contributes to the post-2015 development agenda. The 2014 EPI results are released at an opportune time to inform the UN SDGs. Guided by discussions with water experts contributing to the development of the SDGs, the 2014 EPI introduces a new indicator on wastewater treatment. This indicator shows that, overall, countries are performing poorly with respect to wastewater treatment, which is a major driver of ecosystem water quality.

02. Cities offer opportunities and challenges when it comes to environmental sustainability. Some elements of sustainability, such as wastewater treatment, benefit from denser urban populations. Others, including air pollution, are harder to address under crowded conditions. Singapore, for example, is a highly dense, urbanized nation that ranks in the top 10 of the 2014 EPI. The city-state's high performance on Wastewater Treatment, Access to Drinking Water, and Improved Sanitation speaks to the potential of urban infrastructure to secure some elements of environmental health. In fact, Singapore's wastewater treatment system actually enables it to recycle a high proportion of its water resources.

03. For some priority indicators, measurement capabilities remain distressingly weak. The sustainability of agricultural practices and freshwater resource management, for example, have virtually no reliable metrics by which to identify priority needs, set policy targets, or evaluate national performance. Other key areas lacking adequate measurement include exposure to toxic chemicals, solid waste management, recycling, and wetlands protection. Issue areas that are fundamentally ecological and systems-oriented tend to be measured least effectively. Failing to manage such systems poses increasing risks, and the need to step up to the measurement challenge is dire.

04. The world needs better measurement and indicator systems. To meet the growing demand for environmental performance indicators, the world will need to build on existing strengths and invest in innovative approaches. Such innovation will require tighter partnership between governments, corporations, scientists, and civil society. The EPI documents the tangible benefits that arise where such efforts are pursued and the shameful damage that manifests where they are not.

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Introduction

OUR METHOD

Since the landmark Rio Earth Summit launched the sustainable development movement in 1992, the international community has focused significant attention on critical environmental issues, having seen real progress on some issues, but failure on others. Two decades later, the world is poised to scale up efforts to protect the global environment by identifying a set of Sustainable Development Goals (SDGs). This opportunity comes at a time when there is an unprecedented level of evidence demonstrating that when management and measurement goals align, the international community can achieve progress on environment and human health objectives. Conversely, when they misalign—as is too often the case—progress is stalled and environmental conditions decline.

The Environmental Performance Index (EPI) — a global ranking of countries' environmental results — is a key contributor to the world's increasing ability to assess global environmental movement toward its environmental policy goals.

The 2014 EPI, introduced in this report and in further in detail at www.epi.yale.edu, highlights the value of using robust indicators to track environmental performance at national and global levels.

What is the EPI?

The EPI ranks how well countries perform on high-priority environmental issues in two broad policy areas: protection of human health from environmental harm and protection of ecosystems. Within these two policy objectives the EPI scores country performance in nine issue areas comprised of 20 indicators (see Methods). Indicators in the EPI measure how close countries are to meeting internationally established targets or, in the absence of agreed-upon targets, how they compare relative to the best performing countries.

The EPI gives decisionmakers access to important environmental data organized in a way that is easy to understand and relevant to policy, intending to drive productive competition. It allows countries to compare their performance to neighbors and peers, and, through the analysis of time series data, see how their own performance has changed over time.

Demand for robust, authoritative indicators of environmental performance is at an all-time high. This demand is driven by:

- a widespread recognition of the benefits of data-driven decisionmaking;
- ongoing pressure on governments to invest limited resources as wisely as possible;
- growing concern over the dangers posed by poorly managed environmental risks;
- widespread commitment to making sustainability a central operating principle of the post-2015 international development agenda; and
- rapid diffusion of sustainability strategies in the corporate sector.

NEW DEVELOPMENTS

The 2014 EPI introduces a number of innovations and improvements. One of the key improvements is that the 2014 EPI scores and ranks 178 countries – more than any previous EPI. Newly included countries come, in large part, from Small Island Developing States (SIDS) and sub-Saharan Africa.

Scoring and ranking a broader and more diverse set of countries is particularly important in 2014, as the global community prepares the post-2015 international development agenda.

The 1992 Rio Earth Summit launched this agenda by setting the Millennium Development Goals (MDGs), a roadmap for meeting the world's development needs. The MDGs emphasized the importance of eight development expectations, ranging from the promotion of gender equality and eradication of extreme poverty to ensuring environmental sustainability. At the Rio+20 Summit, which marked the twentieth anniversary of the Rio Earth Summit, the international community agreed that the MDGs would be replaced by Sustainable Development Goals (SDGs), introducing a critical improvement over the MDGs. Unlike the MDGs, the SDGs will include specific, time-bound indicators with clear, universal targets. The 2014 EPI results come forward at an opportune time to inform development of the SDGs (see Box: The EPI and the Sustainable Development Goals).

The 2014 EPI introduces a new indicator on wastewater treatment, guided in large part by discussions with water experts who contributed to the development of the SDGs (see Issue Profile: Water Resources). This new indicator provides, for the first time, a picture of nation-by-nation performance with respect to wastewater treatment. Until now, global understanding of this major driver of ecosystem water quality was poor. As one of the first quantitative indicators to inform the SDG development process, this component of the 2014 EPI can be a template for further success.

The 2014 EPI also informs the global sustainability dialogue by introducing a new strategy for climate change indicators. The climate indicators in the 2014 EPI are based on trends that reflect countries' progress toward achieving emissions reductions. However, targets for climate mitigation differ, depending on a given country's level of economic development and its anticipated development. The climate and energy indicators in the 2014 EPI are responsive to these differences and present a new look at how countries are performing on mitigation goals that are the most relevant for their development pathways. This improvement gives the 2014 EPI's Climate and Energy issue category even greater relevance for policymaking than those of past versions.

Satellite-derived data further contribute to a more accurate picture of environmental policy performance, driving new indicators for air quality and forests. The 2014 EPI makes use of technologies such as remote sensing, which can provide consistent "wall-to-wall" coverage of important environmental parameters, permitting estimates for changes in forest cover and exposure to air pollution. The 2014 EPI's air quality and forestry measures generate metrics that are far more comparable and comprehensive than what has previously emerged from modeling efforts and national reports.

Finally, the 2014 EPI provides a new perspective on historical environmental performance and the impact of national-level environmental policy. Using historical time series data and applying the 2014 EPI framework and methods to environmental data from years past, the 2014 EPI presents "backcasted" EPI scores and ranks for all relevant issues and indicators. In the past, the EPI report has stressed that the methodology does not permit countries to view a change in their rankings as a sign of improvement or decline. For the first time, the EPI provides the tools to compare current performance with historic performance.

WHY MEASUREMENT MATTERS

The EPI was born out of a recognition that environmental policymaking lacked scientific, quantitative rigor. While MDG 7 – to ensure environmental sustainability – first placed the notion of sustainable development on the global policy agenda, that particular goal lacked relevant or dependable metrics.[1] To address this gap, the Yale Center for Environmental Law & Policy (YCELP) and the Center for International Earth Science Information Network (CIESIN) at Columbia University partnered with the World Economic Forum to develop indices assessing environmental sustainability (the Environmental Sustainability Index) and environmental performance (the EPI). Both were created with an eye toward shaping data-driven environmental policymaking.

The need for better data and metrics to to guide decisionmaking could not be more urgent. Effective environmental policy is burdened by two related hurdles, both of which are lowered by better measurement. First, environmental policy debates are subject to deep divisions over the best way forward. Second, substantial uncertainty surrounding the nature of environmental problems makes significant action and allocation of resources difficult to justify. Good environmental measurement can inject more objectivity in environmental policy debates, reducing disagreement on the scope of problems and focusing it instead on solutions.

Robust measurement also gives policymakers a foundation from which to promote environmental policy. When policymakers use data to reduce uncertainty, they can advance policy objectives with more than educated guesses or hunches. The trend of using data, and increasingly "big data," is becoming a common business and government practice. Large corporate entities collect consumer information to better target advertisement campaigns. Government leaders like former New York City Mayor Michael Bloomberg based management decisions on data as diverse as the number of heart attacks and noise complaints.[2]

The business sector has long understood that data can make the invisible visible, and it has used metrics to improve performance. A business collects data and will make changes depending on its sales figures, for example. Environmental indicators have likewise been proven as useful tools in helping policymakers more efficiently allocate scarce resources. As

[1] World Economic Forum (WEF) Global Leaders for Tomorrow Environment Task Force, Yale Center for Environmental Law and Policy (YCELP)/Yale University, and Center for International Earth Science Information Network (CIESIN)/ Columbia University, (2000) *2000 Pilot Environmental Sustainability Index (ESI)*. NASA Socioeconomic Data and Applications Center (SEDAC), Palisades, NY. Available: http:// sedac.ciesin.columbia.edu/data/set/esi-pilot-environmental-sustainability-index-2000. Last accessed: December 29, 2013.

[2] Feuer, A. (2013) *The Mayor's Geek Squad*. The New York Times. 23 March 2013. Available: http://www.nytimes.com/2013/03/24/nyregion/mayor-bloombergs-geek-squad.html. Last accessed: December 29, 2013.

the time-tested mantra goes, "You can't manage what you don't measure."

Measurement matters because it provides an essential tool to policymakers. It also matters because measurement highlights gaps in collective knowledge. Data on environmental problems are severely lacking across the globe. At the local, national, and international levels, decisionmakers need better data. Indices like the EPI help direct attention to vital data gaps, which can help generate better data for the future.

WHY RANK?

Rankings, which are both loved and loathed, create interest and provoke action. They are a vehicle to motivate policy change, and, at the very least, they can spark a conversation about the meaning behind a ranking. How a number is derived, its strengths, and its limitations open debate about what we should value and why. Ultimately, however, rankings and their sensitivity to minute methodological changes have inherent subjective characteristics. Placing countries that face disparate economic and environmental challenges in rank order may not be entirely revealing, but users of the EPI can pare the index down to smaller peer groups that allow for more relevant comparisons.

The primary value of the EPI is its potential to recommend avenues for change. The rankings in and of themselves are not as valuable as the metrics and data that underpin them. A single, national aggregate number may be attention-grabbing, but it is the subsequent inquiry and substantive conversation that are more useful. The transparency with which the EPI is constructed and the open nature of the underlying data make the EPI a starting point for countries to take further action. Ideally, these actions would involve:

- the development of better measurement and monitoring systems to improve environmental data collection;
- the creation of policies to address particularly weak areas;
- the communication and reporting of national-level data and statistics to international agencies such as the United Nations; and
- the delineation of sub-national metrics and targets for improved environmental performance.

ORGANIZATION OF THIS REPORT

The aim of this report is to provide context and narrative by which to understand the environmental challenges faced by all countries, regardless of their level of economic development, geography, land area, or population. It is meant to serve as a foundation upon which to make sense of the complexities and nuances of environmental data and results presented by the complex composite index that is the EPI.

While the report includes enough detail to provide a working knowledge of what the EPI is, its methods, and how it is measured, it is by no means comprehensive. Instead, specific information about the EPI's data, indicator calculation, and statistical methods is included in separate materials both on the 2014 EPI website and forthcoming in academic literature. By separating the technical from the illustrative, this report aims to provide a deep, qualitative look into the critical environmental issues that the EPI examines.

THE EPI AND THE SUSTAINABLE DEVELOPMENT GOALS

It is an auspicious time for environmental metrics. The 2014 EPI is being released while discussions are underway on the Sustainable Development Goals (SDGs) – a global effort to spur sustainable development. The SDGs must be "aspirational, universal, communicable, and measurable," and they must set countries on a path to meet global targets between 2015 and 2030.[1] The SDGs will also help balance environmental objectives with poverty reduction.[2] To that end, the Open Working Group of the United Nations General Assembly is discussing specific environmental themes in early 2014, including forests, oceans, biodiversity, climate change, transport, waste, and chemicals. Once the Open Working Group consolidates the proposals, the entire United Nations General Assembly will vote on the SDGs.

The EPI presents a set of indicators that already fit well with these thematic areas. It addresses policy issues for Forests, Climate and Energy, and Biodiversity and Habitat. Notably, the Water Resources category anticipates a future thematic area of water by assessing the world's state of wastewater management – a likely candidate for an SDG.

Water policy discussions in the past decade have gone beyond basic measures of access to water, broadening the scope to include water quality, management, and the issue of water in human rights. This is important for management globally, but will, especially in places where water resources, become more and more scarce under shifting hydrological systems and in areas with rapid population or urban growth.

The post-2015 international development agenda could include specific targets for wastewater and water quality as part of a proposed SDG on water.[3] One proposed set of water targets could include such items as: ensuring urban populations achieve a target amount of wastewater treatment, aiming to increase water reuse rates, and attempting to ensure a target number of water bodies are in compliance with water quality standards.[4] Each of these targets would require specific indicators.

It will be up to policymakers to link the aspirational targets they set in the SDG process to the concrete indicators they choose.[5] Once the link is made, implementation will encourage higher levels of performance and likely result in better data for future monitoring, similar to the impact the MDGs had in incentivizing the collection of data related to Child Mortality, Access to Drinking Water, and Access to Improved Sanitation.

[1] United Nations Department of Economic and Social Affairs, Division for Sustainable Development. *Sustainable development goals*. Available: http://sustainabledevelopment.un.org/index.php?menu=1300. Last accessed: January 13, 2014.

[2] Sachs, J. D. (2012) From millennium development goals to sustainable development goals. *The Lancet* 379:2206-2211.

[3] United Nations Department of Economic and Social Affairs, Division for Sustainable Development. A/RES/66/288 – *Water and sanitation*. Available: http://sustainabledevelopment.un.org/index.php?page=view&type=2002&nr=18&menu=35. Last accessed: January 13, 2014.

[4] UN-Water, side-event to the Open Working Group (9 December 2013).

[5] Joint UNECE/OECD/Eurostat Task Force (2013) *Framework and suggested indicators to measure sustainable development*. Available: http://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/2013/SD_framework_and_indicators_final.pdf. Last accessed: January 13, 2014.

The Methods

The Environmental Performance Index (EPI) is constructed through the calculation and aggregation of 20 indicators reflecting national-level environmental data. These indicators are combined into nine issue categories, each of which fit under one of two overarching objectives. This section provides an overview of how the EPI is calculated. Complete methodological details and indicator-level metadata are available at www.epi.yale.edu.

Figure 7. The 2014 EPI Framework includes 9 issues and 20 indicators. Access to Electricity is not included in the figure because it is not used to calculate country scores.

What Does the EPI Measure?

The two objectives that provide the overarching structure of the 2014 EPI are Environmental Health and Ecosystem Vitality. Environmental Health measures the protection of human health from environmental harm. Ecosystem Vitality measures ecosystem protection and resource management. These two objectives are further divided into nine issue categories that span high-priority environmental policy issues, including air quality, forests, fisheries, and climate and energy, among others. The issue categories are extensive but not comprehensive (see Box: Data Gaps and Deficiencies). Underlying the nine issue categories are 20 indicators calculated from country-level data and statistics. Figure 7 illustrates the 2014 EPI framework and the objectives, issue categories, and indicators.

CALCULATING THE EPI

Calculating the EPI begins with transforming raw datasets to make comparable performance indicators. Doing so requires standardizing raw values according to population, land area, gross domestic product, or other denominators, which makes data comparable across countries. Then, statistical transformations are performed on some data to better differentiate performance among countries, particularly if the distribution of an underlying dataset is skewed toward one end of a range that makes separation challenging among countries. To aggregate these indicators into a single, composite performance score, they are assigned numerical weightings. For more details of the exact transformations applied to each indicator, see www.epi.yale.edu.

The transformed data are then used to calculate performance indicators. EPI indicators use a "proximity-to-target" methodology, which assesses how close a particular country is to an identified policy target. That target, a high performance benchmark, is defined primarily by international or national policy goals or established scientific thresholds. For example, the benchmarks for protected areas are determined through international policy targets established by the Convention on Biological Diversity (CBD). With 168 signatory countries and 193 Parties to the Convention, those benchmarks are widely accepted.

A high-performance benchmark can also be determined through an analysis of the best-performing countries. Some of our indicators set high performance, for example, at the 95th percentile of the range of data. In other cases, the target is defined by established scientific consensus, as is the case with the World Health Organization's (WHO) recommended average exposure to fine particulate matter ($PM_{2.5}$). Scores are then converted to a scale of 0 to 100 by simple arithmetic calculation, with 0 being the farthest from the target and 100 being closest to the target (Figure 8). In this way, scores convey similar meaning across indicators, policy issues, and the overall EPI.

Each indicator is weighted within each issue category to create a single issue category score. These weightings are generally set according to the quality of the underlying dataset, as well as the relevance or fit of the indicator to assess the policy issue. If the underlying global data for a particular indicator is less reliable or relevant than others in the issue category, it will be weighted less heavily.

For example, the trends in carbon intensity indicators in the Climate and Energy category (Trend in Carbon Intensity and Change of Trend in Carbon Intensity) are weighted according to which indicator is more pertinent based on a country's economic development and policy obligations with respect to climate change mitigation.

Policy issues are typically weighted roughly equal within their objective (i.e., Environmental Health or Ecosystem Vitality). However, contingent upon the strength of data in each category, slight adjustments to this weighting can be made. An important example in the 2014 EPI is in the Ecosystem Vitality objective. Because both of the indicators in the Agriculture category are indirect measures of environmental performance (e.g., subsidies do not directly assess the environmental impacts of intensive agriculture practices), this category only comprises five percent of a country's score in the Ecosystem Vitality objective, as compared to 25 percent for the Climate and Energy category.

Finally, the two objectives, Environmental Health and Ecosystem Vitality, are weighted roughly equal to achieve a single value, the EPI score, for each country.

For a more detailed explanation of the methods used for the 2014 EPI, see www.epi.yale.edu and Measuring Progress: A Practical Guide from the Developers of the EPI.[3]

[3] Hsu, A., Johnson L., and Lloyd, A. (2013) Measuring Progress: A Practical Guide from the Developers of the Environmental Performance Index (EPI). Yale Center for Environmental Law and Policy: New Haven, CT. Available: http://epi.yale.edu. Last accessed: December 29, 2013.

DATA GAPS & DEFICIENCIES

After more than 15 years of work on environmental performance measurement and six iterations of the EPI, global data are still lacking on a number of key environmental issues. These include:

- Freshwater quality
- Toxic chemical exposures
- Municipal solid waste management
- Nuclear safety
- Wetlands loss
- Agricultural soil quality and degradation
- Recycling rates
- Adaptation, vulnerability, and resiliency to climate change
- Desertification

While data for many of these issues exist on the regional, sub-national and local scales, insufficient coverage for every country at a global scale precludes their consideration in the EPI.

A North Korean garden used for growing food. (Credit: Devrig Velly, EU/ECHO)

WHY IS NORTH KOREA MISSING FROM THE 2014 EPI?

When more than a dozen scientists from around the world were invited to North Korea in 2012, the country was well into the environmental tailspin that threatens its long-term welfare. The scientists saw the causes and legacies of North Korean environmental policy—or its absence—firsthand: poor farming techniques, stripped forests, little remaining wildlife, massive soil erosion, widespread hunger, and burning of biomass for heat and cooking fuel. That the scientists had been invited to come and consult with North Korean experts and decisionmakers seemed a hopeful first step.

However, the alarm the North Korean environment must have set off in that group of scientists was matched by their hosts' troubling reluctance to tackle anything of substance. North Korea denied any suggestion that it had a pollution problem. Trips to the countryside were little more than dressed up tours of model farms. Homages to the great leader dominated presentations, and the foreign scientists were prevented from any substantive one-on-one consultation with their North Korean colleagues.[1] This state of denial and insularity would be one thing if the country were self-sufficient. In fact, North Korea is not sufficient at all. Hunger is widespread: a sign of not just political dysfunction but also that environmental-based food production has stalled. A 2012 UN report estimated that two-thirds of North Koreans suffer the effects of malnutrition because of food shortages.[2]

The EPI occasionally excludes countries from the rankings due to missing or incomplete data. In many instances, these countries are too small or lack the resources to provide thorough data on the indicators the EPI measures. Problems of data availability and reliability are well-documented across numerous sectors in North Korea, including those that are vital to the keeping and reporting of data, like statistics and economics.[3,4] Because of the spurious, evasive nature of data reporting and monitoring in North Korea, the EPI team decided that it could not provide a credible measurement of environmental performance there.

If the truth of North Korea's environmental conditions and data were not even made available to scientists invited to the country to help, and even if North Korean scientists seem unwilling to accept the catastrophe they oversee, how can anyone trust national reporting?

Environmental degradation in North Korea has been documented by foreign journalists and visitors for decades.[5] Unfortunately, data adequate to assess the extent of this degradation are not available for the EPI to assess. As such, the world will remain in the dark as to the state of North Korea's environment.

[1] Foster, J. (2012) Q&A: *North Korea's choked environment*. New York Times. Available: http://green.blogs.nytimes.com/2012/03/30/q-and-a-north-koreas-choked-environment/. Last accessed: December 30, 2013.

[2] The United Nations. (2012) *Overview of needs and assistance: the Democratic People's Republic of North Korea*. Available: http://www.wfp.org/sites/default/files/DPRK%20Overview%20Of%20Needs%20And%20Assistance%20 2012.pdf. Last accessed: December 30, 2013.

[3] Bialik, C. (2013) *Statistical diplomacy in North Korea*. The Wall Street Journal. Available: http://blogs.wsj.com/numbersguy/statistical-diplomacy-in-north-korea-1205/. Last accessed: December 30, 2013.

[4] Melvin, C. (2014) *Economic statistics*. North Korean Economy Watch. Available: http://www.nkeconwatch.com/north-korea-statistical-sources/. Last accessed: January 2, 2014.

[5] McKenna, P. (2013) *Inside North Korea's environmental collapse*. Public Broadcasting Service (PBS). Available: http://www.pbs.org/wgbh/nova/next/nature/inside-north-koreas-environmental-collapse/. Last accessed: January 14, 2014.

CHALLENGES OF PRESENTING TREND DATA IN THE EPI

The EPI addresses two primary questions: How do countries perform today, and how have they improved or declined over time? The 2012 edition of the EPI piloted a new way of answering the latter question by introducing a Pilot Trend EPI, which both scored and ranked countries on their rate of improvement or decline over the previous decade. Using simple linear regressions based on a country's historic time series, a score from -50 (representing the worst decliner) to 50 (representing the best improver) was determined for each indicator, policy issue, and objective. The same balance of weightings and materiality considerations were then applied to each score to produce an aggregated "Trend Index" for each country.

The initial intent of the Pilot Trend EPI was to acknowledge countries that may not have performed well on the 2012 EPI but have made significant investments to improve performance over time. For example, Azerbaijan ranked 111th in the 2012 EPI, but had improved significantly since 2000, achieving a second-place ranking on the Trend EPI. The Pilot Trend EPI also revealed the worst decliners, including countries like Russia and Saudi Arabia, who had been experiencing worsening environmental performance over time. The intention was for countries to evaluate whether their policies were taking them in the right direction.

While the Pilot Trend EPI was a useful exercise, it had limited utility in communicating environmental performance information to key users. For example, many wondered why Switzerland could have two strikingly disparate scores and rankings between the 2012 EPI (No. 1) and Pilot Trend EPI (No. 89). Though it makes sense that top-performers would find it increasingly difficult to improve, it was challenging to convey these subtleties through the scores and rankings of the Pilot Trend EPI.

Recognizing the critical nature of trend information to countries, the EPI continues to include trend data. However, the 2014 EPI, uses a more straightforward approach. The 2014 EPI presents back-casted indicator scores that allow users to see exactly how they would have scored and ranked in past years. It also includes 10-year trend calculations that present average improvement over the past 10 years. Accompanying these are visuals of time series data, so countries can see how emission levels, protected areas, or fish stocks have fluctuated over time.

DATA SOURCES

The EPI uses data from multilateral organizations, government agencies, and academic collaborations. Data are either primary or secondary in nature. Primary data are comprised of information gathered directly by monitoring or technology, including satellite-derived estimates of forest cover and air quality. Secondary data include national-level statistics subject to the reporting and quality requirements established by data collection entities, such as the International Energy Agency (IEA). The EPI applies a set of selection criteria to determine which datasets are ultimately selected for inclusion (see Box: Selection Criteria for Data in the EPI). All sources of data are publicly available and include:

- official statistics measured and formally reported by governments to international organizations. These data may or may not be independently verified but are only included if formally reported to international organizations. The EPI does not include ad hoc data submitted by governments directly to the EPI team;
- spatial or satellite data;
- observations from monitoring stations; and
- modeled observations.

The 2014 EPI also includes an indicator based on a dataset compiled directly by Yale Center for Environmental Law & Policy (YCELP) researchers - measuring wastewater treatment and connection rates. This indicator was constructed through the collection and analysis of country statistics and reports (see Issue Profile: Water Resources). The resulting dataset was peer-reviewed by water quality experts. Full details of data sources for each indicator are available at www.epi.yale.edu.

MATERIALITY THRESHOLDS

One of the difficulties of assessing environmental performance is in accounting for differences in natural resource endowments, physical characteristics, and geography between countries. Prime examples include landlocked countries, for whom fisheries or marine sustainability are irrelevant, or desert countries with little to no forest cover. In such cases, fisheries and forests may be considered "immaterial" or insignificant for a particular country. Only if a country meets the criteria for an indicator being "material," or relevant, is the indicator included in the calculation of the country's score. For countries that do not meet the materiality threshold (e.g., a minimum area of land that is forested), the indicator or issue category is not included in the score calculation. For those countries, other indicators in the relevant category or categories

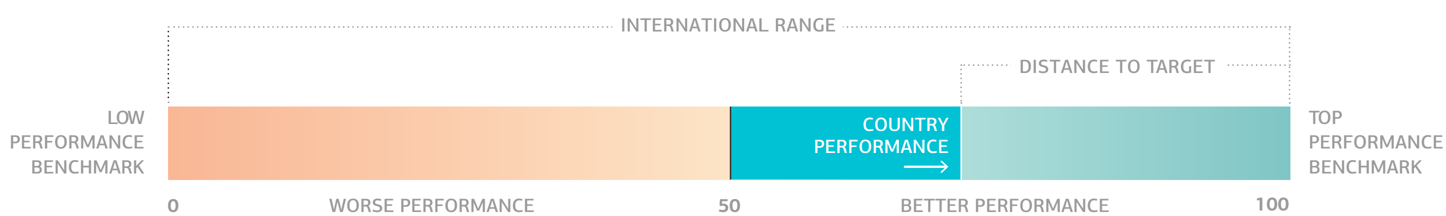

Figure 8. Diagram of proximity-to-target calculation for performance indicators.

receive proportionally greater weight. For example, least-developed countries (LDCs) do not receive a score for Climate and Energy (see Issue Profile: Climate and Energy), so the weightings for the remaining policy issues in the Ecosystem Vitality objective, including Agriculture, Water Resources, Biodiversity and Habitat, Forests, and Fisheries, are adjusted.

PENALTIES

The 2014 EPI penalizes a country when experts or statistical analysis deem nationally reported data inadequate for performance evaluation purposes. These penalties were only given in two issues: Fisheries and Agriculture (for the Persistent Organic Pollutants indicator—POPs).

For example, if a country reported inadequate fish stock data to the United Nations Food and Agriculture Organization (FAO), the country was given the lowest average score for the given year for both the Fish Stocks and Coastal Fishing Pressure indicators. For the POPs indicator, if a country has signed or ratified the Stockholm Convention but has not submitted any reports or information as to whether the POPs covered by the Convention are allowed, restricted, or banned, the country receives zero points for the indicator. This does not mean the country receives a total score of 0, however. A country that fails to report on POPs regulation could still receive up to three points for signing and ratifying the Stockholm Convention.

"Backcasted" Scores and Trends

The 2014 EPI website provides backcasted indicator scores wherever logical. The term "backcasted" refers to the application of the 2014 EPI framework, indicators, and aggregation method to historic data, starting from 2002. In this way, countries can see how

Indicator or Policy Issue	Not evaluated if...
Fisheries	Landlocked or ratio of coastline to land area less than 0.01.
Climate and Energy	Least-developed country, gross national income (GNI) per capita less than US$1,035.
Forests	Total forested area less than 200 sq. km.
Biodiversity and Habitat – Marine Protected Areas	Landlocked or ratio of coastline to land area less than 0.01.
Biodiversity and Habitat – Critical Habitat Protection	Country does not have a critical species site as designated by the Alliance for Zero Extinction.
Agriculture – Agricultural Subsidies	Agriculture comprises less than five percent of a country's total gross domestic product (GDP).
Agriculture – Persistent Organic Pollutants	Is not able to be a Party to the Stockholm Convention.

Table 1. The materiality rules apply when countries meet certain thresholds listed above.

WHAT HAPPENED TO THE AIR (ECOSYSTEM EFFECTS) INDICATOR CATEGORY?

The EPI is not static. Much of its value comes from its regular improvement, and sometimes this improvement comes from subtraction. For example, one important improvement in the 2014 EPI is elimination of the issue category, Air (Ecosystem Effects).

The Air (Ecosystem Effects) category was removed from the 2014 EPI because the data to assess ecosystem impacts of air pollution are experimental at best. Most of the indicators used in the past, including ozone and volatile organic compounds (VOCs), were based on global atmospheric models such as MOZART.[1] While these models give a higher-level picture of emissions, they are less relevant as performance measures to give decisionmakers a clear signal of how policies to tackle air pollution are working to mitigate ecosystem impacts. Moreover, air pollution impacts are more relevant to humans than ecosystems.

However, this is not to say that air pollution is not relevant for ecosystems. Acid rain leads to real environmental impacts, killing fish by acidifying lakes and changing soil properties, which harms forests.[2] The United States' Clean Air Act, for instance, provides air pollution control policies that target acid rain and sulfur dioxide pollution.[3] Nitrogen oxides are another air pollutant that can contribute to acid rain or end up in water bodies where they act as fertilizers for aquatic and marine plants, causing them to grow faster than normal and change the dynamics of the ecosystems. Ozone pollution has been shown to reduce crop yields and plant productivity.[4]

The two indicators in the Air (Ecosystem Effects) policy category for the 2012 EPI both measured sulfur dioxide emissions, which is a cause of acid rain.[5] Unfortunately, the best available measures of sulfur dioxide emissions are modeled, and not validated globally by on-the-ground data. Experts created the data by looking at sulfur dioxide globally and regionally, not nationally.[6] Fossil fuel combustion is a major source of sulfur dioxide emissions, so the experts estimated national sulfur dioxide emissions by looking at how much fossil fuel each country burns. While these estimates provide useful information as to trends over time and rough comparisons between countries, it is not good for making policy decisions because of the inherent uncertainties associated with modeled measures. Policymakers cannot tell if their policies work when the only information they have tells them more about global or regional, rather than national, trends.

The EPI convenes expert scientific opinion for each edition, and the experts agreed that the current sulfur dioxide data is not good enough to assess country-level performance. The EPI also has a team of policy experts who consider the value of each policy category and indicator. Considering the poor fit of the sulfur dioxide data, the policy experts revisited the importance of air pollution to ecosystems and concluded that most policymakers, advocates, and scientists are more concerned with air pollution's impact on human health (see Issue Profile: Air Quality) than ecosystems. To avoid misleading metrics and distracting policymakers from more critical issues, Air (Ecosystem Effects) is not a part of the 2014 EPI.

[1] Emmons, L. K., Walters, S., Hess P. G., et al. (2010) Description and evaluation of the model for ozone and related chemical tracers, version 4 (MOZART-4). *Geoscientific Model Development* 3:43-67.
[2] United States Environmental Protection Agency. (2013) *Environmental effects of acid rain*. Washington, D.C. Available: http://www.epa.gov/region1/eco/acidrain/enveffects.html. Last accessed: December 29, 2013.
[3] Hunter, D., Salzman, J. and Zaelke, D. (eds). (2007) *International Environmental Law and Policy*, 3rd edition. New York: Foundation Press.
[4] Lovett, G. M., Tear, T. H., Evers, D. C., et al. (2009) Effects of air pollution on ecosystems and biological diversity in the eastern United States. *Annals of the New York Academy of Sciences* 1162:99-135.
[5] United States Environmental Protection Agency. (2013) *Causes of acid rain*. Washington, D.C. Available: http://www.epa.gov/region1/eco/acidrain/causes.html. Last accessed: December 29, 2013.
[6] Smith, S. J., van Aardenne, J., Klimont, Z. et al. (2011) Anthropogenic sulfur dioxide emissions: 1850–2005. *Atmospheric Chemistry and Physics* 11:1101-1116.

SELECTION CRITERIA FOR DATA IN THE EPI

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 it 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.

their performance from year to year may have changed on each indicator and what their scores and ranks would have been in years past. However, not every indicator in the 2014 EPI lends itself to backcasted or trend calculations. The Change in Forest Cover indicator, for example, is already a measure of change, as it represents a calculation of net forest loss and gain from 2000 to 2012. Additionally, because the 2014 EPI presents all indicators in the Climate and Energy category as trends (see Issue Profile: Climate and Energy), backcasted scores or trend calculations were not relevant.

Wherever possible, the trend calculations for all other indicators are presented as roughly a 10-year percent difference in performance (e.g., five percent improvement or three percent decline), from 2002 levels to 2012, the latest year of data available for most indicators. Countries that demonstrate greater than a 100-percent improvement from 2002 scores are capped at 100 percent. These trends are presented on the EPI website and downloadable data spreadsheets.

GLOBAL SCORECARD

A "global scorecard" (see Key Findings) provides first-time insight as to the world's collective impact on the major environmental issues of our time. To sensibly aggregate the data for the purposes of a global calculation, most indicators represent weighted averages of country scores where the weights are determined by country population (e.g., a population-weighted average of Access to Sanitation) or area (e.g., a global average of fish stocks overexploited or collapsed weighted by area of the Exclusive Economic Zone—EEZ). Global indicators were not possible for the Climate and Energy or Forest indicators, which already represent 10-year trends. We also stress that these global indicators are useful as a way of assessing global impact rather than "performance," which is more relevant for the country indicators.

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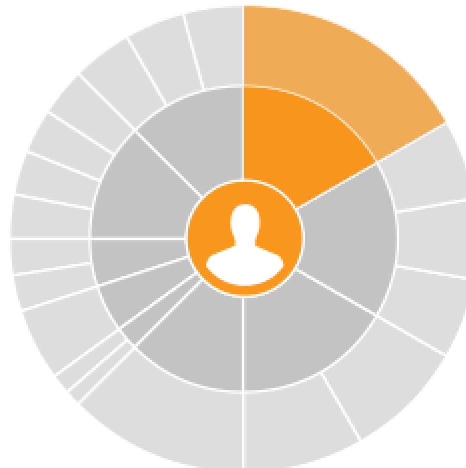
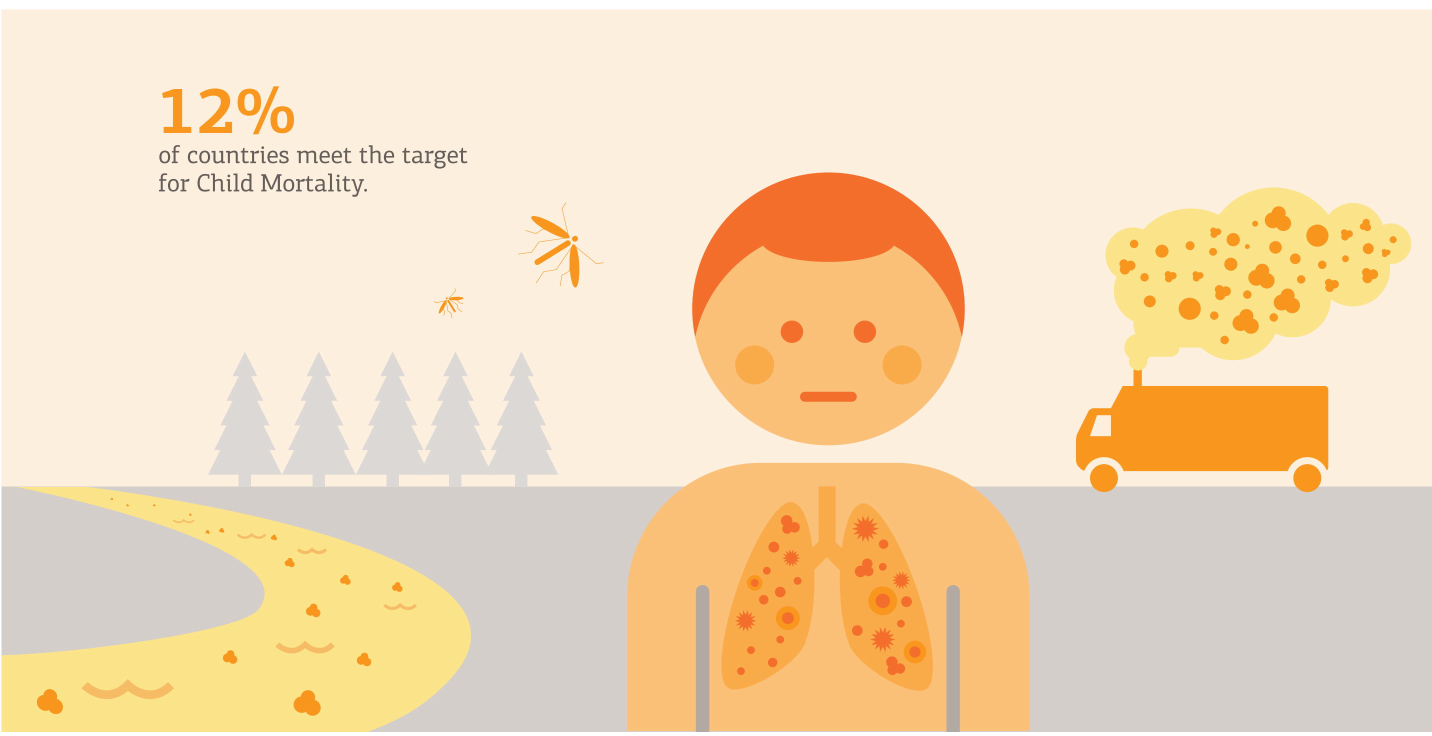
Health Impacts



What It Measures
The indicator Child Mortality measures the probability of a child dying between his/her first and fifth birthday.

Why We Include It
Environmental factors like polluted air and water are major causes of death for children between the ages of one and five. This indicator is a useful proxy for the effects of pollution and poor sanitation on human health. Reducing child mortality is the fourth Millennium Development Goal (MDG). Achieving it will require great improvements to environmental performance along with access to improved health care.

Where The Data Come From
United Nations, Department of Economic and Social Affairs, Population Division: World Population Prospects, the 2012 Revision.



DESCRIPTION

On the surface, the environmental implications of child mortality may seem indirect at best. The 75 countries that account for 95 percent of child mortality cases all have significant proportions of their population that rank among the world's poorest.[4] Malnutrition, poverty, disease, inadequate healthcare, and environmental factors all contribute to high child mortality.

Disentangling the precise contributions is difficult, yet research shows that diarrheal disease, lower respiratory tract infections, and other preventable diseases are highly linked to water and air pollution. The health and fate of a country's most vulnerable population is a good measure of the burden of environmental pressures on human beings.

In the policy arena, child mortality is narrowly defined as the death rate of children between the ages of one and five.

The narrowness has a purpose. Children between one and five live in a critical phase: beyond the shadow of neonatal complications, but still highly vulnerable to health risks that older children tend to overcome. Among these are environmentally borne illnesses, many of which are preventable.

That the two leading causes of child mortality have direct causal links to environmental conditions is a strong rationale for including child mortality in the EPI.[5] Pneumonia, which is the leading cause of child mortality worldwide, is exacerbated by household and outdoor air pollution, both of which are environmental impacts measured by the EPI.[6] Diarrhea is the second leading cause, and it is almost always triggered by poor sanitation and lack of access to clean drinking water. It also affects nutritional uptake in the body, thereby contributing to malnutrition. However once it is acquired—via any of a multitude of bacterial and viral agents—diarrhea is easily treated. Whether a country effectively treats its water, how that water is distributed, and access to sanitation and basic healthcare are revealed in figures on diarrhea-related deaths.

Malaria is the third leading cause of child mortality, and a strong case can be made that it too has environmental causes.[7] Among the integrated strategies for fighting malaria sponsored by major international health organizations, control of malaria's vector—Anopheles mosquitos—figures prominently.[8] Methods to control mosquito populations include reducing deforestation in vulnerable areas, modernized irrigation systems (that also reduce water consumption), and reductions in standing water.[9] In many cases, intervention at the environmental and biological levels has been shown to be as effective at reducing malaria rates as the use of insecticides. Also, research is beginning to show strong correlations between a warming climate and an increase in cases of vector-borne diseases like malaria.

The fourth MDG, to reduce child mortality by two-thirds of 1990 levels by 2015, is an ambitious one. Even so, great reductions have been seen worldwide, largely through intervention programs for diseases and increased sanitation.[10]

[4] World Health Organization and UNICEF. (2013) *Accountability for maternal, newborn, & child survival, the 2013 update*. Available: http://countdown2015mnch.org/documents/2013Report/Countdown_2013-Update_noprofiles.pdf. Last accessed: January 10, 2014.

[5] World Health Organization and UNICEF. (2013) *Ending Preventable Child Death from Pneumonia and Diarrhea by 2025: The integrated Global Action Plan for Pneumonia and Diarrhea (GAPPD)*. Available: http://apps.who.int/iris/bitstream/10665/79200/1/9789241505239_eng.pdf. Last accessed: January 10, 2014.

[6] Liu, L., Johnson, H. L., Cousens, S., et al. (2012) Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. The Lancet 379:2151-2161.

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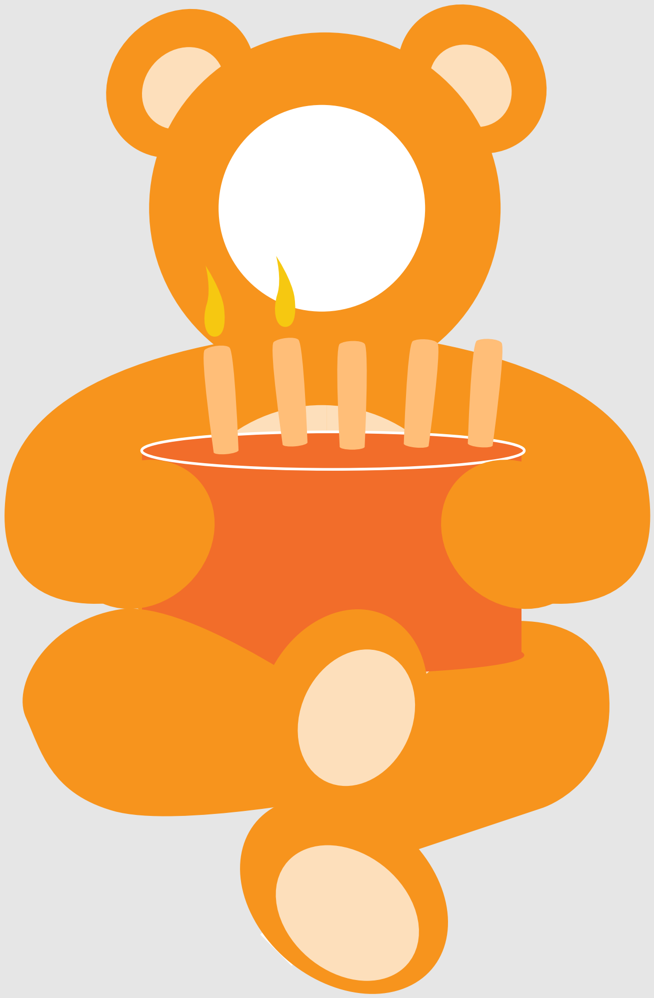
[9] Utzinger, J., Tozan, Y., and Singer, B.H. (2001) Efficacy and cost-effectiveness of environmental management for malaria control. *Tropical Medicine and International Health* 6:677–687.

[10] World Health Organization and UNICEF. (2013) *Accountability for maternal, newborn, & child survival, the 2013 update.* Available: http://countdown2015mnch.org/documents/2013Report/Countdown_2013-Update_noprofiles.pdf. Last accessed: January 7, 2014.

What is Child Mortality?

The Child Mortality indicator represents the probability of death between a child's first and fifth birthdays. In this period, causes of death are strongly influenced by environmental factors, including household air pollution and lack of access to clean drinking water.



Basic Needs

More than one billion children are severely deprived of at least one of the essential goods and services they require to survive, grow and develop. These include nutrition, water, sanitation facilities, access to basic healthcare services, adequate shelter, education and information.

Nutrition

Water

Sanitation Facilities

HealthCare Services

Adequate Shelter

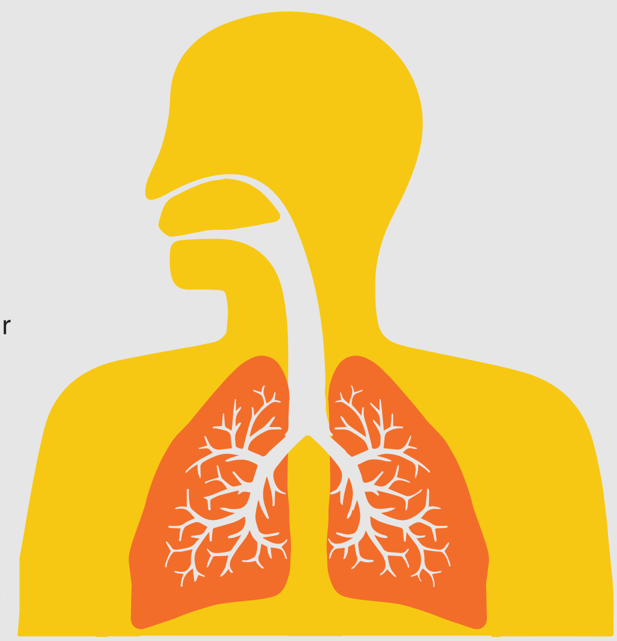
Education & Information

As a result, 6.6 million children under five die every year.

Leading Causes

1 PNEUMONIA

Pneumonia is the leading cause of child mortality worldwide. It is exacerbated by household and outdoor air pollution, both of which are environmental impacts measured by the



2 DIARRHEA

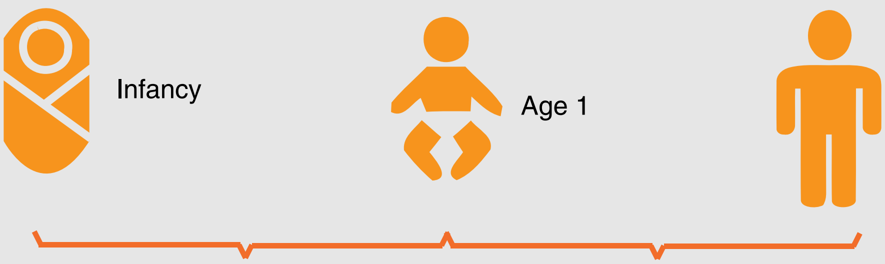
Diarrhea is the second leading cause, and it is almost always caused by poor sanitation and lack of access to clean drinking water. Whether a country effectively treats its water, how that water is distributed, and the level of access to healthcare or sanitary environmental conditions are reflected in diarrhea-related deaths.

3 MALARIA

Malaria is the third leading cause of child mortality. Strategies for fighting malaria by controlling mosquito exposure include reducing deforestation in vulnerable areas, modernized irrigation and agricultural strategies, and other land use considerations. In many cases, intervention at the environmental and biological levels has been shown to be as effective or even more effective at reducing rates of malaria than the use of insecticides.

How do we know?

Most deaths of children under the age of one are tied to maternal health and neonatal complications, but many more deaths of children between the ages of one and five are related to environmental factors.



Not used for EPI analysis

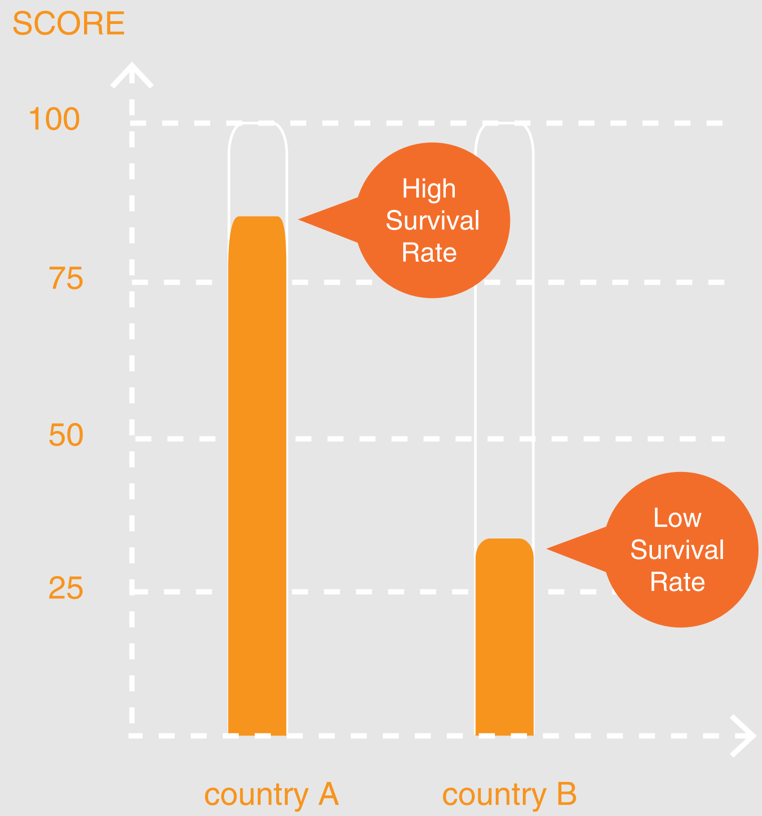
Deaths related to maternal health and neonatal complications

Used for EPI analysis

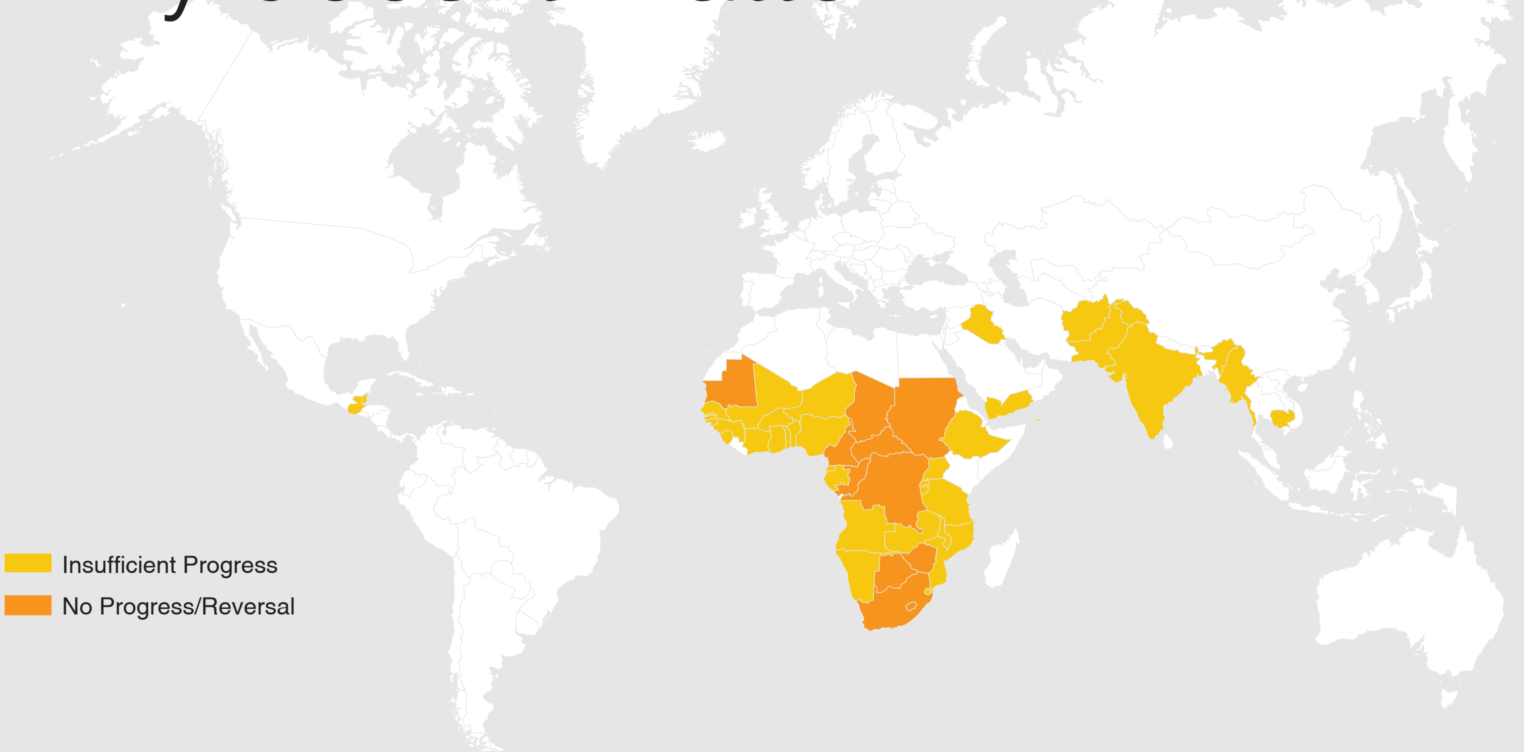
Deaths related to environmental factors

Probability Score

Child mortality data from the United Nations Population Division is divided by 1,000 to estimate the probability of a child dying between his or her 1st and 5th birthday. Based on this probability, a score is given to each country out of 100, with 100 being the best performing.

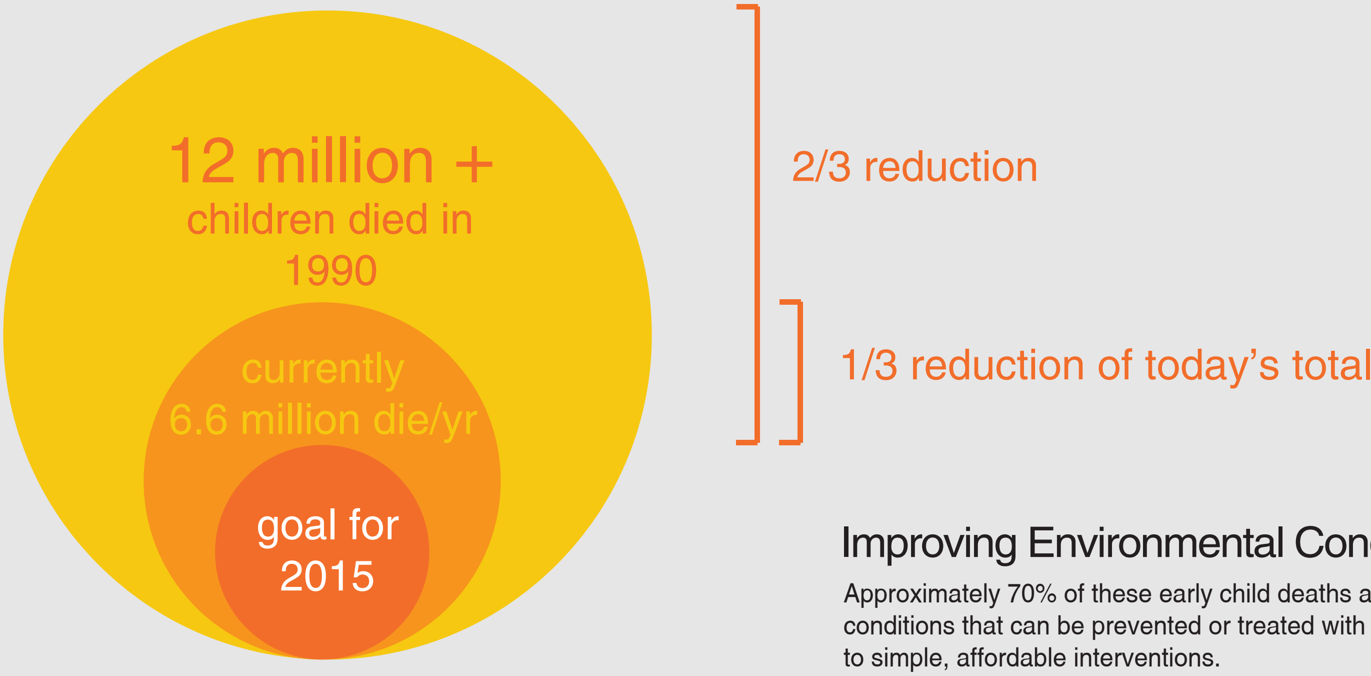


Why does it matter?



Millenium Development Goal (MDG) for Child Mortality

Reducing child mortality was declared the fourth Millennium Development Goal by the UN in 2000. The goal is to reduce the global rate of child mortality by two thirds before 2015, starting with the child morality rate in 1990. Achieving this goal requires great improvements to environmental performance.



Improving Environmental Conditions

Approximately 70% of these early child deaths are due to conditions that can be prevented or treated with access to simple, affordable interventions.

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- "Levels & Trends in Child Mortality: Report 2013," UN Inter-agency Group for Child Mortality Estimation, http://www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2013.pdf
- "MDG 4: reduce child mortality," World Health Organization (WHO), http://www.who.int/topics/millennium_development_goals/child_mortality/en/
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ALTERNATIVE MEASURES OF ENVIRONMENTAL HEALTH IMPACTS

Clean drinking water is an important factor for children's health. (Credit: Vinay Kumar Dudam / iStock-Thinkstock)

About a quarter of the total global burden of disease is attributable to remediable environmental causes.[1] Typically measured as an aggregate of years of life lost among national populations, the causes of this composite social cost vary from air-pollution-related respiratory illness and waterborne diarrhea to the effects of toxins and some infectious diseases. In past iterations of the EPI, the indicator that tracked environmentally caused burden of disease — quantified by the World Health Organization (WHO) as disability-adjusted life years (DALYs) — was our sole measure in the issue category Environmental Health.

For many reasons, the EPI replaced DALYs with a measure of child mortality in 2012 EPI. Primary among them is that DALYs did not offer reliable time series data by which to chart national performance progress. Also, discrepancies that make accurately correlating exposure and risk from country to country called into question the project of sufficiently modeling the relationship between years lost and the environment. Starting in 2012, the EPI began using the WHO's measure of child mortality. Probably most influential in this decision was the much greater correlation between environmental factors and the rate of death of children. While less than a quarter of overall premature mortality is the result of preventable environmental factors, deaths among children up to age 14 were environmentally caused up to 36 percent of the time.[2]

There are a number of problems with too directly equating child mortality and environmental health, however. As DALYs also make clear, it is difficult to tease apart causes and solutions that are environmental in nature from those belonging to the realm of public health. For instance, many of the gains in pursuing the Millennium Development Goal (MDG) of lower rates of child mortality have been achieved through improving access to healthcare, vaccinations, and the distribution of clean cookstoves. Second, many environmental causes of disease occur in conjunction with other causes, a phenomenon known as comorbidity. Malnutrition, for instance,

[1] World Health Organization. (2006) *Preventing disease through healthy environments: towards an estimate of environmental burden of disease*. Available: http://www.who.int/quantifying_ehimpacts/publications/preventingdisease.pdf. Last accessed: January 14, 2014.
[2] *Ibid*.

can exacerbate or be exacerbated by diarrhea. Third, because of the extreme difference in child mortality rates between industrialized and developing countries, child mortality can be seen as a proxy for level of economic development.

The relationship between the environment and human health is complicated by linkages to other causes and effects, including genetics, access to healthcare, level of economic development, and varying degrees of exposure. The latter complication is particularly cogent to understanding risk: two areas may contain identical levels of a pollutant, yet demographic, ecological, or infrastructural variations may lead to wildly different exposure rates among populations. It can also be difficult to unbundle some environmental effects—indoor and outdoor air pollution, for instance.[3] For those reasons, the EPI prefers strict performance-based measures, like rates of child mortality, over modeled data. Still, it is quite possible that additional measurements can be developed. For example, a spate of recent studies have investigated the benefits of green space, an open, usable commons, and parks on people's physical and psychological well-being. This work has been supplemented by other research that explores the importance of local access to nutritional food to the health of populations. While these studies offer a different, and promising, lens for comprehending the effects of the environment and human health, until now the research has predominantly been applied to urban areas in the industrialized world. It is also more relevant to health impacts that are widely considered lifestyle-based, like obesity and heart disease.[4]

Some promise also lies in constructing aggregate indicators that can account for all the various effects of the environment on human health. Researchers from the Netherlands combined data on exposure levels, mortality and illness, and Dutch environmental reports to provide a picture of the relative effects of environmental conditions on national public health. They found that the overwhelming majority of environment-related health loss was due to outdoor air pollution. While their methods were permitted by specific conditions in the Netherlands, particularly as they relate to the consistency of data and demography, the research may serve as a model for future indicators of environmental health.[5] Of course, the kind of data-collection required to construct a normalized global aggregate indicator is still a long way off.

For now, child mortality is the best global measure for the effects of the environment on human health. It may not be perfect, but it speaks with extreme clarity about the importance of a healthy environment to the most vulnerable among us.

[3] Knol, A., Petersen, A. C., van der Sluijs, J. et. al. (2009) Dealing with uncertainties in environmental burden of disease assessment. *Environmental Health* 8:1-13.

[4] Mitchell, R., Popham, F. (2008) Effect of exposure to natural environment on health inequalities: an observational population study. *The Lancet* 372:1655-1660.

[5] De Hollander, A. E. M., Melse, J. M., Lebret, E. et al. (1999) An aggregate public health indicator to represent the impact of multiple environmental exposures. *Epidemiology* 10:606-617.

Between the 2012 and 2014 EPIs, child mortality rates have declined dramatically in many countries. Vast improvements in sub-Saharan African countries such as Gambia and Rwanda can be attributed to public health measures like wide distribution of vaccines to guard against pneumonia and diarrhea, mosquito nets for malaria prevention, and more widespread access to healthcare.[11] While these policy interventions do not directly tie to environmental factors, there is a clear correlation between reductions in child mortality and access to sanitation and clean drinking water –other indicators in the Environmental Health objective—which are strong factors in reducing diarrhea among children.[12]

Despite progress, child mortality rates remain high in many countries in South Asia and sub-Saharan Africa, and a significant reason is that environmental solutions have not kept pace with healthcare-based solutions. India alone accounts for between one-fourth and one-third of all deaths of children under five, mostly because of the effects of diarrhea and pneumonia resulting from water and air pollution.[13] Linking public health and environmental solutions is a must. In Afghanistan, for instance, increased access to healthcare, vaccines for diphtheria, pertussis and tetanus, and treatment for malaria and diarrhea, coupled with the huge advances in access to sanitation and clean drinking water have spurred encouraging gains in child—and maternal—survival.[14] Unfortunately significant improvement is not the norm. Low-performing countries in troubled regions are unlikely to achieve the goals set forth in the MDGs. This concern has prompted new initiatives to directly address environmentally borne disease in sub-Saharan Africa and South Asia.[15]

[11] Black R. E., Cousens, S., Johnson, H. L., et. al. (2010). Global, regional, and national cause of child mortality in 2008: a systematic analysis. *The Lancet* 375:1969-1987.

[12] Bartram, J., and Cairncross, S. (2010). Hygiene, sanitation, and water: forgotten foundations of health. *PLoS medicine*, 7:e1000367.

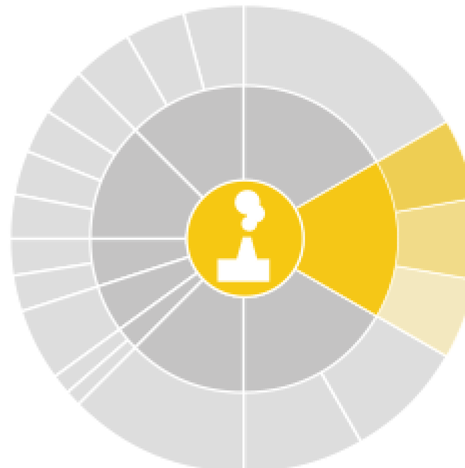
[13] Million Death Study Collaborators, Bassani, D. G., Kumar, R., et al. (2010) Causes of neonatal and child mortality in India: a nationally representative mortality survey. *The Lancet* 376:853-1860.

[14] Rasooly M. H., Govindasamy, P., Aqil, A. et al. (2013) Success in reducing maternal and child mortality in Afghanistan. *Global Public Health*. Published online 5 September 2013: DOI: 10.1080/17441692.2013.827733.

[15] World Health Organization and UNICEF. (2013) *Ending Preventable Child Death from Pneumonia and Diarrhea by 2025: The integrated Global Action Plan for Pneumonia and Diarrhea (GAPPD)*. Available: http://apps.who.int/iris/bitstream/10665/79200/1/9789241505239_eng.pdf. Last accessed: January 10, 2014.

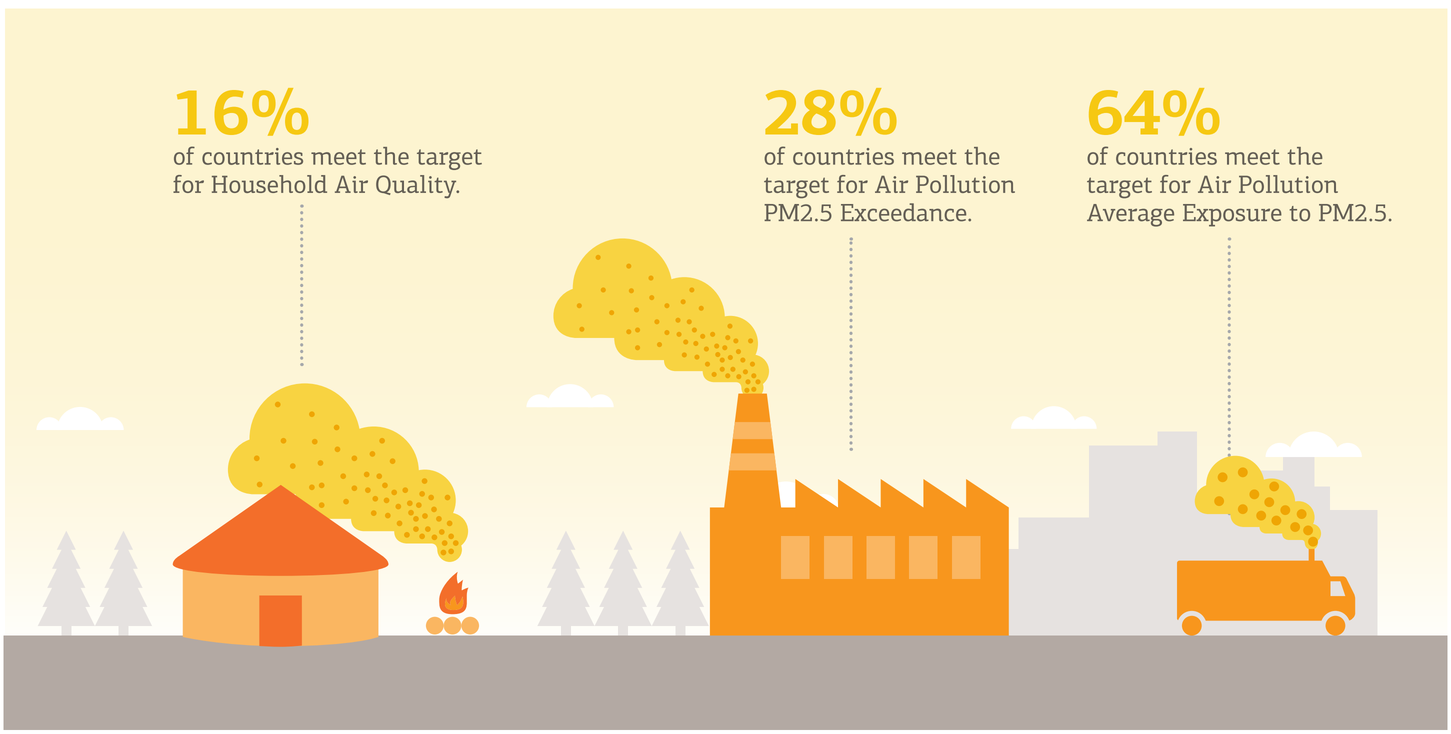
ISSUE PROFILE

Air Quality



What It Measures

This issue category includes three indicators: Air Pollution- Average Exposure to $PM_{2.5}$ (fine particulate matter); $PM_{2.5}$ Exceedance; and Household Air Quality – Indoor Solid Fuel Usage. Respectively, the first two indicators measure: Population-weighted exposure to $PM_{2.5}$ in micrograms per cubic meter (μg/m^3); and an average of the percentage of the population exposed to $PM_{2.5}$ levels at 10 μg/m^3, 15 μg/m^3, 25 μg/m^3, and 35 μg/m^3. These exposure levels represent the World Health Organization's (WHO) air quality guidelines and interim I, II, and III targets specified to help countries gauge progress over time to reduce population exposure to particulate matter.[16] Household Air Quality measures the percentage of the population burning solid fuel (biomass such as wood, crop residues, dung, charcoal and coal) for cooking.



Why We Include It

Suspended particulates contribute to acute lower respiratory infections and other diseases such as cancer. They can penetrate human lung and blood tissue, leading to higher incidences of cardiovascular and lung disease. Most countries currently monitor and report coarse particulate pollution, or PM_{10} (particles between 2.5 and 10 microns in diameter). However, fine particulates, or $PM_{2.5}$ (2.5 microns and smaller), lodge deep in lung tissue and are far more injurious to health than coarser particulates. $PM_{2.5}$ also travel farther from their source than PM_{10} and can have a more toxic composition, including heavy metals and carcinogenic compounds.

Cooking with solid fuels over open fires or in simple stoves exposes households to daily pollutant concentrations that lie between those of second-hand smoke exposure and active smoking.

Solid fuel combustion is associated with increased mortality from pneumonia and other acute lower respiratory diseases among children. Among adults it is connected to increased mortality from chronic obstructive pulmonary disease and, where coal is used, lung cancer.[17]

The most recent Global Burden of Disease project (GBD 2010) found household air pollution responsible for around 3.5 million premature deaths worldwide.[18,19] A measure of solid fuel use - a useful proxy for household air pollution - served as an estimation of health impacts from household air pollution in the GBD 2010 and, until 2007, as an indicator of environmental sustainability for an MDG.[20,21]

Where The Data Come From

The satellite-derived $PM_{2.5}$ data were provided by Aaron van Donkelaar of Dalhousie University. Population data for population weighting of $PM_{2.5}$ concentrations and measurement of the proportion of the population above various $PM_{2.5}$ concentration thresholds were obtained from the Global Rural Urban Mapping Project, v.1 at the NASA Socioeconomic Data and Applications Center hosted by the Center for International Earth Science Information Network (CIESIN) at Columbia University. The Household Air Quality data came from the WHO Household Energy Database,[22] which provides estimates of the percentage of households using solid fuels (coal, wood, charcoal, dung, and crop residues), liquid fuels (kerosene), gaseous fuels (LPG, natural gas, biogas) and electricity. The WHO data come from household surveys, with a total of 586 data points in 155 countries.

DESCRIPTION

Particles smaller than 2.5 microns in diameter, known in shorthand as $PM_{2.5}$, are fine enough to lodge deep into human lung and blood tissue. They place exposed populations at risk of heart and lung diseases, ranging from stroke to lung cancer. In severe cases, they lead to direct fatalities.[23,24] Airborne particulates originate from a variety of sources. $PM_{2.5}$ is generally the product

[16] World Health Organization. (2006) *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: Global 2005 Update*. Available: http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf. Last accessed: December 21, 2013.

[17] World Health Organization. (2011) *Air quality and health*. Available: http://www.who.int/mediacentre/factsheets/fs313/en/. Last accessed: December 21, 2013.

[18] Global Burden of Disease 2010. (2012) *The Lancet*. Available: http://www.thelancet.com/themed/global-burden-of-disease. Last accessed: December 21, 2013.

[19] Lim S. S., Vos, T., Flaxman, A. D., et al. (2012) A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet* 380:2224–2260.

[20] United Nations. (2007) *Annex II- Report of the Secretary-General on the work of the Organization. Supplement No. 1 (A/62/1)*. Available: http://www.un.org/millenniumgoals/sgreport2007.pdf?OpenElement. Last accessed: January 10, 2014.

[21] United Nations. (2012) *MDG Indicator Metadata - Proportion of population using solid fuels*. Department of Economic and Social Affairs, Statistics Division: New York, New York. Available: http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=29. Last accessed: January 10, 2014.

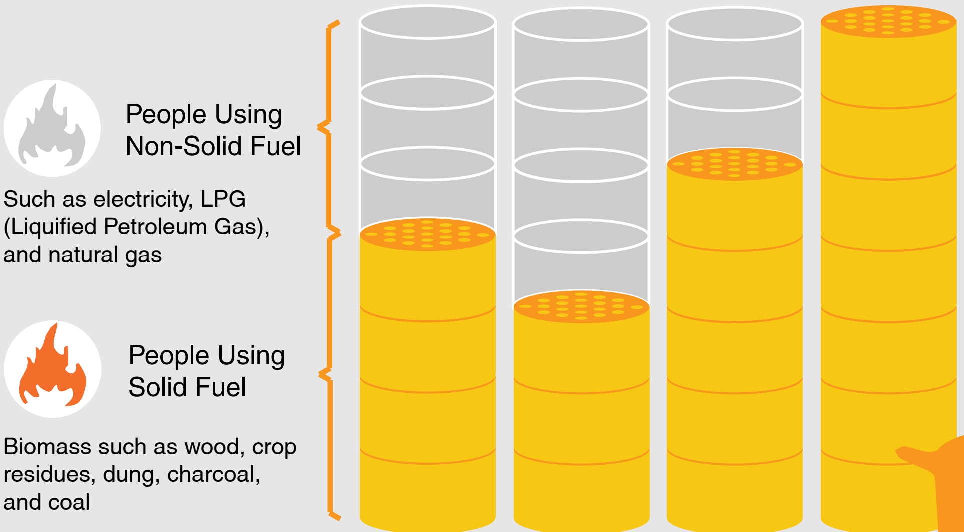
[22] World Health Organization. (2012) *WHO Household energy database*. Available: http://www.who.int/indoorair/health_impacts/he_database/en/index.html. Last accessed: January 10, 2014.

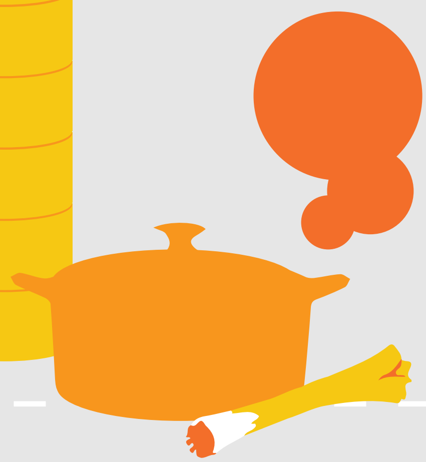
[23] Goldberg, M. (2008) A systematic review of the relation between long-term exposure to ambient air pollution and chronic diseases. *Reviews on Environmental Health*, 23:243-298.

[24] U.S. Environmental Protection Agency - Office of Air and Radiation. (2003) *Particle Pollution and Your Health*. Washington, D.C. Available: http://www.airnow.gov/index.cfm?action=particle_health.page1#3. Last accessed: December 29, 2013.

What is Household Air Quality?

Cooking over open fires or in simple stoves exposes household members to pollutants on a daily basis. Household Air Pollution is the percentage of population using solid fuel as the primary cooking fuel.





Sources

Solid fuels include biomass fuels, such as wood, charcoal, crops or other agricultural waste, dung, shrubs and straw, and coal.

Harmful Effects

Incomplete Combustion

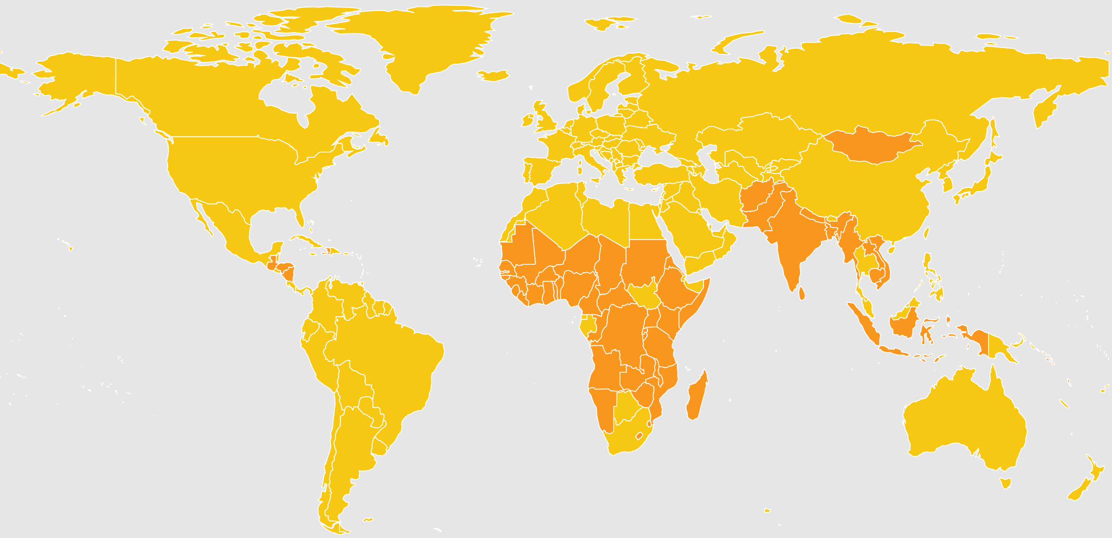
Complete: $C + O_2 \rightarrow CO_2$ Safe

Incomplete: $C + O_2 \rightarrow CO$ Unsafe

Although biomass fuels contain few actual contaminants, they produce substantial pollution mainly as a result of incomplete combustion in traditional stoves and open fires. Unfortunately, since people in developing countries rarely have access to advanced stoves, cooking with biomass exposes them to harmful pollutants.

Countries Burning More Than 50% Biomass for Cooking Fuel

Data from 2004-2008



- Countries Burning More than 50% for Cooking Fuel
- Countries Burning less than 50% for Cooking Fuel

Developing Countries

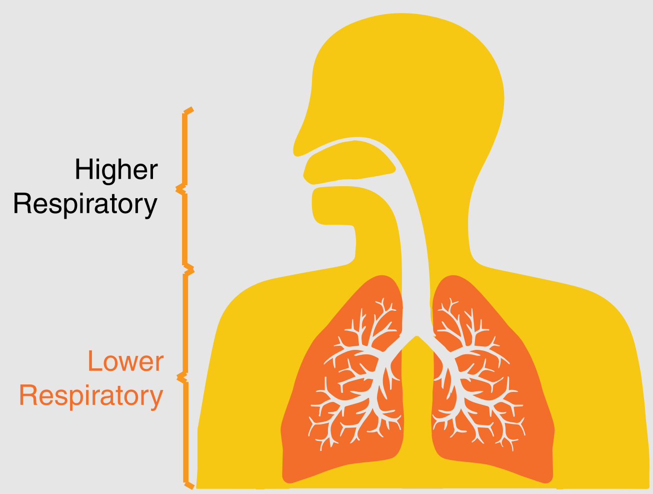
Household air pollution is one of the most important causes of poor health in developing countries.

Women & Children

Particularly for women and children, who are most impacted by household air quality, it's the second most important risk factor for women and girls.

Daily Pollutant Concentration Levels

Cooking with solid fuels over open fires or in simple stoves exposes household members to daily pollutant concentrations that lie between those of secondhand smoke and active smoking.



For Adults
Increased mortality from chronic obstructive pulmonary disease and lung cancer (where coal is used)

For Children
Increased mortality from pneumonia and other acute lower respiratory diseases

How do we know?

Data from World Health Organization

Solid Fuels | Liquid Fuels | Gaseous Fuels | Electricty

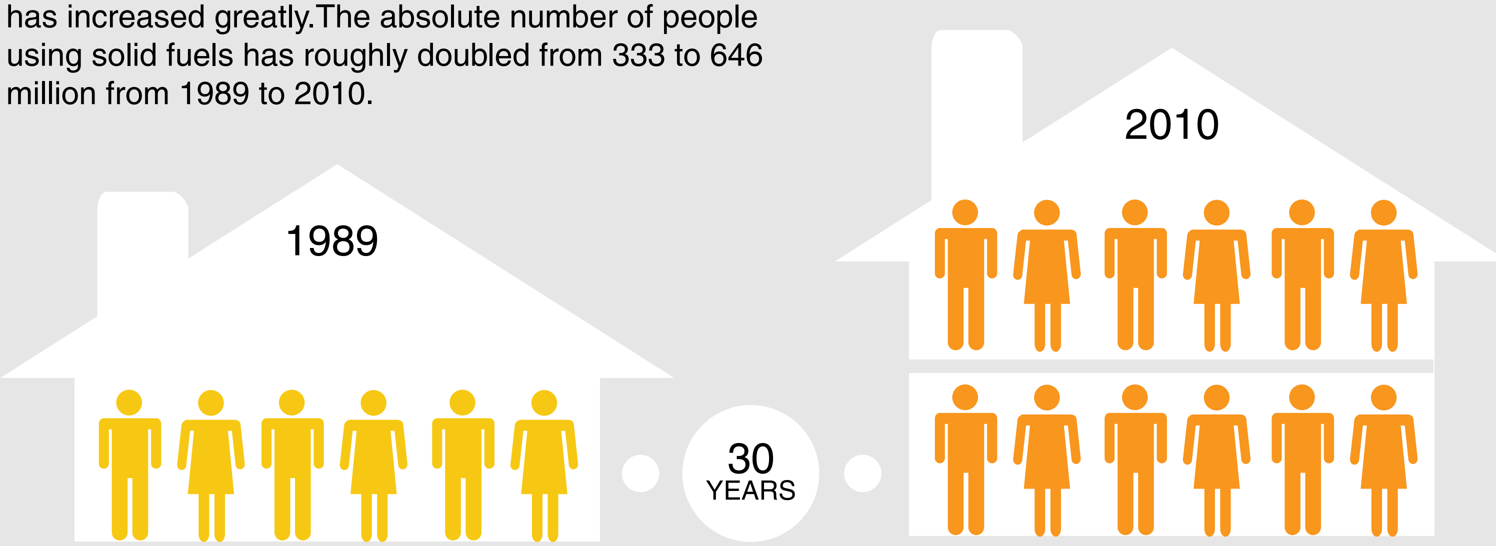
These data were collected from a total of 586 national country-year data points from household surveys in 155 countries. The rest of the data are generated from models predicting solid fuel use.

Households Using Solid Fuels % = People Exposed to Household Air Pollution %

The fraction of people exposed to household air pollution was assumed to be the same as the fraction of households using solid fuels.

How is the world doing?

The number of people using solid fuel as cooking fuel has increased greatly.The absolute number of people using solid fuels has roughly doubled from 333 to 646 million from 1989 to 2010.



333 million

646 million

References

• World Health Organization. (2012). WHO Household energy database. Available: http://www.who.int/indoorair/health_impacts/he_database/en/index.html. Last accessed: January 10, 2014.

cBonjour et al. (2013). Solid fuel use for household cooking: Country and regional estimates for 1980-2010. Environmental Health Perspectives. 121(7): 784-790.

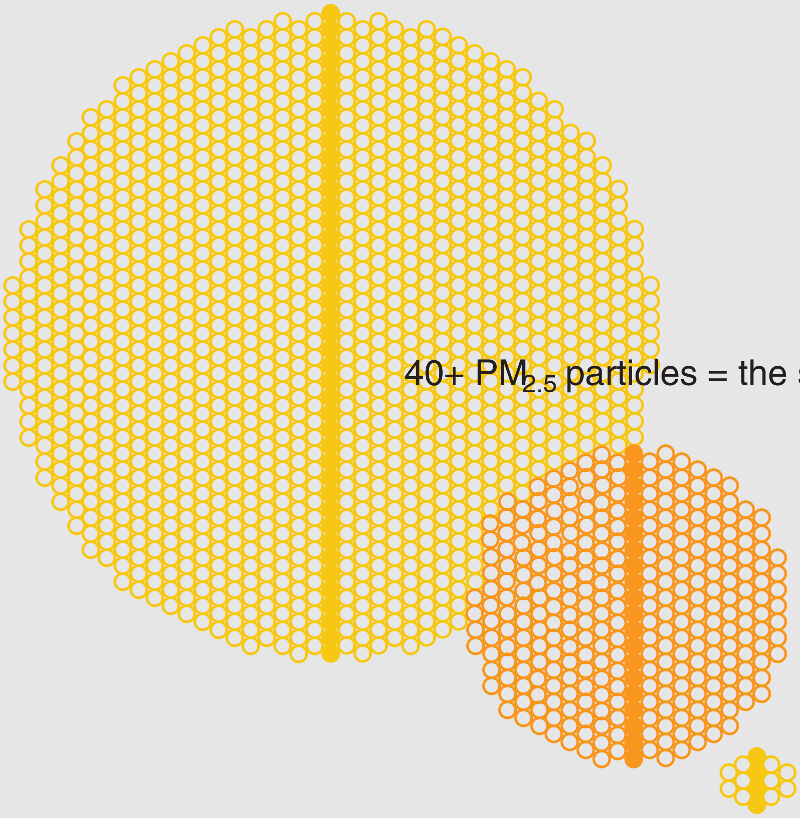
• WHO Household Energy Database. World Health Organization (WHO). http://www.who.int/indoorair/health_impacts/he_databasecon-t/en/index.html

What is $PM_{2.5}$?

Fine Particulate Matter

$PM_{2.5}$, also known as fine particulate matter, refers to particles or droplets in the air that are 2.5 microns or less in width.

Although it is invisible to the naked human eye as individual particles, $PM_{2.5}$ can reduce visibility and cause the air to appear hazy when $PM_{2.5}$ levels are elevated.



40+ $PM_{2.5}$ particles = the smallest particle visible to human eye

20 $PM_{2.5}$ particles = 1 fog particle

4 $PM_{2.5}$ particles = 1 PM 10 particle

1 $PM_{2.5}$ particle ≤ 2.5 microns

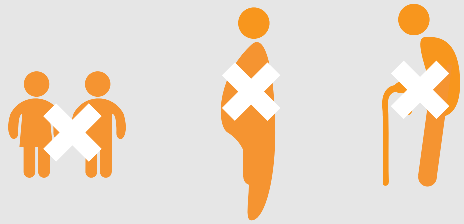
Human Effects

Enter through nose and mouth.

Larger particles such as PM_{10} are eliminated through coughing, sneezing, and swallowing.

Smaller particles such as $PM_{2.5}$ can travel deep into lungs, causing lung and heart problems.

Vulnerable Populations



Unlike other pollutants in the air, $PM_{2.5}$ can go deep into the lungs and bloodstream, leading to health problems. Young children, pregnant women, and the elderly are especially vulnerable.

Sources

Agriculture

Power Plants & Factories

Motor Vehicles

Burning of wood, oil, grass, etc.

How do we know?

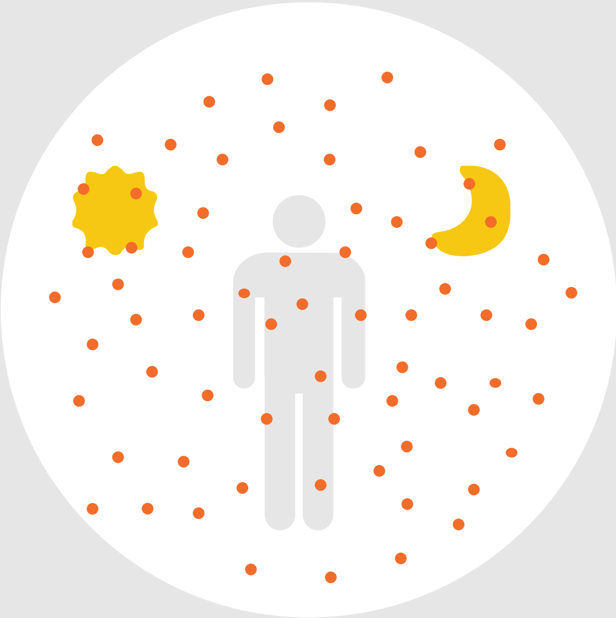
We use satellite-derived estimates that develop a consistent measure for each country, many of which do not yet measure ground-based $PM_{2.5}$.

Satellite vs. Ground

	SATELLITE	GROUND
PROS	• Consistent measure for all countries (important for cross-country comparisons) • Global data coverage for all countries	• Measured typically at the ground level where populations are exposed, which is the most accurate for local exposure to $PM_{2.5}$
CONS	• Uses scientific models to estimate ground-based measures • Uses multi-year averages, so could mute effects of high-pollution events	• Many countries don't have resources to measure $PM_{2.5}$ • Inconsistent spatial coverage • Comparisons between countries difficult, due to measurement and reporting differences

VS

Average Exposure to $PM_{2.5}$ - A 'Typical' Air Pollution Day



Average exposure is calculated by multiplying the $PM_{2.5}$ concentration by the population exposed. It reflects a 'typical' air pollution day a person would experience in a country.

The 2014 EPI includes two ways of looking at exposure:
1) the average exposure to $PM_{2.5}$ at a national scale;
2) an average of the percentage of the population exposed to $PM_{2.5}$ levels at the World Health Organization's different air quality guidelines (10, 15, 25, and 35 µg/m³).

10 µg/m³ **WHO** (World Health Organization) **Recommendation**

U.S. Air Quality Index & Concentration Values

Air Quality Index (AQI)	Levels of Health Concern	Concentration Values (µg/m³)
0 - 50	good	0 -12
51 - 100	moderate	12.1 - 35.4
101 - 150	unhealthy for sensitive groups	35.5 - 55.4
151 - 200	unhealthy	55.5 - 150.4
201 - 300	very unhealthy	150.5 - 250.4
301 - 500	hazardous	250.5 - 500.4

References

• WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global Update 2005, Summary of Risk Assessment", World Health Organization (WHO): http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf
• "Air Quality Index (AQI) - A Guide to Air Quality and Your Health", Air Now: http://airnow.gov/index.cfm?action=aqibasics.aqi
• "Particulate Matter (PM)", United States Environmental Protection Agency (EPA): http://www.epa.gov/pm/basic.html

A national effort to scale up biomass to energy solutions has been ongoing in India since the 1970s. (Credit: Samer Chand / iStock-Thinkstock)

ALTERNATIVES TO BIOMASS BURNING TO ADDRESS AIR QUALITY

The conversion of biomass into usable energy is as old as the human use of fire. Worldwide, it is still the primary source of household energy for hundreds of millions of families, particularly those in the developing world. However, urban and rural burning of biomass—whether to clear land, dispose of agricultural or municipal waste, or for household use—is among the leading contributors to dangerous air pollution. Clean and equitable ways of converting biomass into energy have begun to demonstrate success at alleviating these harms.

Power plants that burn biomass, particularly wood pellets, are widespread in Europe. With its wealth of forest resources, for instance, Finland produces 20 percent of its total electricity from wood burning, usually in the form of pellets made from the leftovers of milling.[1] Fuel in this form can be considered carbon neutral, as replanted trees recapture the carbon released from burning. In some cases, biomass is used as a direct substitute, or cleaner accompaniment, to coal in power plants, a process known as co-firing. Through gasification and anaerobic digestion, biomass is used to produce combustible fuels— most notably methane, which can be used instead of fossil fuels. Because gas production through anaerobic digesters is relatively simple, some countries, including the United Kingdom, have instituted feed-in tariffs for "biogas," repaying small-scale producers for energy they return to the market.[2]

Examples from Europe and North America have instigated a wave of biomass-based energy schemes in the developing world, most notably in India and China. China's capacity to convert biomass to energy has grown tremendously in the last decade, and it is slated to provide 4 percent of the country's primary energy by 2020. That may not sound like a lot, but it represents a fourfold increase since 2010 in a country whose energy sector is booming. Currently, the direct combustion of straw dominates the sector, although gasification and the production of liquid fuels like ethanol are receiving huge boosts from the national government.[3]

A national effort to scale up biomass to energy solutions has been ongoing in India since the 1970s. To date, biomass and waste-to-energy make up about 12 percent of the country's entire renewables sector, itself only about five percent of total energy supply. However, the widespread availability of refuse biomass in rural India, the lack of access to clean energy faced by many rural Indians, and the ecological degradation created by demand for wood make the country a perfect laboratory for small-scale biomass to energy generation.[4]

A number of experimental initiatives trialing household anaerobic digesters, utilizing livestock dung in particular, have shown that distributed, local production of biogas is effective at alleviating the human health and ecological impacts of energy demand.[5] In the case of the Kolar district of the province Karnataka, more than 10,000 digesters have been installed on the properties of local people. Fed by animal dung and household wastewater, the digesters produce gas for cooking and heating. The leftover slurry can then be used as fertilizer. The projects at Kolar were funded in large part by the UN Framework Convention on Climate Change's Clean Development Mechanism, which allows developed countries to achieve their emissions reduction commitments by promoting emissions-reducing projects in developing countries like India.[6]

[1] Ericsson, K. and Nilsson, L. (2006) Assessment of the potential biomass supply in Europe using a resource-focused approach. *Biomass Bioenergy* 30:1-15.

[2] Anaerobic Biodigestion and Biogas. (2012) *Anaerobic digestion and biogas incentives in the UK*. Available: http://anaerobic-digestion-biogas.co.uk/2012/01/anaerobic-digestion-and-biogas-incentives-in-the-uk/. Last accessed: January 11, 2014.

[3] Zhou, Z., Yan, H. (2012) Assessment of the biomass power generation industry in China. *Renewable Energy* 37:53-60.

[4] Rao, P. V., Baral, S. S., Dey, R., et.al. (2010) Biogas generation potential by anaerobic digestion for sustainable energy development in India. *Renewable and Sustainable Energy Reviews* 14:2086-2094.

[5] Aoramoorthy, G. and Hsu, M.J. (2008) Biogas plants ease ecological stress in India's remote villages. *Human Ecology* 36:435-441.

[6] United Nations Framework Convention on Climate Change. (2010) *CDM Project co-benefits in Kolar district, India: Providing rural households with low-cost energy services*. Available: http://cdm.unfccc.int/about/ccb/CDM_Cobenefits_Kolar_India.pdf. Last accessed: January 11, 2014.

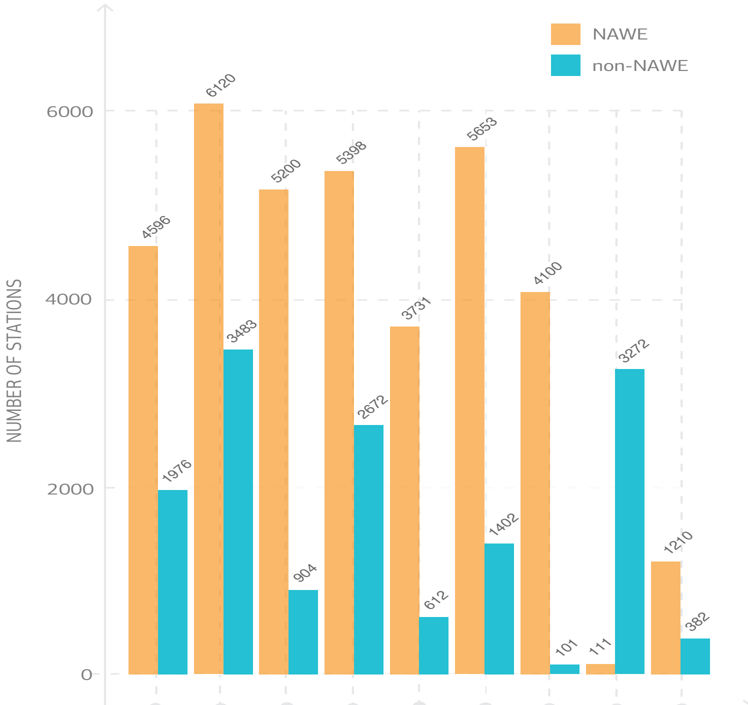


Figure 9. Number of monitoring stations in developed (North America and Western Europe, here called NAWE) versus developing countries (non-NAWE). (Data source: Rudolph Husar and Stefan Falke, for GEO Task US-09-01a.[27] Figure from Hsu et al., 2013.[28])

of combustion, whether anthropogenic, like car emissions and coal burning, or through forest fires and volcanoes. For vulnerable lungs, high concentrations of $PM_{2.5}$ can be a particularly virulent killer. The leading cause of mortality among children aged one to five worldwide is pneumonia, and fine particulates of are a major global contributor to its incidence.[25]

Despite its known health impacts, many countries do not monitor $PM_{2.5}$, usually because of lack of capacity, resources, technology, or public demand. Monitoring gaps primarily occur in developing countries outside of North America and Western Europe, where air pollution is more severe (see Figure 9).[26] Given the sparseness of ground-based monitors, the EPI collaborated with Dalhousie University researchers who use satellite data to assess global, national exposure to $PM_{2.5}$. Unlike ground-based monitors, which are primarily concentrated in urban areas and can be sporadically stationed, satellite data provide consistent and complete values using the same methods and technology for every country.

With this satellite data, the 2014 EPI can

[25] World Health Organization. (2013) *Children: reducing mortality*. Available: http://www.who.int/mediacentre/factsheets/fs178/en/index.html. Last accessed: December 29, 2013.

[26] Engel-Cox, J., Kim Oanh, N. T., van Donkelaar, A., et al. (2013) Toward the next generation of air quality monitoring: Particulate Matter. *Atmospheric Environment*, 80:584-590.

[27] Group on Earth Observations. (2010) *GEO Task US09-01a: Earth Observation Priorities for Health SBA- Air Quality Sub-Area*. Available: http://sbageotask.larc.nasa.gov/AirQuality_US0901a-FINAL.pdf. Last accessed: January 10, 2014.

[28] Hsu, A., Reuben, A., Shindell, D., et al. (2013) Toward the next generation of air quality monitoring indicators. *Atmospheric Environment*, 80:561-570.

CONSIDERING SMOKING AS AN AIR POLLUTION PROBLEM FOR ENVIRONMENTAL HEALTH

Smoking is a widely acknowledged danger to human health. Tobacco smoke causes or exacerbates conditions including asthma, respiratory infections, and cancer. According to the Center for Disease Control (CDC), smoking leads to 440,000 deaths a year in the United States.[1] However, smoking is less frequently viewed in terms of environmental health. In its tally, the CDC includes nearly 50,000 deaths from second-hand smoke, a risk associated with proximity to a smoker and a form of air pollution.

Environmental tobacco smoke contains cancer-causing compounds that the U.S. government regulates as hazardous air pollutants. Further, environmental tobacco smoke has a very high content of fine particulate matter, or $PM_{2.5}$ - the EPI indicator for air pollution. A cigarette in the mouth of a passerby may represent more than just an occasion to hold one's breath. It may be a pollutant potent enough to rival a passing car. A 2004 study conducted by researchers at Italy's National Cancer Institute compared the output of three lit cigarettes and a diesel engine.[2] After 30 minutes of continuous exposure in a controlled garage, the scientists found that the cigarettes released ten times the particulate matter of the engine.

Environmental tobacco smoke poses a significant health risk after long-term exposure in enclosed spaces, though it still ranks low on gross causes of air pollution, a list topped by transportation, industrial and agricultural emissions, power generation and residential heating and cooking. Yet while smoking is not a leading human cause of air pollution, air pollution has now been deemed a leading environmental cause of cancer deaths. The International Agency for Research on Cancer, a branch of the World Health Organization, announced in October 2013 that air pollution causes lung cancer and increases the risk for bladder cancer.[3] As air pollution, like tobacco smoke, is found to be carcinogenic, the line between human and environmental health blurs. Public health strategists, air quality experts, and policymakers alike have every incentive to make clean air a priority.

[1] Center for Disease Control and Prevention. (2013) *Smoking & tobacco use: tobacco-related mortality.* Available: http://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/tobacco_related_mortality/. Last accessed: January 11, 2014.

[2] Invernizzi, G., Ruprecht, A., Mazza, R., et al. (2004) Particulate matter from tobacco versus diesel car exhaust: an educational perspective. *Tobacco Control* 13: 219-221.

[3] Loomis, D., Grosse, Y., Lauby-Secretan, B., et al. (2013) The carcinogenicity of outdoor air pollution. *The Lancet Oncology* 14:1262-1263.

TOWARD THE NEXT GENERATION OF AIR QUALITY MONITORING

The Air Pollution indicators in the 2014 EPI are the result of a collaboration between the Yale Center for Environmental Law & Policy, Columbia University's Center for Earth Science Information Network at the Earth Institute, and the Asian Institute for Energy and Environmental Sustainability (AIEES). These organizations came together to work toward a "next generation" of air quality indicators. This effort, which was launched in April 2012, aimed to identify investments and improvements needed in air quality monitoring and data to provide a future blueprint for better, more policy-relevant indicators. A more immediate aim was to design new air quality indicators for the 2014 EPI.

The initiative convened scientific experts and policy representatives to have a conversation about the state of knowledge and policy needs with respect to air quality monitoring in Seoul in October 2012. As an Asian megacity with a population of over 10 million and home to over half of South Korea's people, Seoul suffers from severe air pollution – both as a result of traffic congestion within the capital city and from transboundary sources originating from China and other parts of East Asia. The impetus for South Korea to cooperate regionally, therefore, could not be more urgent.

These regional considerations, along with investments needed to bolster on-the-ground, satellite monitoring, and modeling to understand pollutant transport, were detailed for four pollutants – particulate matter, persistent organic pollutants (POPs), ozone and mercury. While particulate matter and ozone are currently being addressed by many governments in both developed and now, developing countries, POPs and mercury are complicated by transport mechanisms that mean their impacts are not directly perceived in the air, but instead embodied in food chains that eventually impact human health. For these reasons, many countries do not report national-level POPs or mercury emissions, although recent international developments through the Minimata Convention indicate future commitment on the part of countries to cooperate globally on mercury.[1]

The finished report was published in a special issue of *Atmospheric Environment* in December 2013.[2] Included are a series of background papers each focused on each pollutant, as well as a synthesis linking these measurement methods to policy. With this information and an eye toward the next generation of indicators, scientists and policy makers alike may take the crucial next step toward improving global air quality.

[1] United Nations Environment Programme (UNEP). (2013) *Minimata Convention on Mercury*. United Nations Environment Programme: Nairobi, Kenya. Available: http://www.mercuryconvention.org. Last accessed: January 10, 2014.

[2] Hsu, A., Reuben, A. A., Shindell, D., et al. (2013) Toward the next generation of air quality monitoring indicators. *Atmospheric Environment* 80:561-570

An air quality monitoring station outside a business district in China. (Credit: Wilimedia / Ahleong) include the only national indicator of population exposure to $PM_{2.5}$ on a global scale.

More than half of the population in 71 countries lives in regions with annual mean $PM_{2.5}$ concentrations in excess of the WHO guideline of a 10 µg/m^3 annual mean.

Large, urbanizing centers with heavy industrial activity and high concentrations of vehicles suffer from heavy contamination.[29] In Beijing, for instance, dangerous air pollution levels have dominated international headlines and incited citizens to protest.[30]

Developed countries are not immune from pollution, however. While the United States meets air quality standards at the national level, some sites reveal discrepancies. Bakersfield, California, for example, had the highest level of particulate pollution out of 277 metropolitan areas in the United States in 2013. There, annual average $PM_{2.5}$ concentrations have been nearly two times the WHO recommended guideline over the last decade.[31] Salt Lake City, Utah, experienced temperature inversions on 57 percent of winter days from 1994 through 2008, leading to spikes in particulate matter pollution exceeding National Ambient Air Quality Standards.[32]

While air pollution in developed countries is primarily the product of industrialization and urbanization, air pollution in many developing countries generally has a different source: biomass burning. The combustion of organic refuse, charcoal, wood, animal dung, and agricultural waste, such as straw, nut shells, or rice husks, is prevalent in rural and urban areas of the developing world. In India, where 60 percent of the population is agrarian, biomass is burned to clear fields, releasing pollutants that drift into nearby cities.[33] In June 2012, Wuhan, a major city in central China, experienced the worst air pollution in a decade. Levels exceeded the top range of measurement indices, and the city was engulfed in a dense, greenish cloud of smoke. Satellite imaging revealed fires in rural areas across the region, suggesting biomass burning as a likely culprit for the extreme pollution spikes.[34]

Acknowledging the contribution of biomass burning to local and regional air pollution, some governments in developing countries have started to provide farmers alternatives to harness otherwise wasted biomass for cleaner energy production (see Box: Alternatives to Biomass Burning to Address Air Quality). These include the construction of waste-to-energy plants, which produce electricity by burning biomass with less pollution than outdoor fires.

Contributions to air pollution are not restricted to industry or agriculture. Biomass and coal are often burned in simple stoves or open fires in poorly ventilated cooking spaces. In fact, chronic exposure to air pollution produced

[29] World Health Organization. (2006) *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: Global 2005 Update*. Available: http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf. Last accessed: December 21, 2013.

[30] Riggs, M. (2013) *Intense Smog Is Making Beijing's Massive Surveillance Network Practically Useless*. The Atlantic Cities. 5 November. Available: http://www.theatlanticcities.com/technology/2013/11/intense-smog-making-beijings-massive-surveillance-network-practically-useless/7481/. Last accessed: December 29, 2013.

[31] American Lung Association. (2013) *State of the Air.* Washington, D.C.. Available: http://www.stateoftheair.org/2013/city-rankings/most-polluted-cities.html. Last accessed: January 10, 2014.

[32] Bailey, A., Chase, T. N., Cassano, J. J., et al. (2011) Changing temperature inversion characteristics in the US southwest and relationships to large-scale atmospheric circulation. *Journal of Applied Meteorology and Climatology*, 50:1307-1323.

[33] Yee, A. (2013) *India Increases Effort to Harness Biomass Energy*. The New York Times. 9 October 2013. Available: http://www.nytimes.com/2013/10/09/business/energy-environment/india-increases-effort-to-harness-biomass-energy.html?_r=1&. Last accessed: December 29, 2013.

by the combustion of cooking fuels is among the world's most significant and silent killers. And its effects are not isolated to kitchens. Data have shown that smoke may pervade the rest of the house and move outdoors. Families that cook outdoors also experience adverse health effects, though at a lower rate. Households using clean fuel sources amidst a community of solid fuel users may still be exposed to harmful smoke by their neighbors.

The burning of solid fuels is far more prevalent in developing countries and in places where a majority of the population lacks access to modern cooking technology. The 2014 EPI indicator for Household Air Pollution reveals a clear correlation between national income and household air pollution. The population most significantly affected by solid fuel contamination, low-income households from developing countries, is likely even larger than the data indicate, as families in developing countries tend to be larger. At 77 percent, sub-Saharan Africa has the highest proportion of households using solid fuels. It is also the region with the least improvement over a 30-year period of measurement. There, the absolute number of people using solid fuels has roughly doubled from 333 to 646 million, reflecting both explosive population growth and the marginal changeover to modern fuels.[35]

Solutions to address household air pollution must focus on reducing emissions through the use of cleaner fuels, such as liquid petroleum gas and electricity. While installing chimneys or smoke hoods on simple stoves might seem an easy fix, the scarcity of wood and the potential risks to the environment posed by the collection of biomass are yet another argument against in-home biomass use. Largely prompted by these environmental concerns, China in the early 1980s undertook a large-scale attempt at improved rural household stoves. Since then the country has installed nearly 200 million improved stoves, reducing household air pollution and easing the environmental burden of biomass demand.[36] An initiative called the Global Alliance for Clean Cookstoves has tried to foster public and private cooperation to make clean cookstoves and fuels widely available in the greater developing world.

Ultimately, policy has an important role to play in reducing both outdoor and household air pollution. Efforts to address outdoor air pollution have surfaced during the latter half of the 20th century. National and international laws aimed at phasing out dirty industrial fuels such as coal, regulating auto emissions, and incentivizing better energy efficiency have all proven effective at improving air quality. [37] While the MDGs have to some extent encouraged policy interventions to reduce household air pollution, the 2014 EPI shows one-third of countries ranked still have more than 50 percent of their population using solid fuels indoors. However, unlike other environmental health issues included in the EPI that improve with economic growth, air pollution for many countries worsens with industrialization and urbanization, making the call for policymakers to address it all the more urgent.

[34] Hsu, A. (2012) *Wuhan's decades' worst air pollution*. Available: http://hsu.me/2012/08/wuhans-decades-worst-air-pollution. Last accessed: December 29, 2013.

[35] Bonjour, S., Adair-Rohani, H., Wolf, J., et al. (2013) Solid fuel use for household cooking: Country and regional estimates for 1980-2010. *Environmental Health Perspectives* 121:784-790.

[36] Sinton, J. E., Smith, K. R., Peabody, J. W., et al. (2004) An assessment of programs to promote improved household stoves in China. *Energy for Sustainable Development* 8:33-52.

[37] Wald, M. L. (2013) *Power plants try burning wood with coal to cut emissions*. The New York Times. 4 November 2013. Available: http://www.nytimes.com/2013/11/04/business/power-plants-try-burning-wood-with-coal-to-cut-emissions.html?ref=earth&_r=1&. Last accessed: December 29, 2013.

Water and Sanitation

What It Measures

This category includes two indicators: Access to Drinking Water and Access to Sanitation. Access to Drinking Water measures the proportion of a country's total population with access to an "improved drinking water source" as a main source of drinking water. An improved drinking water source is defined as a facility or delivery point that protects water from external contamination—particularly fecal contamination. This includes piped water into a dwelling, plot, or yard; public tap or standpipe; tubewell or borehole; protected spring; and rainwater collection.

Access to Sanitation measures the percentage of a country's population that has access to an improved source of sanitation. "Improved" sanitation sources include connection to a public sewer, connection to a septic system, pour-flush latrine, simple pit latrine, or ventilated pit latrine. The system is considered "improved" if it hygienically separates human excreta from human contact and is not public, meaning that it can either be private or shared.

Why We Include It

Access to Drinking Water is the best currently available proxy for access to clean drinking water. Access to reliable, safe water reduces exposure to pollution, disease, and harmful contaminants, thereby promoting health and wellbeing. For example, diarrhea is the leading cause of death among children, and is directly caused by consumption of contaminated water. Access to sanitation is vital for maintaining healthy drinking water supplies, minimizing contact with dangerous bacteria and viruses, and minimizing environmental threats associated with improper waste management.

Where The Data Come From
2012 WHO/United Nations Children's Fund (UNICEF) Joint Monitoring Programme for Water Supply and Sanitation (JMP).

DESCRIPTION

In 2010, the United Nations (UN) formally acknowledged that clean drinking water and sanitation are essential to the fulfillment of human rights.[38] Access to safe drinking water is a critical component to human health, socioeconomic development, and individual wellbeing. Improved access to safe drinking water is often considered one of the great successes of the MDGs set of eight international development goals established following the Millennium Summit of the UN in 2000. Between 1990 and 2010, more than two billion people gained access to improved drinking water sources. As a result, the MDG of halving the proportion of people without access to improved sources of water was met in 2010—a full five years ahead of schedule.

However, this global progress can easily mask broad regional disparities. While China and India have made great progress in improving access to drinking water, only 63 percent of the population in Sub-Saharan Africa has access to an improved water source.[39]

Additionally, within countries there are often stark disparities between urban and rural communities. At the end of 2011, 83 percent of the population without access to an improved drinking water source lived in rural areas. Globally, 768 million people continue to rely on unimproved drinking water sources.[40]

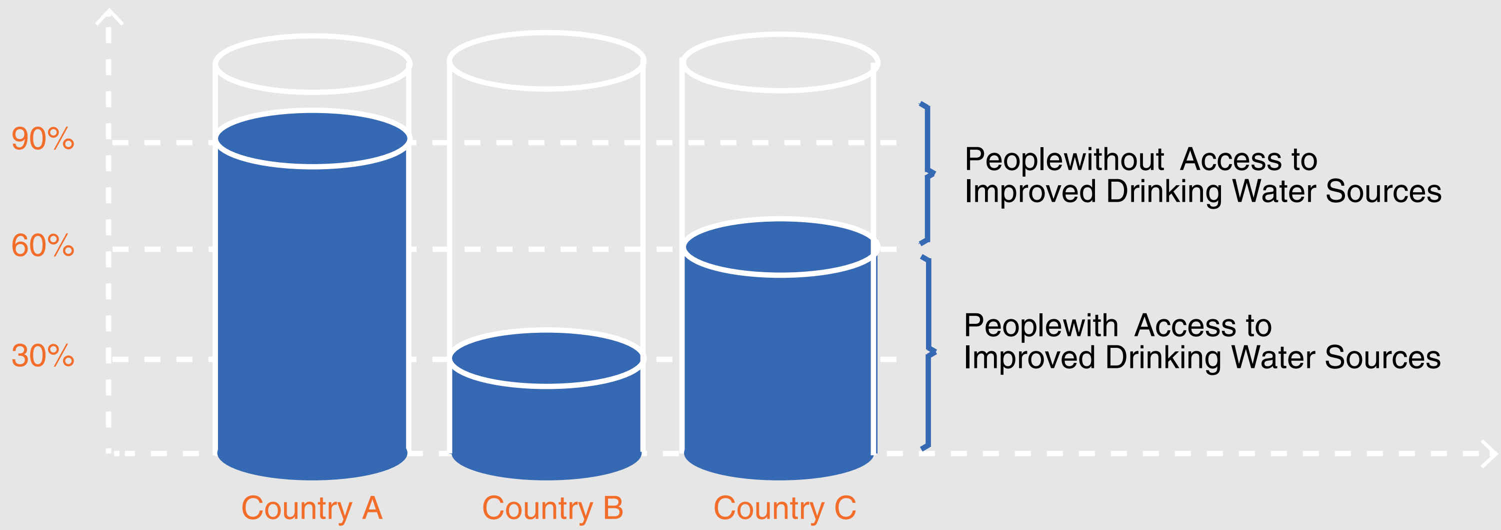
While the world has made great strides in increasing access to improved drinking water sources, only 55 percent of the global population[41] has access to piped drinking water. This has both social and public health implications, as piped drinking water supplies on premises are associated with the best health outcomes and minimize the disproportionate burden placed on women and children to retrieve water. Additionally, improving global access to sanitation has been slow. UNICEF estimates that approximately 2.5 billion people worldwide still lack access to adequate sanitation, and 15 percent of the world's population is forced to defecate in the open. These one billion people are primarily (71 percent) rural. In sub-Saharan Africa the number of people practicing open defecation continues to grow.[42]

The combination of inadequate access to safe drinking water and sanitation kills and sickens thousands of children every day. Inadequate sanitation further impacts quality of life for millions of people, extending beyond public health by exacerbating gender inequality issues and stunting economic development. Data from the WHO and UNICEF indicate that it is the poorest, the young and the elderly, excluded groups, and women and girls who suffer most from poor sanitation.[43]

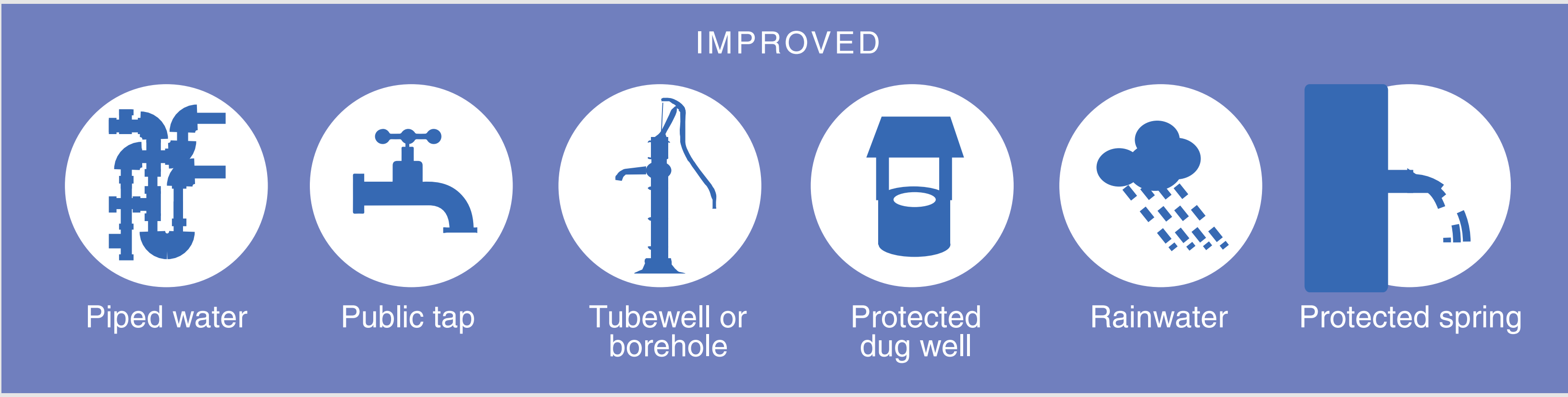
[38] United Nations Resolution 64/292. (2010) *The human right to water and sanitation*. Resolution adopted by the General Assembly on 28 July 2010. Available: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/64/292. Last accessed: January 11, 2014.
[39] World Health Organization and UNICEF. (2013) *Progress on sanitation and drinking water: 2013 Update*. Available: http://www.unicef.org/wash/files/JMP2013final_en.pdf. Last accessed: January 11, 2014.
[40] *Ibid.*
[41] *Ibid.*
[42] *Ibid.*
[43] World Health Organization and UNICEF Joint Monitoring Programme. (2013) *WASH water supply, sanitation and hygiene – human rights that are crucial to health and development*. Available: http://www.wssinfo.org/fileadmin/user_upload/resources/Fact_Sheets_1_eng.pdf. Last accessed: January 11, 2014.

What is
Access to Drinking Water?

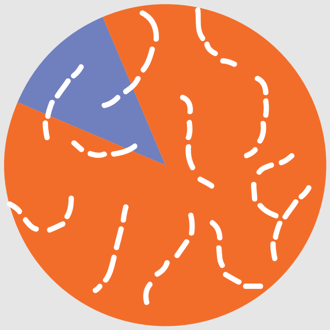
The Access to Drinking Water indicator measures the percentage of the population with access to improved drinking water sources.



Improved vs Unimproved Sources of Drinking Water

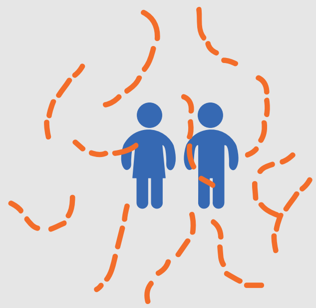


The Dangers of Unimproved Drinking Water



88%
Diarrheal Causes

Unsafe drinking water, inadequate availability of water for hygiene, and lack of access to sanitation together contribute to about 88% of deaths from diarrheal diseases.



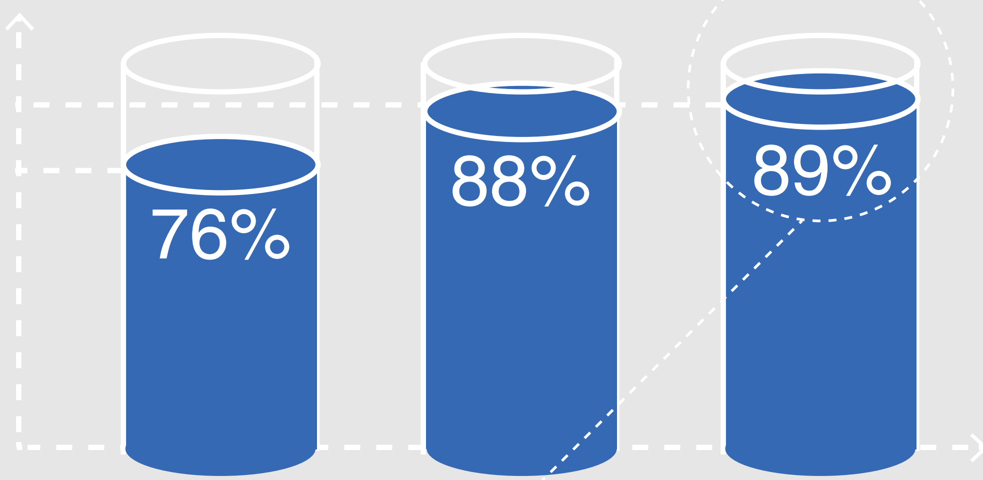
0-5 Years Old
Leading Cause of Death

Diarrheal disease is a leading cause of deaths among children and is frequently contracted through contaminated water sources. It is also a leading cause of malnutrition in children under five years old.

How is the world doing?

Millennium Development Goals (MDGs) for Access to Drinking Water

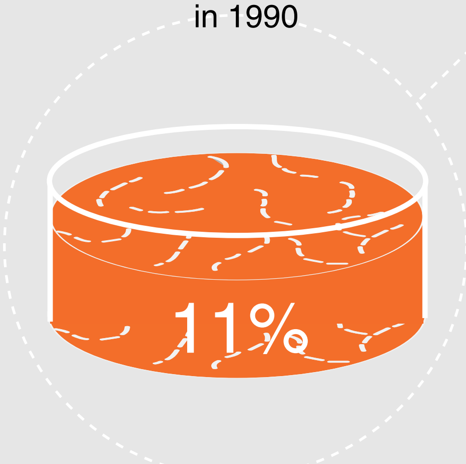
In Goal 7: Ensure Environmental Sustainability, Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation.



Set the Goal in 1990 | The MDG Goal by 2015 | Achieved Early in 2010

↑ 13 %
↑ 2.1 billion
→ 21 years

Since 1990, 2.1 billion people have gained access to improved drinking water sources. In 2010, 89% of people had access to drinking water, which meant that MDG Drinking Water Target was met five years ahead of the target date.



The Remaining 11%

Although we have reached the MDG goal for access to drinking water, we still have a long way to go. There is still 11% of the world's population, about 783 million people, who do not have access to improved drinking water. Also, water safety and quality in rural areas still remain problems.

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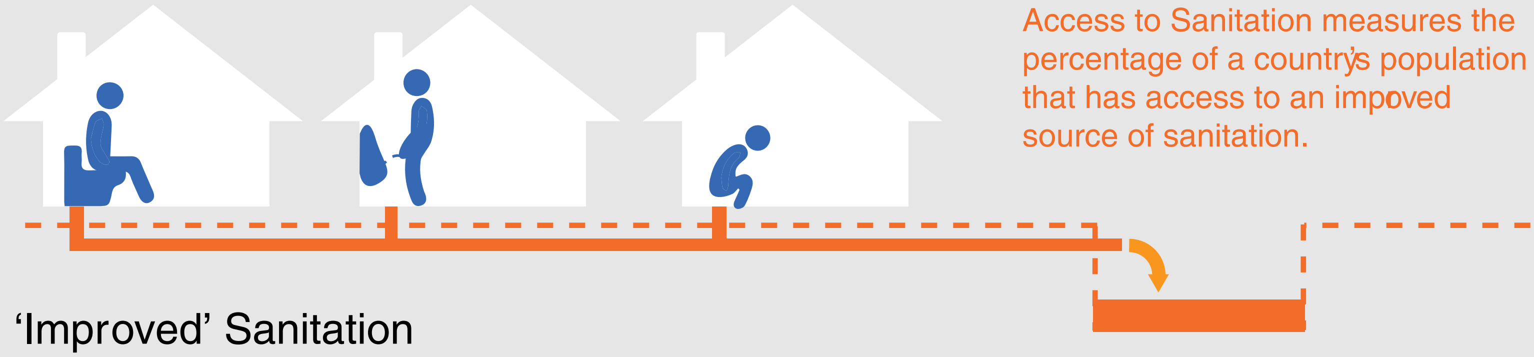
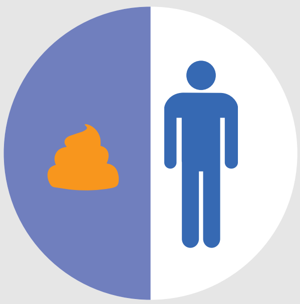
What is Access to Sanitation?

Access to Sanitation measures the percentage of a country's population that has access to an improved source of sanitation.



'Improved' Sanitation



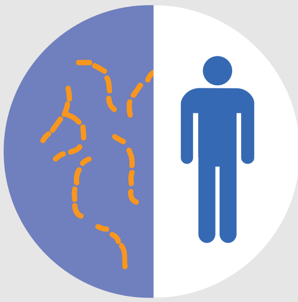
Separate Human Excreta from Human Contact

The system is considered "improved," if it hygienically separates human excreta from human contact and is not public, meaning that it can either be private or shared.

Non-public (Private or Shared)

Health Implications

Maintain healthy drinking water supply



Minimize contact with dangerous bacteria and viruses

Minimize environmental threats

How is the world doing?

Although there has been significant progress in access to sanitation worldwide, there are 2.5 billion people without access to basic sanitation worldwide.

40%

of global population doesn't have access to a clean hygienic toilet.

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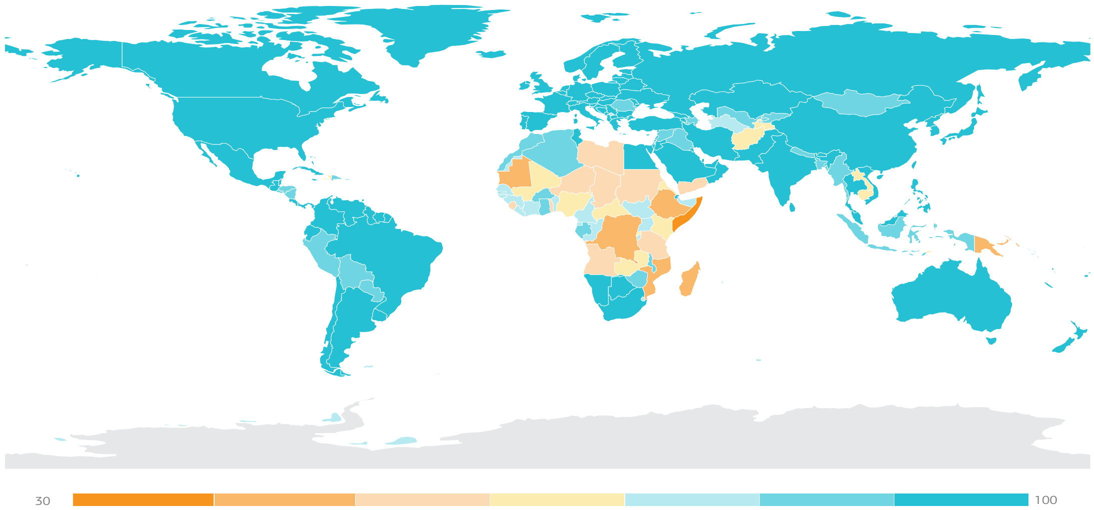


Figure 10. Global distribution of access to drinking water in 2011.

The quality of the datasets that make up these indicators is considered robust. The JMP,[44] which has made improvements to its methods, is a success story in coordinated international data collection. Prior to 1990, the WHO relied on self-reported data provided by country agencies and ministries of health to assess the global status of water supply and sanitation. By the late 1990s the limitations of self-reported data became clear, as definitions of access to water and sanitation varied both between and within countries. As the official UN mechanism tasked with monitoring progress towards the MDGs related to drinking water and sanitation, the JMP, beginning in 2000, made improvements in data collection, data standardization, and reporting. Today, the JMP estimates are derived from user-based data from nationally representative household surveys. Provider-based data is only used when no other source is available. The number of national surveys available to the JMP has increased over the years, and currently includes over 1,400 national datasets, the majority of which are nationally representative household surveys and censuses.[45]

While these datasets are robust, they do not comprehensively address concerns relating water to environmental and public health outcomes. Key information missing from the Access to Water dataset includes whether or not water is priced affordably (a factor for access) and if the quality of water is actually safe for consumption.[46] For example, naturally occurring arsenic in groundwater affects nearly 140 million people worldwide who rely on "improved" drinking water sources. Additionally, while providing adequate sanitation and access to improved drinking water minimizes the risk of coming into contact with dangerous bacteria and viruses, it is important to note that the dataset that informs the Access to Sanitation indicator

[44] World Health Organization and UNICEF. (2013) *History of the JMP*. Available: http://www.wssinfo.org/about-the-jmp/history/. Last accessed: January 11, 2014.

[45] World Health Organization and UNICEF Joint Monitoring Programme. *Data Updates*. Available: http://www.wssinfo.org/country-collaborations/data-updates/. Last accessed: January 11, 2014.

[46] Cooley, H., Ajami, N., Ha, M., et al. (2013) *Global water governance in the 21st century*. The Pacific Institute. California, United States. Available: http://www.pacinst.org/wp-content/uploads/2013/07/pacinst-global-water-governance-in-the-21st-century.pdf. Last accessed: January 11, 2014.

WORLD TOILET DAY RAISES AWARENESS TO SANITATION

Improved sanitation facilities have helped contribute to better health and cleaner living conditions around the world. (Source: vau902 / iStock-Thinkstock)

In 2011, more than 2.5 billion people worldwide did not have access to sanitary living conditions.[1] Put bluntly, two-fifths of the world's population did not have a clean, hygienic toilet. Questions of privacy and comfort aside, this shortcoming contributed to increased disease by directly exposing people to polluted water supplies. It reduced ecosystem function by increasing bacterial load in water. And it was one among many conditions that mired the global poor in relatively bad health. Political intransigence, stubborn cultural norms and taboos, and lack of investment all stymied the distribution and use of toilets worldwide.

So when the United Nations (UN) made increasing safe water and sanitation one of its Millennium Development Goals, toilets—once kept out of the international spotlight— took center stage.

In 2013, 48 years after joining the United Nations, Singapore proposed its first UN resolution, "Sanitation for All," which established an annual UN World Toilet Day recognized every November 19.[2] World Toilet Day calls for collective action to solve the global sanitation crisis by drawing attention to the problem. Part of raising awareness of the need for sanitation is working to break cultural taboos around toilets and sanitation by making the issue public and the unmentionable mentionable. If policymakers did not shy away from talk about toilets and were able to close the sanitation gap it could prevent the death of close to 2,000 children each day and prevent annual economic losses of roughly US$260 billion in developing countries.

World Toilet Day brings together the private sector, media, and international organizations to raise awareness of the sanitation issue. Using humor, such as its "Big Squat" campaign, World Toilet Day also stimulates serious dialog by highlighting the world's dire sanitation statistics. By talking about toilets every day and putting them in the spotlight once a year, World Toilet Day will help to save lives and improve economies.

More information about World Toilet Day can be found at http://worldtoiletday.org/.

[1] World Health Organization & United Nations Children's Fund (UNICEF). (2013) *Progress on Sanitation and Drinking Water 2013 Update*. Available: http://www.wssinfo.org/fileadmin/user_upload/resources/JMPreport2013.pdf. Last accessed: January 11, 2014.

[2] Chan, R. (2013) *Singapore's first UN resolution adopted; now, every Nov 19 is World Toilet Day*. The Straits Times. Available: http://www.straitstimes.com/breaking-news/singapore/story/singapores-first-un-resolution-adopted-now-every-nov-19-world-toilet-d. Last accessed: January 11, 2014.

[3] Eliasson, J. (2013). Statement by United Nations Deputy Secretary-General Jan Eliasson On the adoption by the General Assembly of "Sanitation for All" Resolution. New York. 24 July 2013. Available: http://www.un.org/sg/dsg/statements/index.asp?nid=424. Last accessed: January 11, 2014.

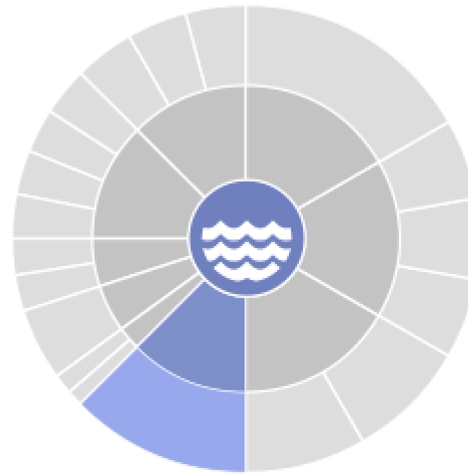
does not measure what proportion of waste is treated before it is released back into the environment. Untreated sewage pollutes freshwater sources and ocean ecosystems and puts human health at risk. To address this deficiency we have introduced a new indicator on wastewater treatment in the Ecosystem Vitality component of the overall 2014 EPI (see Issue Profile: Water Resources).

As the 2015 expiration date for the MDG draws closer, there is considerable interest within the UN to continue to work toward universal access to clean drinking water and sanitation through the creation of a Sustainable Development Goal (SDG) for water.[47] An SDG for water currently being proposed through this UN process would continue and extend goals for access to clean drinking water and sanitation for developing countries.[48] It would also apply universal targets for developed countries, since the developed world still has water management gaps that have yet to be addressed.[49] While much progress has been made to improve access to sanitation and drinking water worldwide, there are still millions of individuals that lack this basic human right.[50]

[47] World Health Organization and UNICEF Joint Monitoring Programme. (2013) *Goals, targets, indicators: post-2015 global monitoring*. Available: http://www.wssinfo.org/post-2015-monitoring/overview/. Last accessed: January 15, 2014.
[48] United Nations. Sustainable Development Goals. *United Nations Sustainable Development Knowledge Platform*. Available: http://sustainabledevelopment.un.org/index.php?menu=1300. Last accessed: January 11, 2014.
[49] World Health Organization and UNICEF Joint Monitoring Programme. (2013) *Goals, targets, indicators: post-2015 global monitoring*. Available: http://www.wssinfo.org/post-2015-monitoring/overview/. Last accessed: January 15, 2014.
[50] United Nations Resolution 64/292. (2010) *The human right to water and sanitation*. Resolution adopted by the General Assembly on 28 July 2010. Available: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/64/292. Last accessed: January 11, 2014.

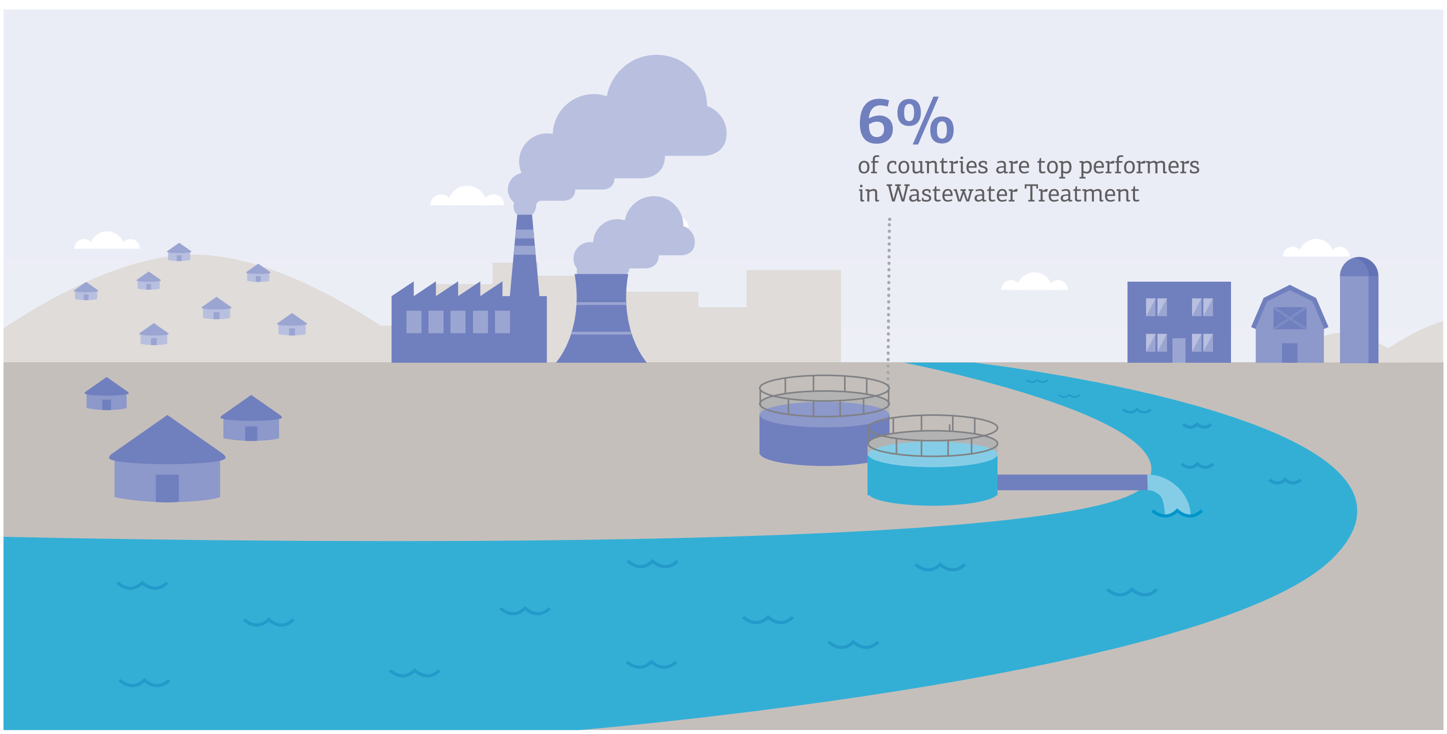
ISSUE PROFILE

Water Resources



What It Measures
The proportion of collected wastewater that is treated.

Why We Include It
The sole indicator in this category is Wastewater Treatment. Untreated sewage can disrupt the functioning of downstream ecosystems. Wastewater is comprised of domestic grey-water (water from baths, sinks, washing machines, and kitchen appliances) and black-water (water from toilets), as well industrial wastewater that may have additional chemical contaminants. It typically contains nutrients and chemicals that pollute natural water systems, resulting in a range of impacts from algal blooms to biological endocrine disruption. In rural areas, where pit latrines or septic systems are prominent, pollutants tend to be dispersed in the environment. In urban areas, however, functioning sewage systems that collect and treat wastewater concentrate the pollutants into discrete discharges that are more easily treatable.



The practice of water treatment is vital for the health of aquatic systems, provides health benefits for local residents, and ensures that clean water is available for re-use. Good wastewater management is especially relevant for areas facing more significant impacts of climate change and rapid population growth, since such areas may face more constrained water resources in the future.

Where The Data Comes From
This novel dataset was developed by the Yale Center for Environmental Law & Policy (YCELP). It represents a combination of environmental statistics reported from national ministries along with official statistics from the Organization for Economic Cooperation and Development (OECD), the United Nations Statistical Division (UNSD),

and the Food and Agriculture Organization of the United Nations (FAO), with inputs from the Pinsent Masons Water Yearbook and additional expert advice.

DESCRIPTION

Management of water resources is important for ecosystem health, and treatment of wastewater is an important component of overall management. Up to 90 percent of the discharged wastewater produced in developing countries is untreated when it is released back to the environment.[51]

Untreated wastewater contributes to high pollution levels, eutrophication of water bodies, high coliform bacteria counts, and, in extreme cases, hypoxia and fish-kills, as described below.

The Wastewater Treatment indicator measures how countries engage in treatment efforts at the municipal level, weighting the results for multiple municipalities by city population size as measured by the coverage of the sewerage network. It is distinct from other related indicators such as the JMP's "Access to Sanitation" metrics which only survey latrine access at a basic level and do not speak to water quality or ecosystem health.

Wastewater is the water that has been used by households and industries that, unless treated, no longer serves a useful purpose. Gray-water is from household sinks, washing machines, and kitchen appliances and contains nutrients and chemicals. Black-water comes from toilets. Left untreated, nutrients and chemicals go into natural water systems where they cause harm to the environment and human health. Wastewater treatment requires a system for collection—normally through sewage pipes—and treatment at different levels, which are described below. Treatment plants can be public or private utilities that serve a given municipality.[52]

Even where wastewater treatment plants exist, they may not have the capacity to treat all of the water collected. This situation can arise when the population of a city outpaces the development of new treatment facilities or because of a lack of funding. As a result, many wastewater treatment facilities discharge excess wastewater directly into waterways or coastal areas, and, in other cases, the existing treatment plants are simply dysfunctional.[53]

Ideally, the Wastewater Treatment indicator would measure the proportion of all household waste that is treated. Unfortunately, this is impossible as figures on total wastewater generation are unavailable for most countries. Furthermore, while centralized treatment systems may be appropriate for dense urban areas, in many rural areas, decentralized treatment systems may be the better solution. But because rural areas do not always provide data, this indicator is limited to an urban scope. This presents an obvious problem for rapidly growing places where many new residents live in areas outside the municipality's core infrastructure, and hence are not connected to centralized sewage treatment facilities.

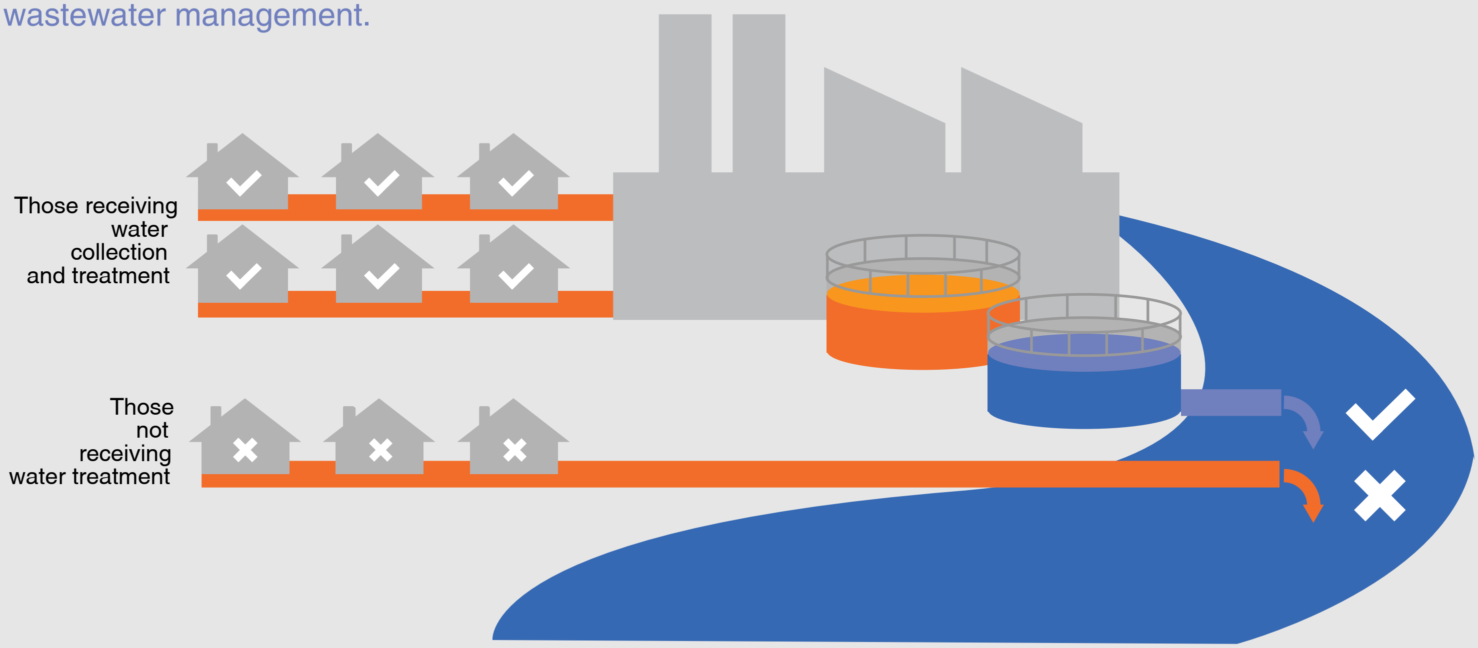
[51] Corcoran, E., Nellemann, C., Baker, E., et al. (eds). (2010) *Sick Water? The central role of wastewater management in sustainable development: A Rapid Response Assessment*. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. Available: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=617&ArticleID=6504&l=en&t=long. Last accessed: January 7, 2014.

[52] *Ibid.*

[53] *Ibid.*

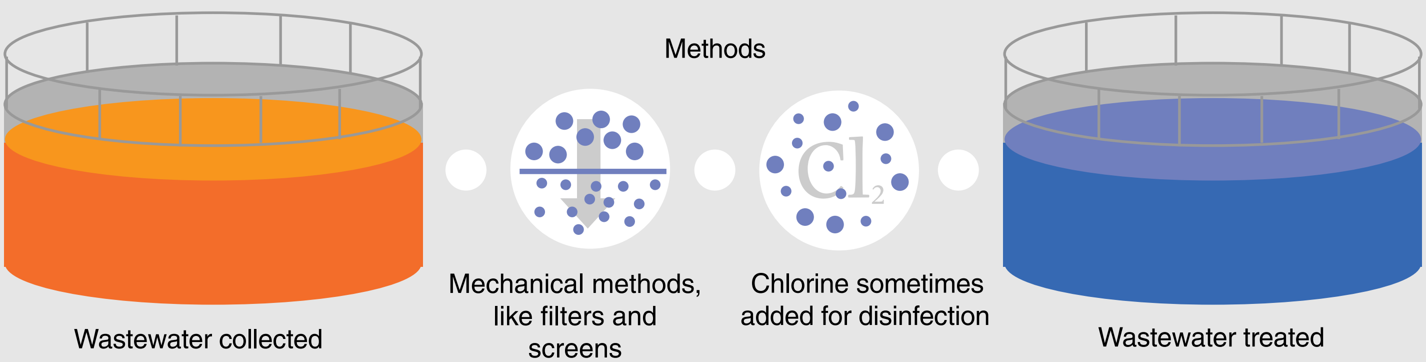
What is Wastewater Treatment?

This indicator tracks how well countries treat wastewater from households and industrial sources before it is dumped into the environment. It tracks the performance of basic wastewater management.



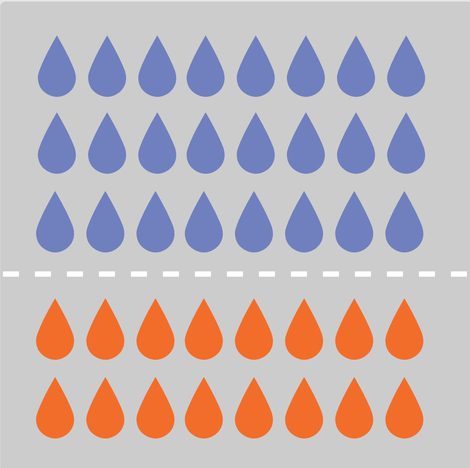
Primary Treatment and Beyond

There are different levels of wastewater treatment. We consider the definition "at least primary treatment," which removes a lot of suspended solids and reduces biochemical oxygen demand. Extra steps may be taken to treat the water further.



How do we know?

The Percentage of Wastewater Treated in the Sewerage System × The Percentage of Population Connected to the Sewerage Network = The Index Score for Wastewater Treatment



The total amount of wastewater in the system, from household and some industrial sources.

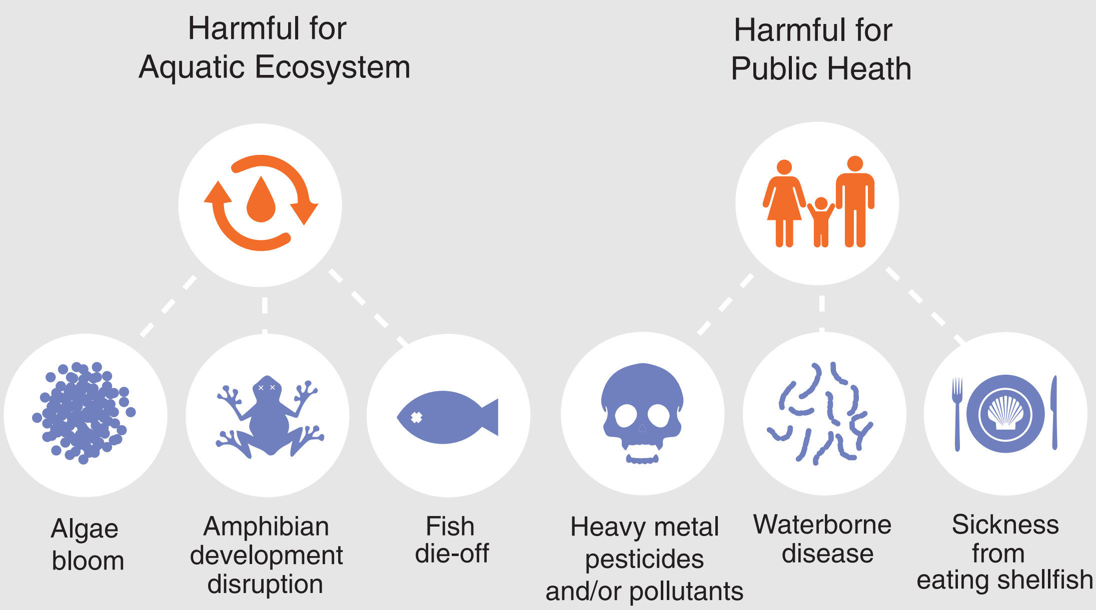
The total resident populationin a country.

Why does it matter?

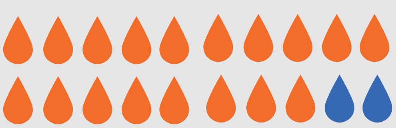
Downstream Effects of Wastewater

The downstream effects of untreated wastewater are bad for public health and the health of aquatic ecosystems.

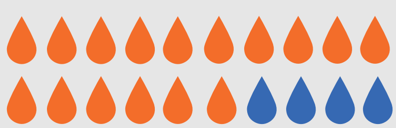
When pollutants enter the water cycle, aquatic species and humans can be directly harmed through infection or the disruption of their biological development, and they can be harmed indirectly through nutrient loading that causes eutrophication.



Do you know?



90% Up to 90% of wastewater in developing countries is sent into rivers and open water bodies.



80% 80% of the world's marine pollution comes from sources onland, and wastewater contributes to much of it.

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- World Bank. Introduction to wastewater treatment processes." Available: http://water.worldbank.org/shw-resource-guide/infrastructure/menu-technical-options/wastewater-treatment
- Baum, R., Luh, J., & Bartram, J (2013). Sanitation: A global estimate of sewerage connections without treatment and the resulting impact on MDG progress. Environmental Science & Technology, 47, 1994-2000.oxide Emissions?", What's Your Impact (WYI): http://www.whatsyourimpact.org/co2-sources.php

Thus, this indicator assesses the proportion of wastewater that is treated for those households that are connected to the sewerage system. It measures wastewater that mostly comes from household sources, but in some cases industrial sources contribute if they share the municipal collection network. This varies on a country-by-country basis. Despite the known limitations, expert review confirms that this measure still provides a useful metric against which to judge country performance.

Wastewater pollution can lead to algal blooms from eutrophication, which is the addition of enough nutrients to an ecosystem to cause certain plant species such as algae to proliferate at the expense of other species. Eutrophication, in turn, can lead to fish die-offs because the decomposition of organic plant matter depletes the water of oxygen. This can lead to economic hardship for those people living off such aquatic resources. Shellfish poisoning may also occur since such organisms tend to accumulate biological and chemical contaminants and consumers often eat raw shellfish.[54] Similarly, biological effects such as

[54] Shuval, H. (2003) Estimating the global burden of thalassogenic diseases: human infectious diseases caused by wastewater pollution and the marine environment. *Journal of Water and Health* 1:53-64.

EVOLUTION OF WATER QUALITY INDICATORS IN THE EPI

Over the past 15 years of the EPI (and its predecessor, the Environmental Sustainability Index), we have seen improved data and indicators in a number of areas, including biodiversity conservation, oceans and fisheries, and climate change. Data challenges, however, have persisted in some key areas such as water quality, water scarcity, and water management. The gap is especially glaring since improvements in water quality are generally seen as a major benchmark of environmental performance, and water resources management is a critical factor in sustainable development.[1] Scalable[2] indicators that describe the management of water resources and the status of aquatic ecosystems – and that can guide government efforts in water resources management – are certainly in demand.

Over the years, the EPI has sought to measure country-level water quality in a number of ways using at different times *in situ* monitoring data and modeled data (including data from hydrological models). Early versions of the Environmental Sustainability Index relied on modeled data of biochemical oxygen demand from the World Bank, and crude estimates of national water availability from the United Nations Food and Agriculture Organization’s Aquastat. Later versions of the Environmental Sustainability Index attempted to aggregate data from the United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme database, GEMStat, with limited success. In 2006, modeled nitrogen loads were used to calculate nitrogen concentrations by river basin. From 2008 to 2010 the EPI team partnered directly with GEMS/Water to produce a Water Quality Index based on *in situ* monitoring data for dissolved oxygen, conductivity, pH, nitrogen, and phosphorus, but this effort was eventually abandoned owing to data gaps.[3] For the 2012 EPI, indicators of water quality endocrine-disruption can occur due to the presence of pharmaceutical products or chemicals in waterways.[55]

Harmful human health effects can also result from untreated wastewater. There are a host of bacterial, viral, and protozoan organisms that can survive in human waste and fecal matter, most notably the bacterium *Escherichia coli* (or *E. coli*), which can cause various forms of diarrhea.[56] Other pathogens include the bacteria *Vibrio cholerae*, *Shigella* spp., and *Campylobacter* spp., as well as noroviruses and rotaviruses. As a consequence, diseases such as bancroftian filariasis worm-caused schistosomiasis can result from human consumption of untreated wastewater.[57]

[55] Corcoran, E., Nellemann, C., Baker, E., et al. (eds). (2010) *Sick Water? The central role of wastewater management in sustainable development: A Rapid Response Assessment*. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. Available: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=617&ArticleID=6504&l=en&t=long. Last accessed: January 7, 2014.

[56] World Health Organization. (2011) *Guidelines for drinking-water quality, 4th edition*. Available: http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/. Last accessed: January 7, 2014. World Health Organization. (2011) Guidelines for drinking-water quality, 4th edition. Available: http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/. Last accessed: January 7, 2014.

[57] Baum, R., Luh, J., and J. Bartram. (2013) Sanitation: A global estimate of sewerage connections without treatment and the resulting impact on MDG progress. *Environmental Science & Technology* 47:1994-2000.

were discarded in favor of a measure of alterations in natural river flow caused by water withdrawals and reservoir construction (based on modeled data from Doll et al. 2009),[4] but this was a crude proxy at best and suffered from the lack of regularly updated data. The EPI has also experimented with a number of water stress indicators, mostly based on calculations derived from global hydrological models. Examples include percent of territory under water stress (where withdrawals are greater than 40 percent of supply), and a measure of scarcity that allowed arid countries to compensate for limited natural endowments with desalination and treated wastewater.

Collectively, these indicators are not capturing the most policy-relevant issues, and in many cases are too heavily influenced by each country's water endowment. Conversations with other groups seeking to develop country-level water indicators suggest that these challenges are widely shared. Therefore, the 2014 EPI includes a new indicator of national wastewater treatment. Designed and compiled by the Yale Center for Environmental Law & Policy, this new indicator is a first step toward developing more performance-relevant measures of ecosystem water quality.

[1] United Nations Environment Programme Global Environment Monitoring System (GEMS) /Water Programme. (2008) *Water Quality for Ecosystem and Human Health Second Edition*. Ontario, Canada. Available: http://www.unep.org/gemswater/Portals/24154/publications/pdfs/water_quality_human_health.pdf. Last accessed: January 11, 2014.

[2] A scalable indicator can be developed for any level of jurisdiction, from district/county up to country level.

[3] Srebotnjak, T., Carr, G., de Sherbinin, A., et al. (2012) A global water quality index and hot-deck imputation of missing data. *Ecological Indicators* 17:108-119.

[4] Döll, P., Fiedler, K., and Zhang, J. (2009) Global-scale analysis of river flow alterations due to water withdrawals and reservoirs. *Hydrology and Earth Systems Science* 13:2413-2432.

Settlement ponds are an effective part of the wastewater treatment process.
(Credit: antikainen / iStock-Thinkstock)

THE WASTE REUSE ENERGY NEXUS

Linkages between environmental phenomena mean that policy actions do not have impacts in isolation. In some cases, strong performance on one indicator may lead to a worse score on another indicator. One example of such a trade-off is the relationship between wastewater treatment and per capita carbon dioxide emissions.

Wastewater treatment rate is a valuable measure of water quality. However, wastewater treatment is generally an energy-intensive process, and in a world where energy consumption is dominated by fossil fuels, the intensive use of energy implies heavy emissions of carbon dioxide. According to the U.S. Environmental Protection Agency, drinking water and wastewater systems in the United States account for approximately 3 to 4 percent of energy use, and they are responsible for over 45 million tons of greenhouse gases each year.[1] This is equivalent to the emissions of roughly nine million passenger vehicles.[2]

Generally speaking, countries devote their limited resources to the problems with the highest materiality and relevance to their specific circumstances. Many Middle Eastern and Northern Africa countries treat a large percentage of wastewater collected for reuse. Thus the Middle East and Northern Africa region has the highest wastewater treatment rate in the developing world. (The Arab Water Council reported that up to 83 percent of the treated wastewater in the Arab Region was reused in the agricultural sector in 2011).[3] The higher treatment rate correlates with higher energy input and emissions, exacerbating a trend of poor climate and energy performance in the region. Five out of the 10 countries with the highest per capita carbon dioxide emissions in 2010 were in the Middle East and Northern Africa, with Qatar topping the charts.[4] The fact that this region's countries are willing to spend a vast amount of energy to treat a high percentage of their wastewater for reuse reflects the region's energy-rich, water-stressed reality.

Trade-offs like these may seem to prevent countries from performing well on the EPI. Fortunately, there are ways to minimize the conflict between responsible water treatment and climate protection. The most straightforward and cost-effective solution is increased energy efficiency within wastewater treatment plants. Studies have estimated readily achievable, cost-saving energy reductions of 15 to 30 percent in water and wastewater plants. Such efficiency improvements would pay for themselves, generating significant financial returns.

A second, larger-scale solution is the increased incorporation of renewable, carbon-free energy sources into the electricity grid. While this fix would not reduce the energy consumption of wastewater plants, it would mitigate their carbon emissions.

Lastly, some researchers have suggested that municipalities could ultimately take advantage of the organic and thermal content of wastewater, converting the treatment process into a net energy generator.[5] While such a result would require the further development of new membrane processes and the complete anaerobic treatment of wastewater, the net generation of energy from wastewater treatment ought to serve as a goal toward which all governments strive.

[1] US Environmental Protection Agency. (2013) *Greenhouse gas equivalencies calculator.* Washington, D.C. Available: http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results. Last accessed: January 4, 2014.

[2] *Ibid*.

[3] Choukr-Allah, R. (2011) *Regional experience of wastewater treatment and reuse in the Arab countries*. Presentation at Expert Consultation Wastewater Management in the Arab World on 22-24 May 2011: Dubai, United Arab Emirates. Available: http://www.arabwatercouncil.org/administrator/Modules/CMS/ICBA_Choukrallah-Wastewater-treament-reuse-Arab-region.pdf. Last accessed: January 11, 2014.

[4] The World Bank. *CO2 emissions 2009-2013*. Available: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC?order=wbapi_data_value_2010+wbapi_data_value+wbapi_data_value-last&sort=desc. Last accessed: January 11, 2014.

[5] National Biosolids Partnership. *The potential power of renewable energy generation from wastewater and biosolids fact sheet*. Water Environment Federation: Alexandria, Virginia. Available: http://www.wef.org/uploadedFiles/Biosolids/Biosolids_Resources/Newsletter/Newsletter_PDFs/Potential%20Power%20of%20Renewable%20Energy%20Generation.pdf. Last accessed: January 11, 2014.

Fortunately, many of these problems can be ameliorated by good wastewater treatment, since treating has been shown to drastically reduce pathogen concentrationst.[58]

Treatment is done in sequential steps that have different levels of complexity depending on the resources available. The typical range of treatment options is primary, secondary, and tertiary treatment. Primary treatment involves basic processes such as settlement tanks to remove suspended solids from water and to reduce biochemical oxygen demand (BOD). Secondary treatment involves biological degradation that allows bacteria to decompose elements in the wastewater more, further reducing nutrient levels and BOD. The highest form of wastewater treatment is tertiary treatment, which is any process that goes beyond the previous steps and can include the use of sophisticated technology to further remove contaminants or specific pollutants. Tertiary treatment is typically employed to remove phosphorous or nitrogen content, which cause eutrophication.[59]

While the Wastewater Treatment indicator would ideally consider more advanced levels of treatment, data availability and gaps restrict consideration to only the wastewater that receives “at least primary treatment” because it’s the only common definition available for globally comparable measurements.

Water and sanitation policy discussions in the past decade have gone beyond basic access measures, with increasing focus on wastewater treatment. This change shows that interest is shifting toward including water quality as well as water quantity in performance metrics.[60] However, there is global need for more and better data on wastewater generation, treatment, and use.

Discussions on the post-2015 international development agenda and SDGs at the UN will potentially lead to a specific goal on water, which may include focused targets on wastewater treatment.[61] The SDGs, which must be “aspirational, universal, communicable, and measurable,” aim to create global targets for all countries between 2015 and 2030. They are based on the model of the MDGs set in 2000.[62] Following the 2013 World Water Week, YCELP hosted an expert workshop in Stockholm, Sweden. Experts at the meeting provided strong encouragement for the development of this indicator.

The development of an SDG on wastewater treatment is critical since it will encourage higher levels of performance and likely result in better data for future monitoring. This effort represents a first important step in this direction.

[58] World Health Organization. (2011) *Guidelines for drinking-water quality, 4th edition*. Available: http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/. Last accessed: January 7, 2014.

[59] World Bank. *Introduction to wastewater treatment processes*. Available: http://water.worldbank.org/shw-resource-guide/infrastructure/menu-technical-options/wastewater-treatment. Last accessed: January 7, 2014.

[60] Bjornsen, P. (2013) *Post-2015 targets and their monitoring: SDG on water*. Presentation at World Water Week. 1-6 September 2013. Stockholm, Sweden.

[61] *Ibid*.

[62] United Nations, Sustainable Development Knowledge Platform. *Sustainable development goals*. Available: http://sustainabledevelopment.un.org/index.php?menu=1300. Last accessed: January 7, 2014.

CREATING THE WASTE WATER TREATMENT INDICATOR

Despite the critical nature of wastewater treatment for freshwater quality, no global databases exist to measure it. Decisionmakers are discussing water quality in the context of United Nations Sustainable Development Goals (SDGs) (see Box: The EPI and the SDGs), highlighting the need for metrics, and the EPI team has worked in parallel with global water experts to conceptualize an indicator to assess wastewater treatment performance—the latest attempt of its kind. This indicator can now provide a valuable baseline by which to measure progress. After all, whether countries treat wastewater effluent says a lot about how those countries manage their overall water quality.

The Yale Center for Environmental Law & Policy team initially researched as widely as possible to track down every existing source of data on wastewater treatment. After conducting an extensive literature review, we found that no single database existed that was comprehensive enough to develop a global indicator. So the team decided to make its own dataset. In what was an innovation for the EPI, the team went country-by-country to find data wherever available, and, after a burst of research activity, eventually found enough data to put this issue on the Index.

However, there were challenges in the process. Wastewater data were often reported at only local or regional scales, limiting the study to a mainly urban scope. Data were also reported from various sources ranging from national state-of-the-environment reports to annual reports from private utilities. They were also reported sparsely through time. On top of that, definitions for “wastewater” varied. For instance, many sources did not make it clear whether the effluent they were describing was from industrial, municipal, or household waste. Often it was a combination, which is reflected in the indicator. Many reports also did not clarify whether the level of treatment was primary, secondary, or tertiary, so the EPI indicator covers them all (see Box: Primary vs. Secondary Wastewater Treatment). Reported statistics also had to be parsed for whether they referred to populations served or volumes of water treated.

The final dataset combines the team’s country-level findings with official statistics from the Organization for Economic Cooperation and Development, the United Nations Statistical Division, the Food and Agriculture Organization of the United Nations, and inputs from the Pinsent-Masons Water Yearbook. In cases where country-level data were not available, city-level data for major cities were used. In a few other cases, the team had to make judgment calls based on evidence, using peer-reviewed literature and conversations with in-country experts. To address consistency, multi-year averages were used, and, to ensure environmental rigor, the final treatment values were weighted by sewerage connection rates to create the final indicator.

Despite the early challenges of its construction, this intensive effort was worthwhile in the end. The international community now has a starting point by which to judge this major driver of both ecosystem and public health.

PRIMARY VERSUS SECONDARY: TYPES OF WASTEWATER TREATMENT

Wastewater treatment is done in a series of steps that can have increasing effectiveness and complexity depending on the resources available. The conventional sequence goes from primary, secondary, to tertiary treatment.[1]

Primary treatment involves basic processes to remove suspended solid waste and reduce its biochemical oxygen demand (BOD) – the amount of oxygen microorganisms must consume to breakdown the organic material present in the wastewater. This, in turn, increases dissolved oxygen, which is good for aquatic organisms and food webs.[2] Primary treatment can reduce BOD by 20 to 30 percent and suspended solids by up to 60 percent.[3]

Secondary treatment uses biological processes to catch the dissolved organic matter missed in primary treatment. Microbes consume the organic matter as food, converting it to carbon dioxide, water, and energy.[4] While secondary treatment technologies vary, from the activated sludge process New York City deploys, to constructed wetland systems, the final phase of each involves an additional settling process to remove more suspended solids.[5] Secondary treatment can remove up to 85 percent of BOD and total suspended solids.[6]

The highest level of wastewater treatment is tertiary treatment, which is any process that goes beyond the previous steps and can include using sophisticated technology to further remove contaminants or specific pollutants. Tertiary treatment is typically used to remove phosphorous or nitrogen, which cause eutrophication.[7] In some cases,

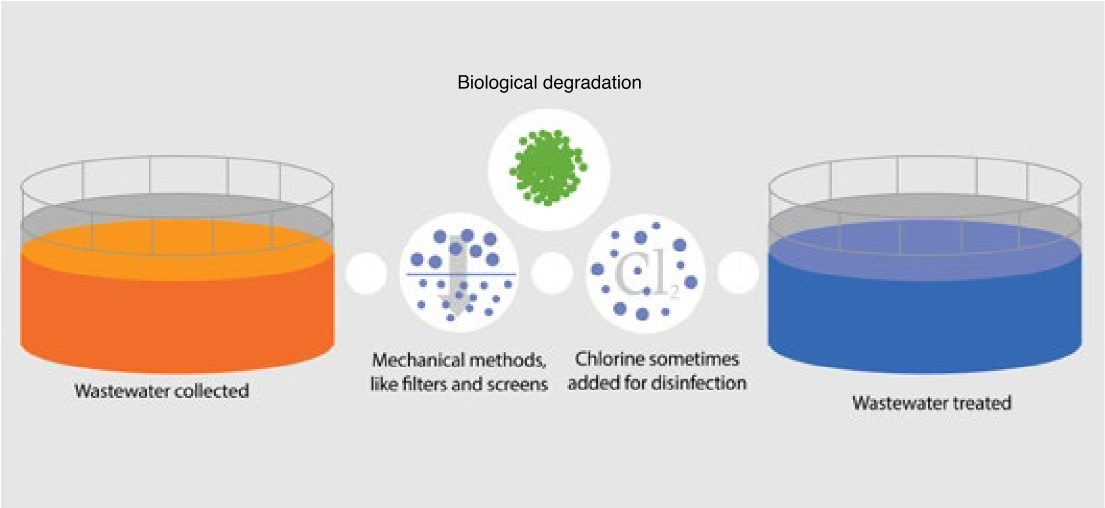
[1] World Bank. *Introduction to wastewater treatment processes*. Washington, D.C. Available: http://water.worldbank.org/shw-resource-guide/infrastructure/menu-technical-options/wastewater-treatment. Last accessed: November 30, 2013.
[2] Encyclopedia Britannica. *Wastewater treatment*. Available: http://www.britannica.com/EBchecked/topic/666611/wastewater-treatment. Last accessed: December 24, 2013.
[3] Flörke, M., personal communication. December 5, 2013.
[4] *Ibid*.
[5] NYC Environmental Protection. *New York City's wastewater treatment system*. Available: http://www.nyc.gov/html/dep/html/wastewater/wwsystem-process.shtml. Last accessed: January 2, 2014.
[6] Flörke, M., personal communication. December 5, 2013.

treatment plant operators add chlorine as a disinfectant before discharging the water. All in all, tertiary treatment can remove up to 99 percent of all impurities from sewage, but it is a very expensive process.[8]

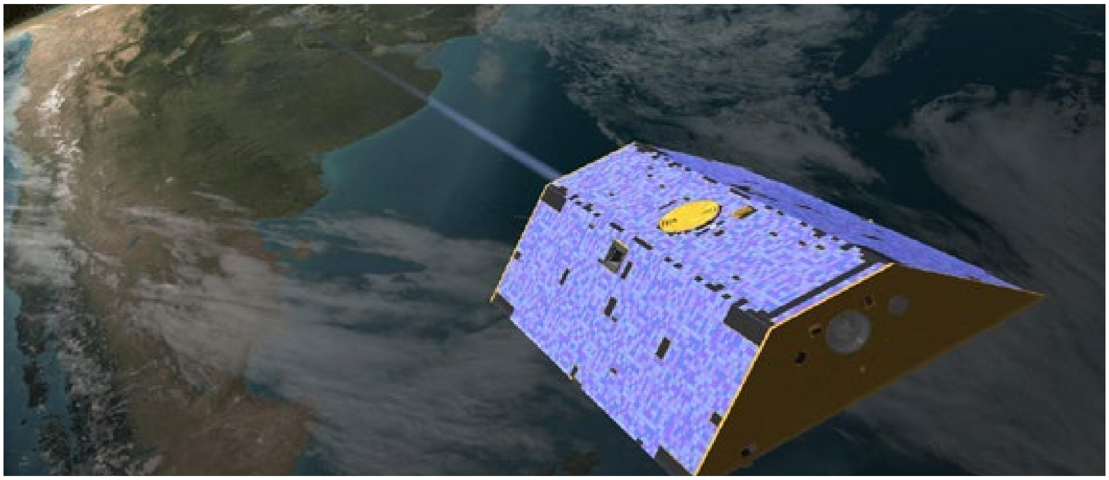
Ideally the Wastewater Treatment indicator would showcase more advanced levels of treatment, but most countries lack the necessary data. The EPI's indicator considers "at least primary treatment," because reported values of overall treatment performance entail going through primary treatment first. Hopefully, layers of specificity can be added in the future as more refined data becomes available.

[7] World Bank. *Introduction to wastewater treatment processes*. Washington, D.C. Available: http://water.worldbank.org/shw-resource-guide/infrastructure/menu-technical-options/wastewater-treatment. Last accessed: November 30, 2013.

[8] Flörke, M., personal communication. December 5, 2013.



A sequence of steps is required to ensure wastewater gets treated. (Source: Yinan Song)



The GRACE satellites have been useful for identifying droughts and other hydrological conditions in real time (Credit: NASA)

THE FUTURE OF WATER RESOURCE MANAGEMENT

Technological breakthroughs from the U.S. National Aeronautics and Space Administration (NASA) are changing the possibilities for future water resource measurements. Using satellite-derived data, researchers can now estimate how much water countries have by tracking how their aquifer levels change over time. Researchers Matthew Rodell and Jay Famiglietti first used the Gravity Recovery and Climate Experiment (GRACE) satellite to observe the depletion of the whole U.S. High Plains aquifer.[1] Subsequently, the technique has been used to investigate aquifers around the world, showing that everywhere – from California's Central Valley[2] to northern India's Rajasthan, Punjab, and Haryana states[3] – precious water supplies are being drained.

The GRACE project, initially started to observe fluctuations in the Earth's gravity field, uses a pair of satellites that travel in tandem to measure slight changes in their relative distances to each other while they orbit. These variations are caused partly by huge masses of water residing in the world's water basins, which are large enough to affect the pull of gravity. There are limits to what the satellites can do, however. The spatial resolution for aquifers is roughly only 75,000 square miles, which limits its utility for tracking water resources on a smaller scale.[4] Furthermore, basins don't necessarily conform to national boundaries, which makes national policy responses to water loss more difficult.

Still, the satellite data offers empirical measurements free from economic or political drivers, and it is highly time-relevant. In 2011, for example, researchers used GRACE data to monitor the Texas drought and report the local groundwater water levels every week to the American public.[5] Perhaps in the future these techniques can be used to communicate just how critical the need is for better water management worldwide.

[1] Rodell, M. and Famiglietti, J.S. (2002) The potential for satellite-based monitoring of groundwater storage changes using GRACE: the High Plains aquifer, Central US. *Journal of Hydrology* 263:245-256.

[2] Berringer, F. (2011) *Groundwater depletion is detected from space*. The New York Times, 31 May 2011. Available: http://www.nytimes.com/2011/05/31/science/31water.html?pagewanted=all. Last visited: January 11, 2014.

[3] Cook-Anderson, G. (2009) *NASA satellites unlock secret to northern India's vanishing water*. National Aeronautics and Space Administration: Washington, D.C. Available: http://www.nasa.gov/topics/earth/features/india_water.html. Last accessed: January 7, 2014.

[4] Berringer, F. (2011) *Groundwater depletion is detected from space*. The New York Times, 31 May 2011. Available: http://www.nytimes.com/2011/05/31/science/31water.html?pagewanted=all. Last visited: January 11, 2014.

[5] National Aeronautics and Space Administration (NASA). (2011) *Texas drought visible in new national groundwater maps*. Washington, D.C. Available: http://www.nasa.gov/topics/earth/features/tx-drought.html#.UrvZKWRDvZ4. Last accessed: January 7, 2014.

ASSESSING EMBODIED WATER CONSUMPTION

Water is necessary for just about everything we buy and use: powering our buildings and infrastructure, at every step in global supply chains, in great volumes for agriculture and food production; the list is endless. As its availability declines due to climate change, an account of how much people use may go a long way toward managing future scarcity. Unfortunately a means for doing that has proven elusive. Although direct use, like drinking, bathing, and cooking, is relatively easy to monitor, it only accounts for a portion of water use. It follows that indirect consumption of water is difficult to track.

The Water Footprint Network, an organization hosted by the University of Twente in the Netherlands, has made incredible strides toward pointing the way. Based on pioneering research by Arjen Hoekstra, the Water Footprint Network has developed a method for calculating the average total freshwater use per capita in most countries on the planet. This endeavor is inherently difficult and made even more so by the fact that not all water withdrawals in a country are used within its borders—consider exported products and services, for instance. And what about the difference between water withdrawals and the volume of water that is polluted through industry? All of these considerations are accounted for in the Water Footprint Network's methodology.

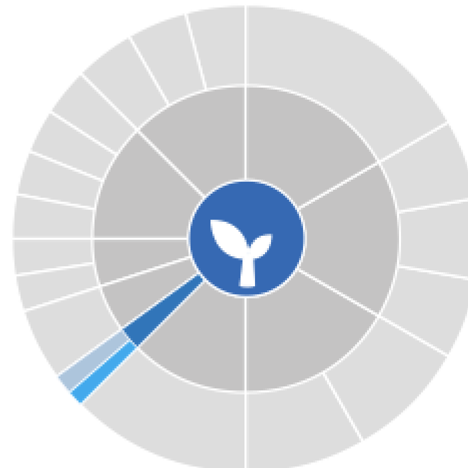
The Water Footprint Network's webtool allows users to calculate per capita water use, aggregate national use, use by corporations, and to search by industrial sector, region, and even watershed. The goal, of course, is to improve water policy and management at all scales. However the ingenuity of the tool, and its ease of use is an innovation in and of itself. Embedded water consumption values are highly variable among nations, and merely playing around with the tool yields interesting insights about the state of world consumption. The average consumer in the United States, for example, has a water footprint of 2,842 cubic meters per year, while the average consumer in China has a water footprint of 1,071 cubic meters per year.[1]

The data derived from the application of this Water Footprint Index's methods provide valuable snapshots of consumption patterns and comparative demand for internal and external water resources. However, there are limits. It is difficult to read too much about the welfare of human and ecological systems within countries simply by understanding water consumption data. And because the information given is at a national scale, without regional or local data per capita, it can be difficult for individuals to know where they stand or how they can improve. The primary significance of the Water Footprint Network's tools—to begin to account for and manage real water use—cannot be overstated.

The Water Footprint concept helps consumers understand the resources required for the production of basic goods. (Source: crossstudio / iStock-Thinkstock)

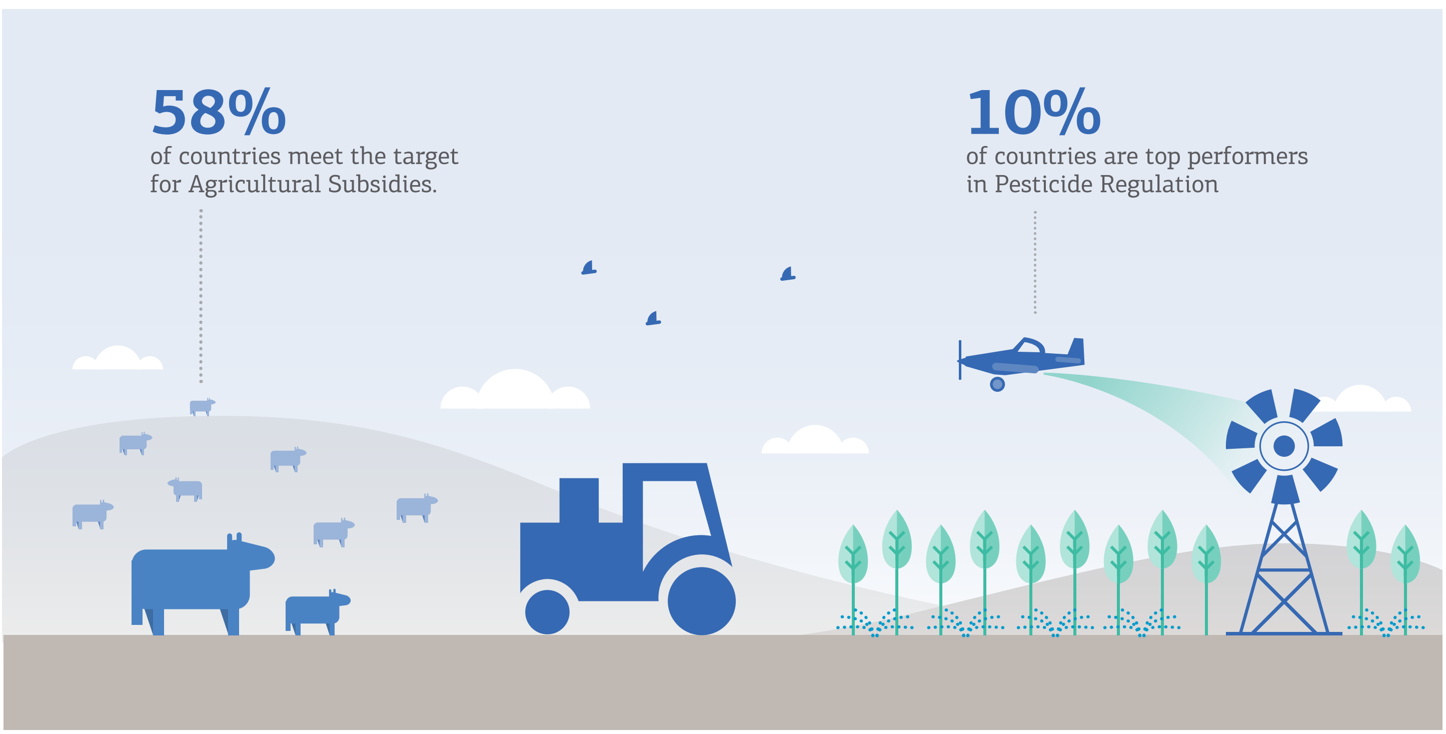
[1] Mekonnen, M. M. and Hoekstra, A. Y. (2011) *National water footprint accounts: the green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No. 50*, UNESCO-IHE: Delft, the Netherlands. Available: http://www.waterfootprint.org/Reports/Report50-NationalWaterFootprints-Vol1.pdf. Last accessed: December 26, 2013.

Agriculture



What It Measures

There are two indicators in this category. Agricultural Subsidies is a proxy measure for the degree of environmental pressure exerted by subsidizing agricultural inputs. Pesticide Regulation assesses the status of countries' legislation regarding the use of chemicals listed under the Stockholm Convention on Persistent Organic Pollutants (POPs). Pesticide Regulation also scores the degree to which these countries have followed through on limiting or outlawing these chemicals.



Why We Include It

According to a report by the OECD,[63] public subsidies for agricultural protection and agrochemical inputs exacerbate environmental pressures through the intensification of chemical use, the expansion of farmland into sensitive areas, and the overexploitation of resources like water and soil nutrients. Pesticides are a significant source of pollution in the environment. They kill beneficial insects, pollinators, and fauna, and human exposure to pesticides has been linked to increased rates of neurological and reproductive disorders, endocrine disruption, and cancer.[64]

Where the Data Come From

The World Bank provides a database of Nominal Rate of Assistance, which is defined as "the percentage by which government policies have raised gross returns to farmers above what they would be without the government's intervention […]."[65]

The pesticides included in this indicator are the 'dirty dozen' POPs. A few notorious POPs include DDT and dioxins and furans, which are known to be extremely toxic and harmful to human and wildlife health and ecosystems at large.[66]

DESCRIPTION

Industrial agricultural activity has a direct and profound impact on the environment. At the local and landscape scales, its influences coincide with many major environmental concerns: soil quality, water quality and availability, air quality, carbon pollution and climate change, habitat fragmentation, deforestation, and biodiversity loss.[67,68] Even fisheries can be affected, as evidenced by dead zones in the Gulf of Mexico and the Chesapeake Bay, both of which were largely caused by fertilizer runoff.

In the 2014 EPI, two indicators comprise the Agriculture category. Combined, these indicators evaluate countries on actions they have taken to reduce the harmful effects of inputs related to intensive agriculture. Unfortunately, neither indicator in this category is a direct measurement of agricultural environmental performance. Instead, they are both proxies related to policy intent. The indicators assess policy performance regarding practices that adversely affect ecosystems. Research has shown that agro-subsidies and the relative strength of regulations on pesticides correlate strongly to the environmental impacts of agricultural activities.[69]

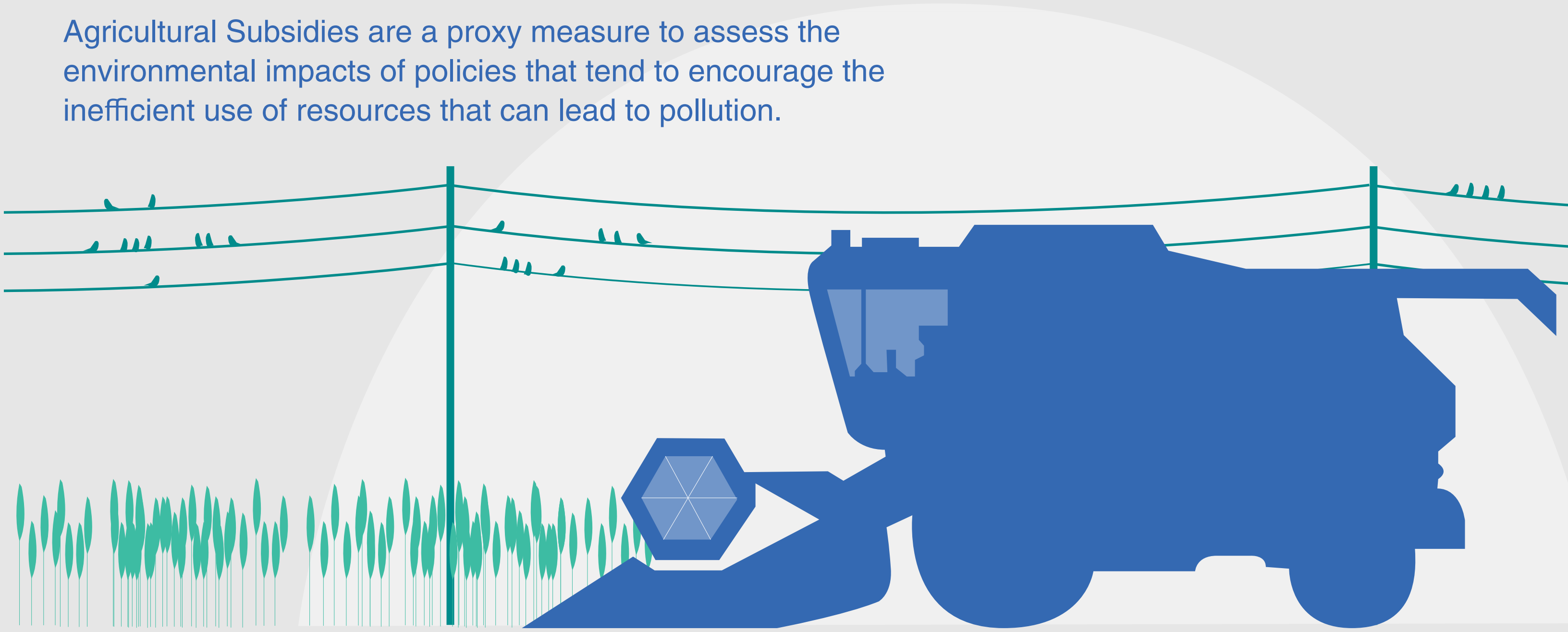
Agricultural Subsidies

Agricultural subsidies, which are generally adopted only by countries that are wealthy enough to afford them, promote the use of fertilizers and pesticides. The relationship is pretty simple: with subsidization, the more intensive agriculture tends to become, which can lead to heavier environmental footprints.[70] While it historically has been the case that only wealthy countries have been able to subsidize agricultural products, many developing countries are following suit – a move that is already proving to have negative environmental externalities. Since the 2001 Doha round talks of the World Trade Organization (WTO), the developing countries that voiced the most opposition to agricultural subsidies in the United States and the European Union – primarily China, Brazil, India, Russia, and Indonesia – have grown their own

[63] Organization for Economic Cooperation and Development Working Group on Environmental Information and Outlook. (2004) *OECD Workshop on Material Flows and Related Indicators: Chair's Summary. ENV/EPOC/SE(2004)2*. Paris, France. Available: http://www.oecd.org/env/indicators-modelling-outlooks/32367214.pdf. Last accessed: January 10, 2014.
[64] Alavanja, M. C. R., Hoppin, J. A., and Kamel, F. (2004) Health effects of chronic pesticide exposure: Cancer and Neurotoxicity. *Annual Review of Public Health* 25:155-97.
[65] Anderson, K. (2009) Distorted agricultural incentives and economic development: Asia's experience. *The World Economy*, 32:351-384.
[66] Jones, K. C. and de Voogt, P. (1999) Persistent organic pollutants (POPs): state of the science. *Environmental Pollution* 100:209-221.
[67] Tilman, D, Cassman, K. G., Matson, P. A., et. al. (2002) Agricultural sustainability and intensive production practices. *Nature* 418:671-677.
[68] Aneja, V. P., Schlesinger, W. H., and Erisman, J. W. (2009) Effects of agriculture upon the air quality and climate: research, policy, and regulations. *Environmental Science & Technology* 43:4234-4240.
[69] Lingard, J. (2002) Agricultural Subsidies and Environmental change. In *Encyclopedia of Global Environmental Change*, I. Douglas (ed.). John Wiley and Sons, Ltd., New Jersey, United States.
[70] Matson, P., Parton, W. J., Power, A. G., et al. (1997) Agricultural intensification and ecosystem properties. *Science* 277:504-509.

What are Agricultural Subsidies?

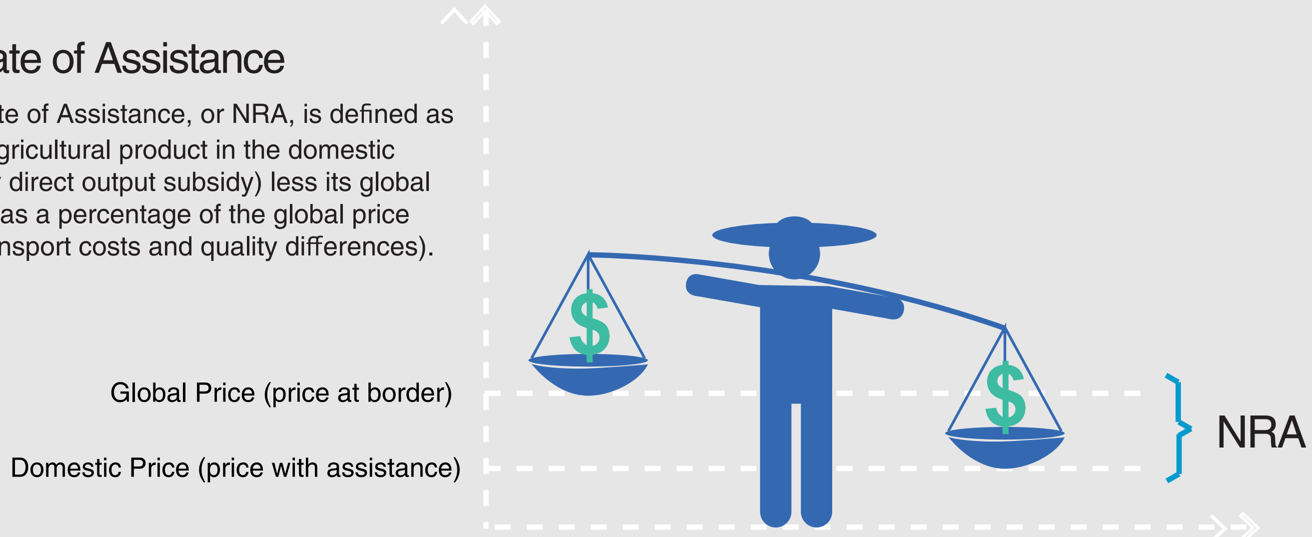
Agricultural Subsidies are a proxy measure to assess the environmental impacts of policies that tend to encourage the inefficient use of resources that can lead to pollution.



How do we know?

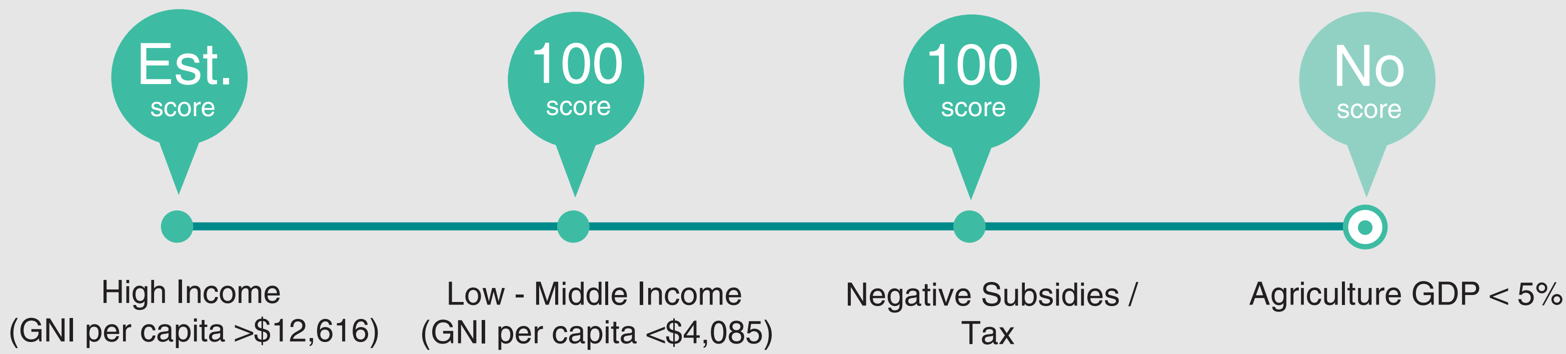
Nominal Rate of Assistance

The Nominal Rate of Assistance, or NRA, is defined as the price of an agricultural product in the domestic market (plus any direct output subsidy) less its global price expressed as a percentage of the global price (adjusting for transport costs and quality differences).



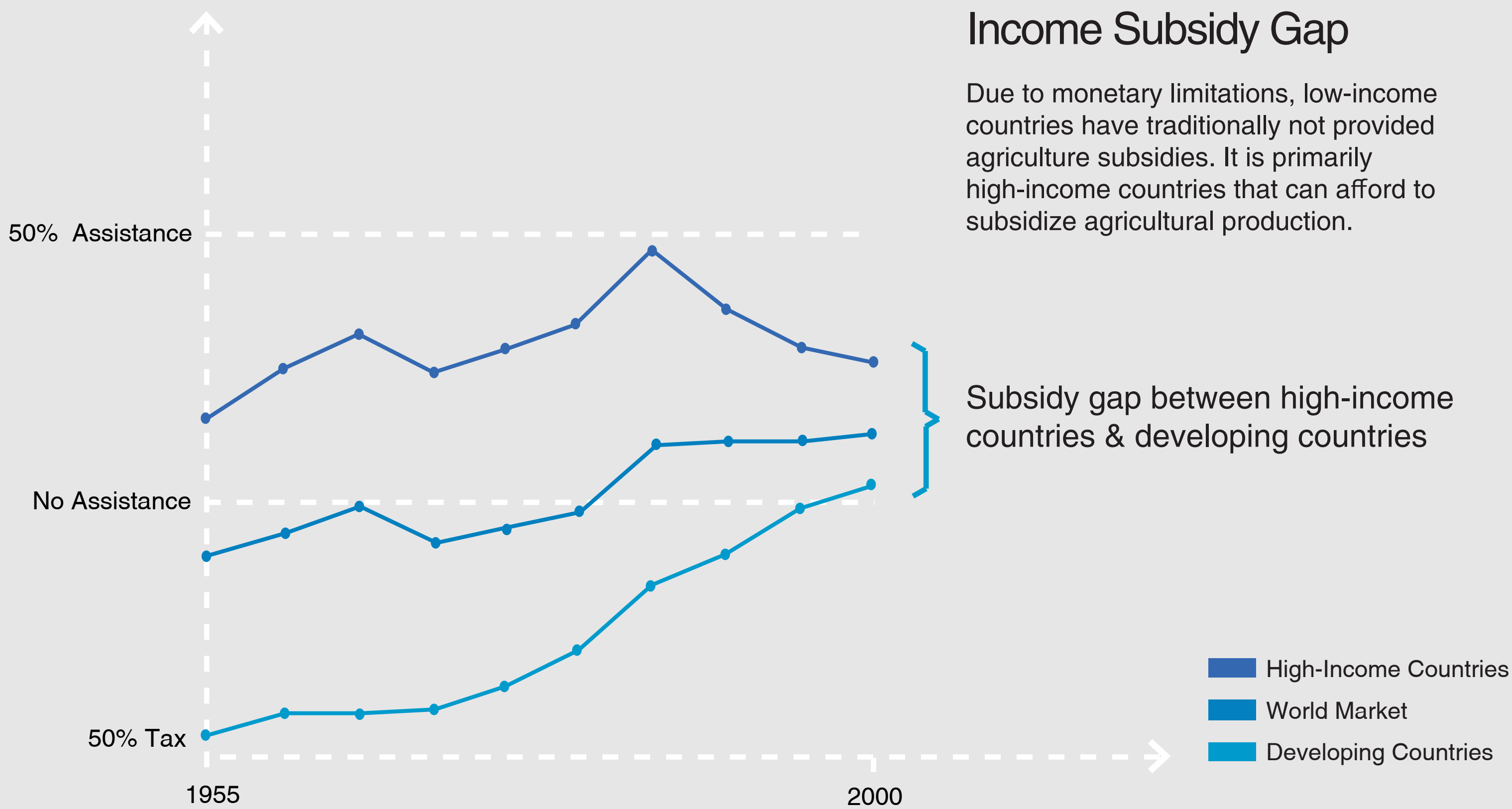
HOW TO SCORE WHEN DATA ARE MISSING?

The World Bank only provides NRA data for around 82 countries. For all others, we use a set of rules to determine how to estimate a score for countries. Countries that have a negative NRA (i.e., taxation) receive the top score of 100. Countries with low to middle income (GNI per capita < $4,085). also receive a score of 100, as poor countries are less likely to subsidize their agriculture sectors (see figure below). For high income countries (GNI per capita > $12,616) with agriculture GDP > 5% of the total GDP, a point value is based on a regional GDP model. Countries that have negligible agriculture sectors (agriculture GDP < 5%) do not receive a score at all.



Income Subsidy Gap

Due to monetary limitations, low-income countries have traditionally not provided agriculture subsidies. It is primarily high-income countries that can afford to subsidize agricultural production.

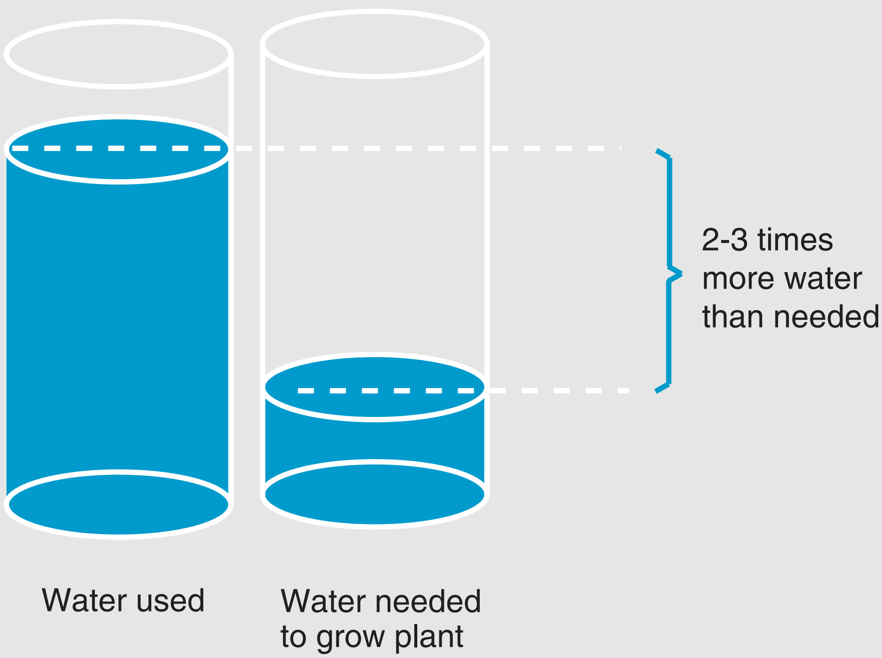


Why does it matter?

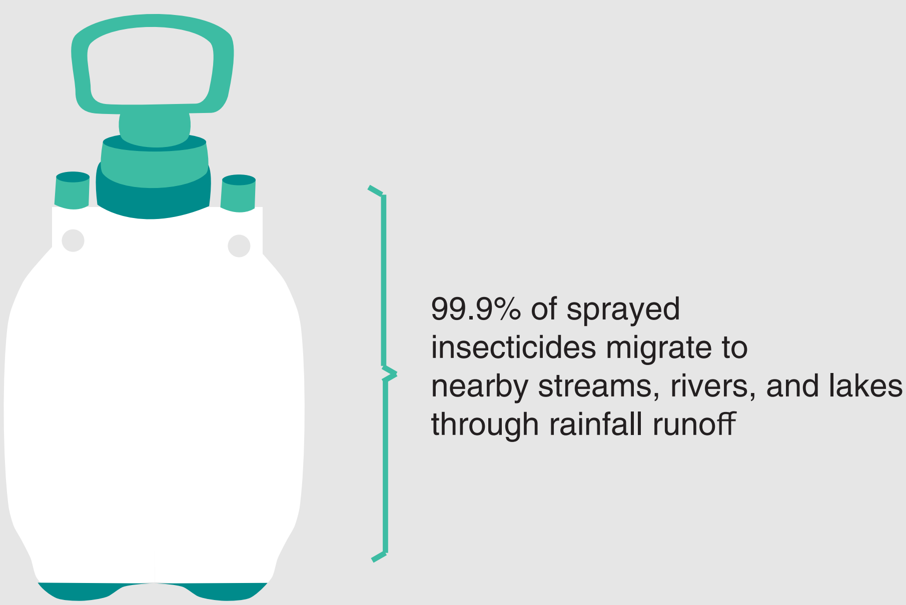
Increased Environmental Pollution

Agricultural subsidies have been found to lead to more intensive agriculture, inefficient use of resources such as water and agricultural inputs, and can lead to increased environmental pollution through the greater use of pesticides, insecticides, and fertilizers.

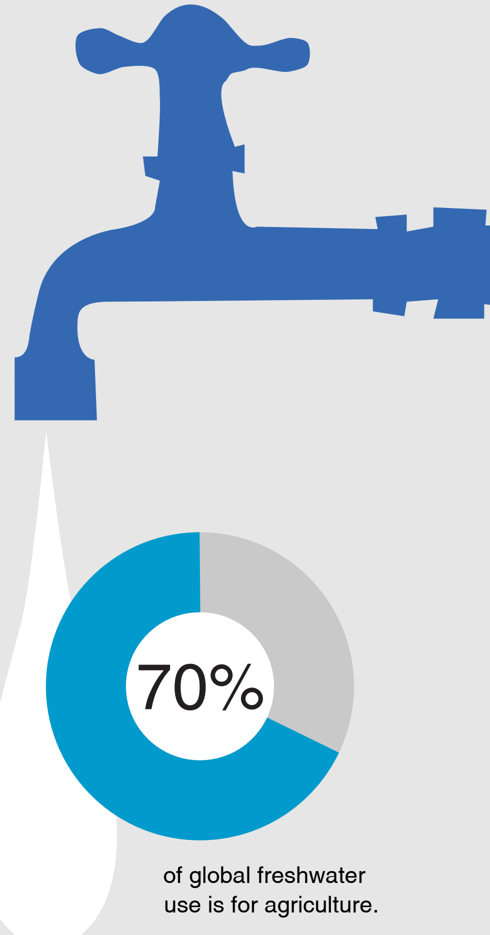
Increased Use of Water



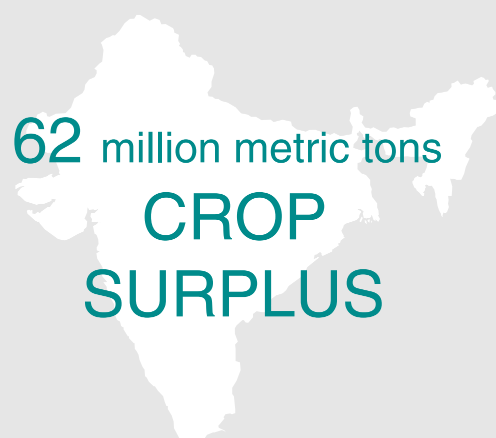
Increased Use of Pesticides



85 2014 EPI



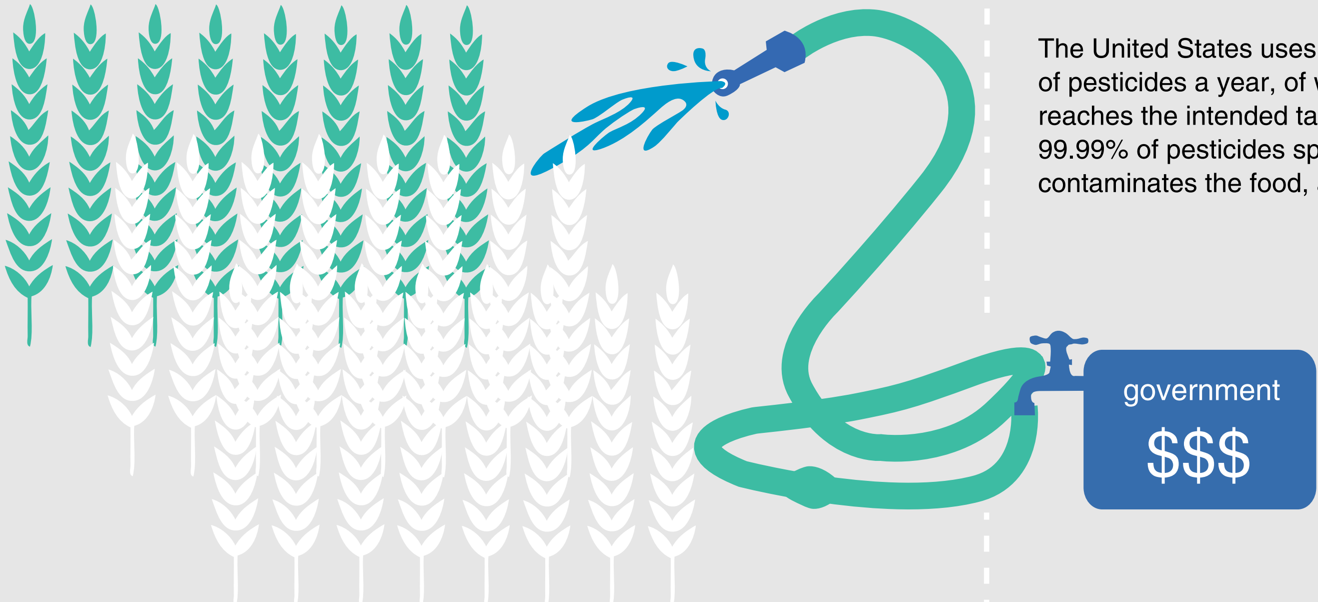
of global freshwater use is for agriculture.



Free water and electricity in India led to massive surpluses of 62 million metric tons. This was 60% of the nation's harvest in 2012 and the third largest grain harvest in the world.

Over-Production

The over-production of government-favored crops distorts global commodity markets. Not only does this affect the global economy, but also food security and poverty.



The United States uses 1.2 billion pounds of pesticides a year, of which only 0.01% reaches the intended target. The other 99.99% of pesticides sprayed contaminates the food, air, and water.

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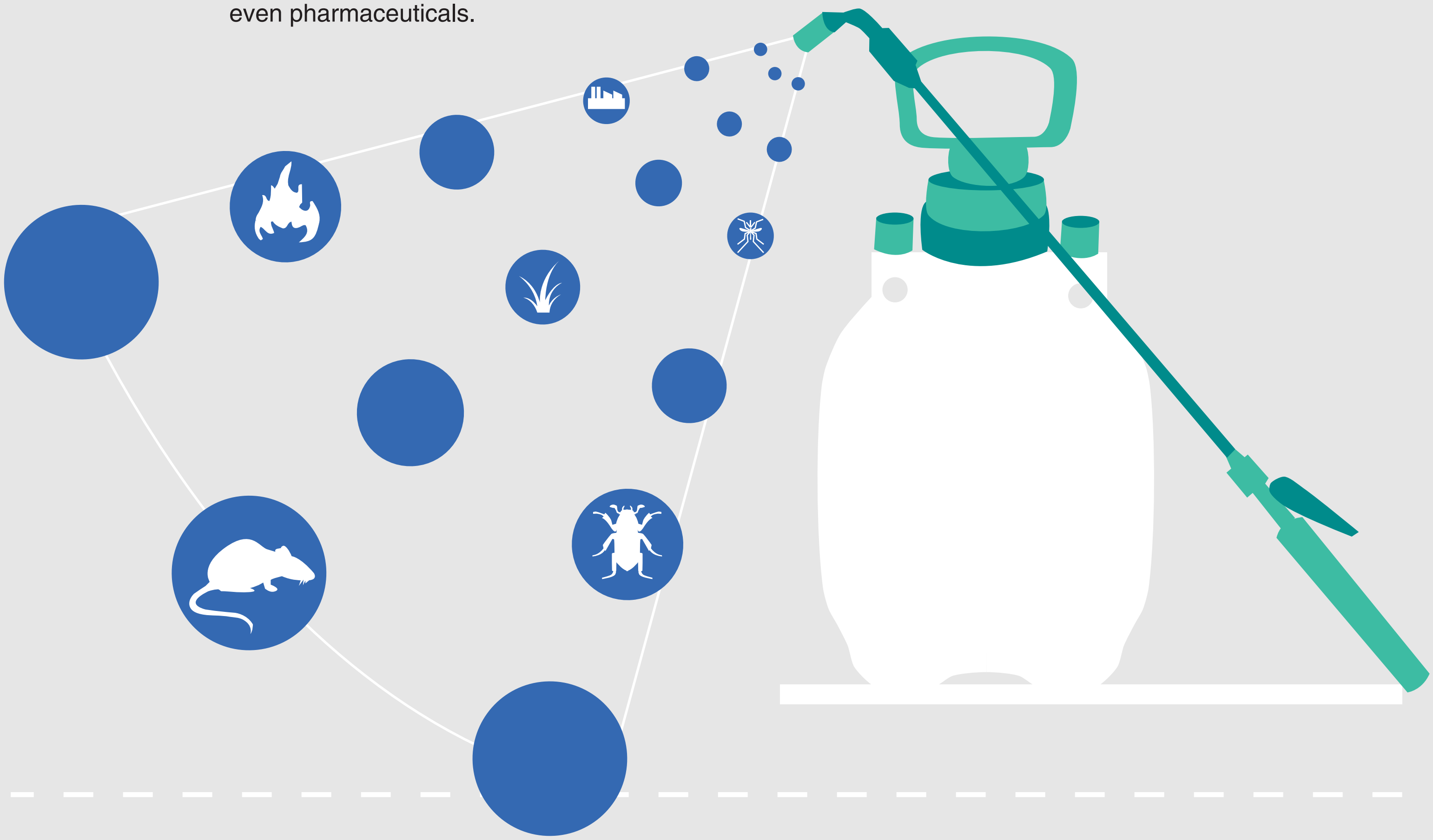
- “Communities in Peril: Global Report on Health Impacts of Pesticide Use in Agriculture.”Pesticide Action Network International: http://www.pan-international.org/panint/files/PAN-Global-Report.pdf
- G.T. Miller. “Chapter 9.” Sustaining the Earth. 6th ed. Pacific Grove, California: Thompson Learning, Inc. (2004): 211–216
- “World Development Report 2008”, The World Bank: http://go.worldbank.org/2DNNMCBGI0

What is Pesticide Regulation?

The 'Dirty Dozen' Pesticides

Also known as Persistent Organic Pollutants or POPs, the so-called 'Dirty Dozen' are 12 highly toxic chemicals. They are used in agriculture, industry, and some household products such as pesticides, solvents, and even pharmaceuticals.

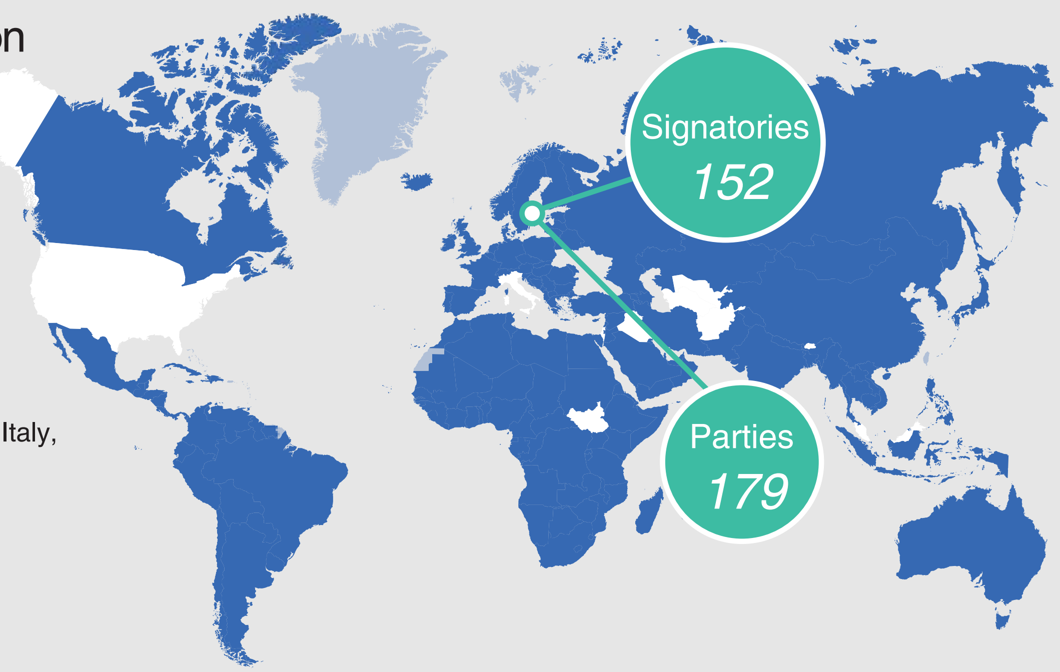
Pesticide Regulation is a measure of whether countries allow, restrict, or ban the 'Dirty Dozen' Persistent Organic Pollutants (POPs) under the Stockholm Convention.



The Stockholm Convention

The Stockholm Convention is an international treaty to protect human health and the environment from these toxic chemicals. Regulation of POPs can occur within or outside the framework of the Stockholm Convention.

- Non-ratifying States
- Non-eligible States
- Ratifying States



Non-ratifying states include Iraq, Israel, Italy, Malaysia, and the United States.

How do we know?

The Scorecard

Countries are awarded points depending on whether they have signed and/or ratified the Stockholm Convention, as well as whether or not they allow, restrict, or ban the 'dirty dozen' POPs regulated.

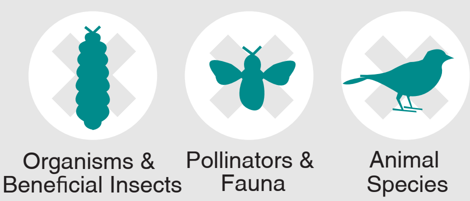
25 Maximum Points Awarded

Why does it matter?

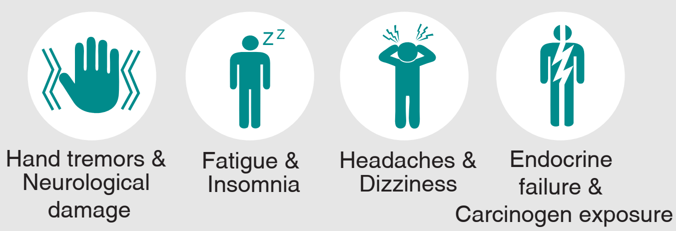
Ecosystem & Human Health

These toxic chemicals impact both ecosystem and human health. In the environment they kill beneficial insects, pollinators, and fauna. For humans, exposure to these pesticides have been linked to severe headaches, fatigue, insomnia, dizziness, hand tremors, and other neurological symptoms. Furthermore, many of the pesticides included in this index are endocrine disruptors and carcinogens.

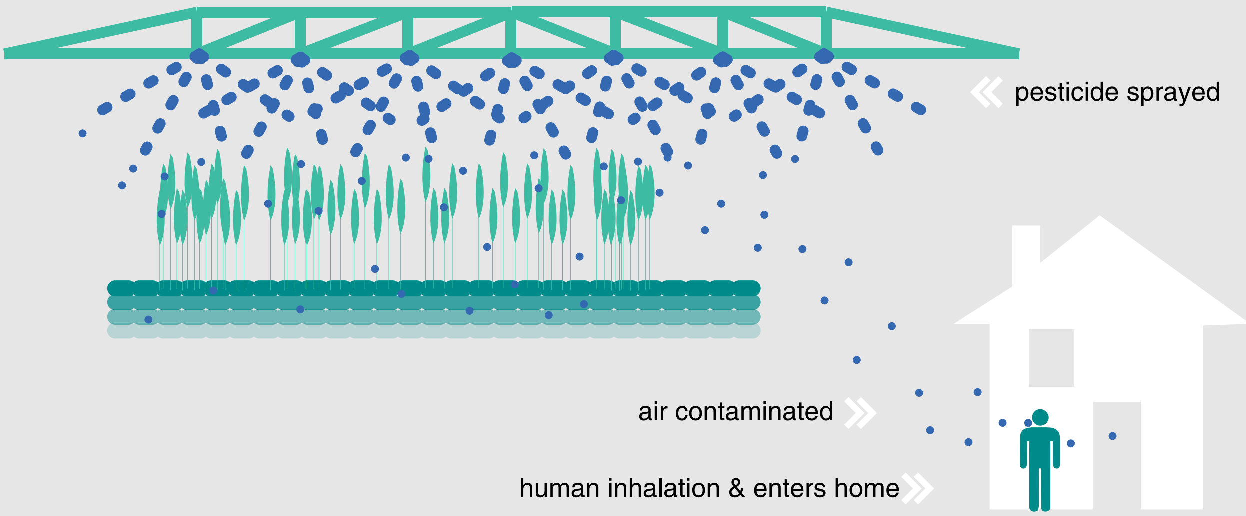
Damage to Ecosystem



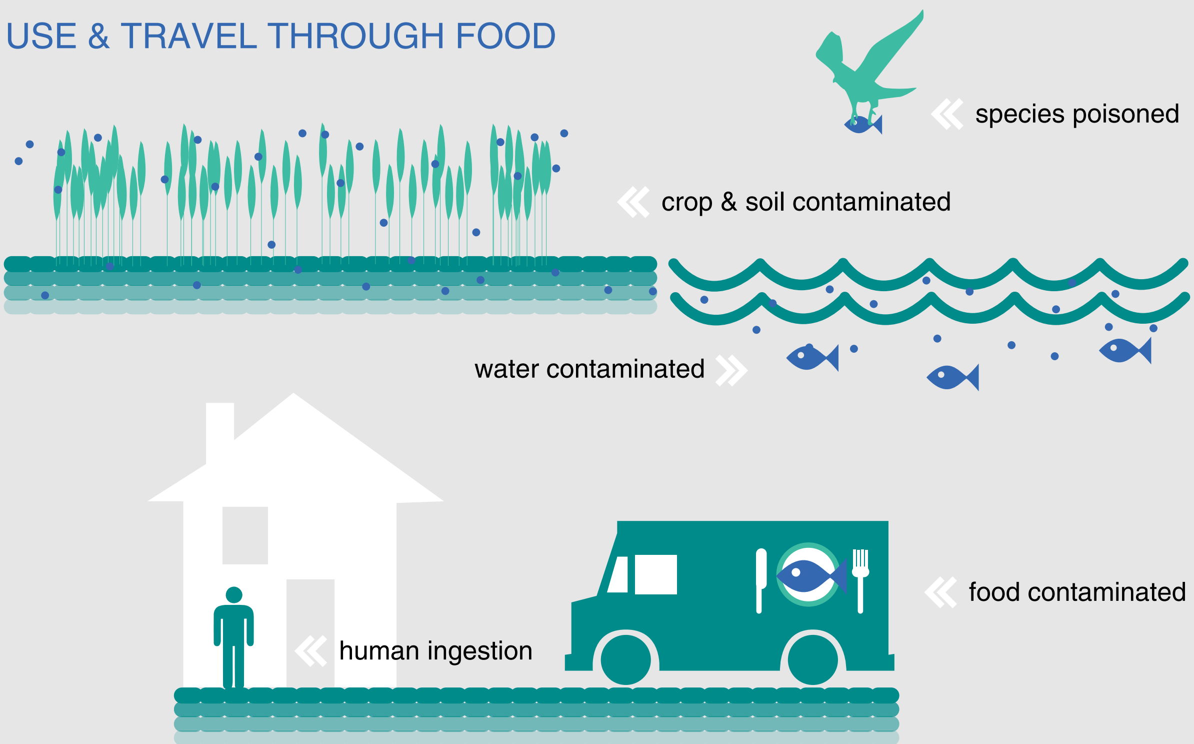
Damage to Human Health



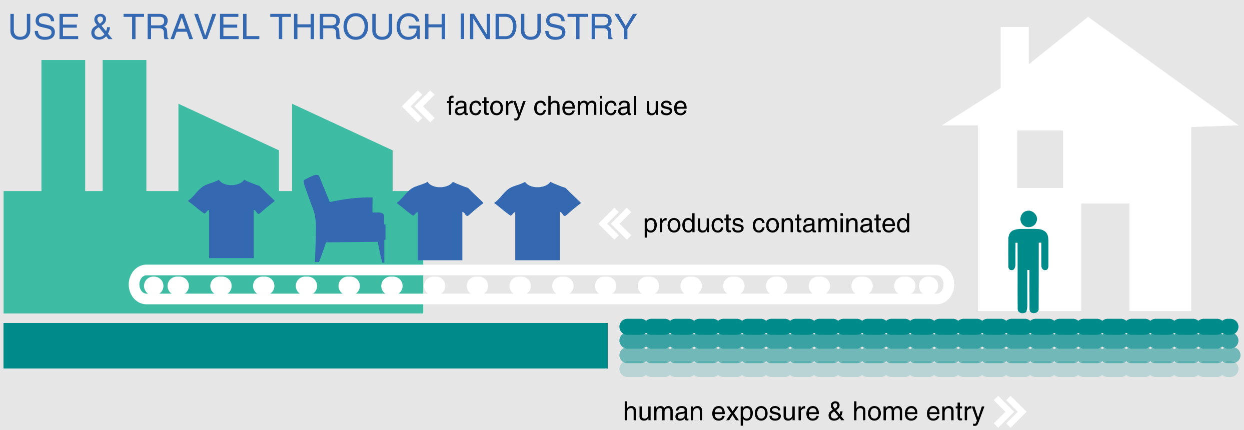
USE & TRAVEL THROUGH AIR



USE & TRAVEL THROUGH FOOD

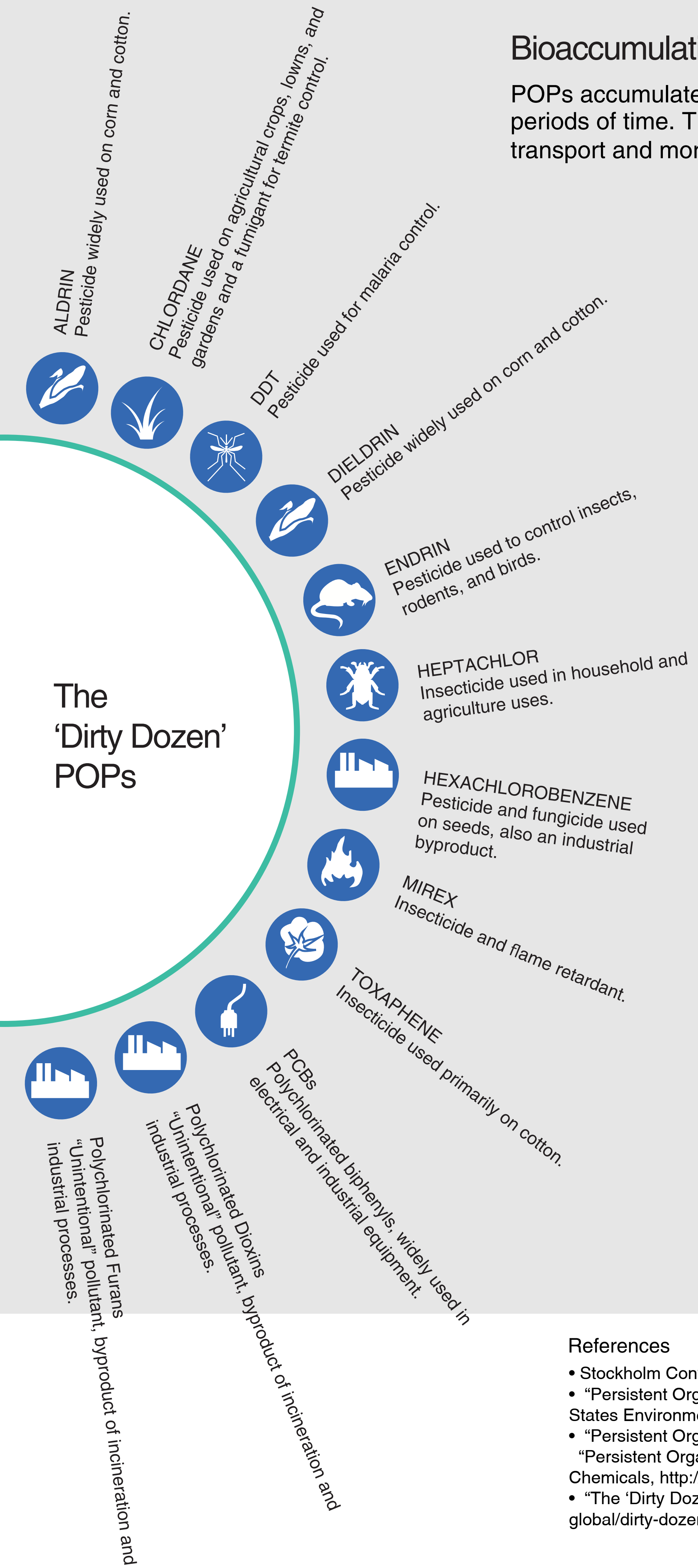


USE & TRAVEL THROUGH INDUSTRY



Bioaccumulation

POPs accumulate in the environment and remain intact for long periods of time. Therefore, they are capable of long-range transport and more harmful effect.



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- "Persistent Organic Pollutants", The World Bank, http://web.worldbank.org
  "Persistent Organic Pollutants", United Nations Environment Programme: Chemicals, http://www.chem.unep.ch/pops/
- "The 'Dirty Dozen' POPs", US POPs Watch, http://www.uspopswatch.org/-global/dirty-dozen.htm

AMENDMENTS TO THE STOCKHOLM CONVENTION

At its fourth and fifth meetings in 2009 and 2011, the Conference of the Parties to the Stockholm Convention adopted amendments to list 10 additional persistent organic pollutants (POPs) in its Annexes. These new POPs, which include the infamous pesticides lindane and endosulfan, are among many commonly used chemicals around the world.

Lindane and endosulfan were introduced in the 1950s as insecticides.[1,2] Due to the persistence of these chemicals in the environment, they can bioaccumulate in the food chain, causing toxic effects to both terrestrial and aquatic species. The health effects of both to humans are also of concern. Lindane is commonly used as a topical treatment for scabies and lice, but due to evidence of deleterious effects in laboratory studies, it has only been given a specific exemption as a secondary treatment option.[3] Endosulfan was found to pose unacceptable risks to workers after many years of use in agriculture.[4] Its potential to cause congenital physical disorders, mental retardation and death warranted its prohibition in many countries before its listing on the Stockholm Convention.[5]

As scientific research continues to evolve and the health effects of POPs are more thoroughly understood, new chemicals will be added to the Stockholm Convention. At its 2013 meeting in Rome, the Convention's POPs Review Committee recommended the inclusion of two additional chemicals under the Convention, polychlorinated napththalenes and hexachlorobutadiene. Both of these are industrial chemicals used in various applications, such as wood preservation, paint and insulation, and industrial processes.[6] The recommendation for these chemicals includes listings in Annexes A and C of the Convention. Countries will not only have to target the intentional production of these chemicals, but also any unintentional releases of them. As with previous banned or restricted POPs, Parties will need to perform national assessments of the uses of these chemicals before making appropriate management and policy decisions to control and eventually eliminate their use. The POPs Review Committee will evaluate these proposed listings, and a decision on the inclusion of these chemicals in the Convention will be made at the 2015 meeting.

Full details on the Stockholm Convention and POPs can be found at http://www.pops.int.

[1] Cornell University (1998) *Pesticides and breast cancer risk: lindane. Fact Sheet #15*. New York, United States. Available: http://envirocancer.cornell.edu/FactSheet/Pesticide/fs15.lindane.cfm. Last accessed: January 11, 2014.
[2] United States Environmental Protection Agency. (2002) *Endosulfan RED Facts*. Washington, D.C., United States. Available: http://www.epa.gov/oppsrrd1/REDs/factsheets/endosulfan_fs.htm. Last accessed: January 10, 2014.
[3] Stockholm Convention. (2008) *The New POPs under the Stockholm Convention*. Available: http://chm.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx. Last accessed: January 10, 2014.
[4] *Ibid.*
[5] Environment News Service. (2011) *Pesticide Endosulfan to Be Banned Worldwide*. Available: http://www.ens-newswire.com/ens/may2011/2011-05-05-01.html. Last accessed: January 10, 2014.
[6] United Nations Environment Programme. (2013) *UN chemical experts recommend phase out of two industrial chemicals, with uses range from wood preservation to pest control, due to human health risks*. Available: http://rona.unep.org/documents/news/Basel%20Convention.pdf. Last accessed: January 11, 2014.

agricultural subsidies the fastest.[71]

Nowhere are the relationships between subsidies and ecosystems more apparent than the United States, where agricultural subsidies have promoted industrial-scale commodity crop production. Without huge inputs of fertilizers and pesticides, the ecologically unsustainable practices of industrial agriculture would not occur. American subsidies foster large-scale, intensive farming. Increased soil erosion and massive runoff of animal waste and unutilized chemicals have been the general result.

The Mississippi River watershed is a glaring example of the widespread and direct impact that heavy inputs have upon landscapes. Along with public health and localized ecological effects, a large area of hypoxic waters has plagued the Gulf of Mexico's ecosystem and fishing economy. Similar "dead zones" exist near the coasts of other countries with heavy subsidies, including China, India, and in the Baltic Sea, where much of the runoff flows from the subsidy-heavy Scandinavian countries, Russia, and Poland.[72]

Input subsidies also distort markets, favoring farmers in countries that can afford them over those in poorer countries. Worldwide, this has resulted in a global shift toward commodity crops over traditional techniques that have been sustained for generations without many inputs. The agricultural subsidies indicator is responsive to this economic inequity.

Countries in which agriculture comprises a low proportion of their gross domestic product are given a pass. It is assumed that the impacts of these countries' subsidies— in the rare cases they even exist— are negligible compared to those of economic powerhouses.

In many cases, the potential social benefits of subsidies in poorer nations can outweigh ecological impacts. In much of sub-Saharan Africa, for instance, the increased yields that can only be produced with the use of some inputs are a necessary factor for future food security. As the capacity for conservation agriculture practices— like increased tillage, crop rotation, and intercropping with trees—expands throughout the developing world, the careful use of inputs can help produce those greater yields while also protecting ecosystems.[73]

Such combined practices have already shown great success in Malawi, where in the past, monocropping of maize has led to intense soil degradation. After a poor season devastated the food supply in 2005, input subsidies to small-holder farmers were instituted, encouraging fertilizer use. The very next year farmers produced a huge surplus and were able to export to surrounding countries.[74] The success of that year has led to an explosion of public programs, including many that promote conservation agriculture practices. Early research is showing that in those projects, yield is further increased, even up to 40 percent.[75]

[71] Clay, J. (2013) *Are agricultural subsidies causing more harm than good?* The Guardian. 8 August 2013. Available: http://www.theguardian.com/sustainable-business/agricultural-subsidies-reform-government-support. Last accessed: January 10, 2014.
[72] Scherr S. and J McNeely. (2008) Biodiversity conservation and agricultural sustainability: towards a new paradigm of 'ecoagriculture' landscapes. *Philosophical Transactions of The Royal Society B* 363:477-494.
[73] World Resources Institute. (2013). *The global food crisis explained in 18 graphics*. Washington, D.C. Available: http://www.wri.org/blog/global-food-challenge-explained-18-graphics. Last accessed: January 10, 2014.
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[75] Thierfelder C., Chisui, J.L., Gama, M., et al. (2013). Maize-based conservation agriculture systems in Malawi: long-term trends in productivity. *Field Crops Research* 142:47-57.

Still, the Agricultural Subsidies indicator is not ideal. It is not capable of differentiating between subsidies that encourage sustainable practices. It is too coarse to give useful distinctions between countries with developing economies. More than 90 countries, all with very different agricultural profiles, occupy the first ranking with the same exact score, and the rankings cannot be effectively read as a measure of environmental quality, policy intent, or impacts of farming upon the land. Norway comes out as a low performer because the typical Norwegian farmer receives most of his or her income through subsidies. But it would be difficult to argue that farming impacts there were that much worse than those in the United States, which comes out as a high performer among ranked countries. For this reason, this indicator is merely a proxy, and not an ideal one. Recognizing these shortcomings, the Agricultural Subsidies indicator is down-weighted so that it has a lower impact on the overall EPI score. It is a top priority to completely overhaul agricultural indicators for future EPIs.

Pesticide Regulation

Concerns over POPs are related to their mobility, toxicity, and ability to remain in water and soil for a long time. Many of the first 12 chemicals regulated under the Stockholm Convention—known as the "dirty dozen"— travel through waterways far from farms, affecting downstream populations and ecosystems. Some, like PCBs, DDT, and dioxins have received a lot of notoriety over the years. Others, including heptachlor, hexachlorobenzene, and endrin, still remain obscure to the public, despite their comparable danger.

This indicator is a measurement of countries' performances in regard to the usage of POPs, as it takes into account not only the signing of the Stockholm Convention, but also the ratification of it. The criteria for the adoption status include the year of signature and/or ratification of the Stockholm Convention for each country. But, the indicator goes further than that, scoring whether countries have taken steps to ban or restrict the dirty dozen and penalizing those who have not.

Over 180 countries have ratified the Stockholm Convention and made commitments to address POPs. For example, Eritrea, a country where up to 80 percent of the population is employed in agriculture,[76] is revitalizing its agriculture to enhance food security and provide jobs as it recovers from two decades of war. After signing the Stockholm Convention in 2005, Eritrea's Ministry of Agriculture included POPs in a list of banned pesticides. Of all the pesticides included in the Convention—including the most recent ten additions in 2009 and 2011 (see Box: Amendments to the Stockholm Convention)— only DDT and endosulfan are used in the country, and only under heavy restriction.

Since the implementation of the Stockholm Convention in 2001, many agriculture-driven countries have worked to understand the harmful effects of some POPs and establish legal frameworks to meet obligations to better manage them. These countries have set important precedents. The Global Environmental Trust Fund facilitated implementation in Eritrea, providing over US$340,000 dollars to strengthen the nation's capacity and capability to prepare their National Implementation Plan on POPs.[77] National

[76] Department of Environment of the Ministry of Land, Water and Environment, The State of Eritrea. (2012) *National implementation plan for the Stockholm convention on persistent organic pollutants*. Asmara, Eritrea.

[77] Global Environment Facility. *Enabling activities to facilitate early action on the implementation of the Stockholm convention on POPs*. Available: http://www.thegef.org/gef/project_detail?projID=3139. Last accessed: January 10, 2014.

Efforts are being made in Europe to gather better data on good agricultural practices. (Credit: Wikimedia Commons / Pelle Frederiksson)

TOWARD IMPROVED INDICATORS OF AGRICULTURAL SUSTAINABILITY

The OECD Agri-Environmental Indicators

Over the past decade, member countries of the Organisation for Economic Cooperation and Development (OECD) – those countries generally considered wealthy and developed – have collectively reduced the amount of pesticides, water, irrigation, and surplus nutrient runoff from agriculture. This improvement was made possible through a new effort to establish a set of agri-environmental indicators that assess the environmental impact of agricultural practices in OECD countries.

In June 2013, the OECD, in conjunction with Eurostat and the Food and Agriculture Organization of the United Nations, released the OECD Compendium of Agri-Environmental Indicators to measure environmental performance in agriculture. The compendium provides data for 34 OECD countries from 1990 to 2010 and allows users to compare performance trends among countries.[1] The indicators provide a measure for the most critical topics when examining environmental performance as it relates to agriculture, including agricultural production, land use, organic farming, transgenic crops, nutrients, pesticides, energy consumption, and biofuels, among others.[2]

These indicators are more comprehensive than those used in the 2014 EPI and are better suited to assess the various environmental impacts of agricultural practices in these countries. The relative economic comparability of OECD countries and their similar data measurement and reporting capabilities contribute to the project's success. While similar measures could lend insight into global agricultural sustainability and environmental performance, they do not yet exist for many countries, or at the global scale.[3] This is why the OECD agri-environmental indicators are not appropriate for the EPI.

[1] Organization of Economic Cooperation and Development. (2013) *Compendium of Agri-environmental indicators*. Paris, France. Available: http://www.oecd-ilibrary.org/agriculture-and-food/oecd-compendium-of-agri-environmental-indicators_9789264186217-en. Last accessed: January 11, 2014.
[2] *Ibid*.
[3] Organization of Economic Cooperation and Development. (1999) *Environmental indicators for agriculture, Volume I: Concepts and Framework*. Paris, France. Available: http://www.oecd.org/tad/sustainable-agriculture/40680795.pdf. Last accessed: January 11, 2014.

Illegal fishing equipment is so extensive that it can be seen from outer space. (Credit: Rob Bouman / iStock-Thinkstock)

REMOVAL OF AGRICULTURAL SUBSIDIES IN NEW ZEALAND

Agricultural subsidies are generally the policy of countries wealthy enough to afford them. By and large, the practice is destructive to the land, distorting markets, and, in the age of a global economy, detrimental to the livelihoods of farmers in countries without subsidies. And because subsidies promote the production of commodity crops beyond market demand, they encourage farmers to rely on them instead of consumer demand. This reliance on industrial production of single crops has had disastrous consequences for the environment the world over.

Recognizing these pitfalls, the government of New Zealand removed its subsidy regime in 1984. The move offers a classic illustration of the relationship between agricultural subsidies, farming economies, and the environment. Before 1984, New Zealand farming boomed, largely in response to aggressive subsidies. During this period, a steady trend of increasing agriculture intensification occurred. Stocking rates increased, as did the use of agricultural inputs like fertilizers and pesticides.[1]

Immediately after dismantling its subsidy regime, farmers were afraid and furious, marching on the capitol in protest. However, despite predictions that 10 percent of its farms would go bankrupt, New Zealand retained 99 percent of its farms. Herds were consolidated, and breeds that reflected market demand—producing leaner milk, for instance—rose to prominence. And benefits to the land were dramatic. Pesticide use declined by 50 percent. Soil erosion, land clearing, and overstocking also declined. The entire agricultural sector was forced to shift toward better practices that increased efficiency and yield. Livestock farming, previously stimulated by output subsidies, was curbed and, for the most part, relocated away from erodible hillsides to more sustainable pastures.[2]

Today the agricultural sector is New

Zealand's export lifeblood, dominated by family farms and experiencing constant, enviable growth. Milk and wool are the country's biggest exports, and there are more livestock in the country than people. Despite evidence that a new era of intensification is underway in the country – and though the applicability of its policies might not be relevant for larger, subsidy-dependent countries like the United States – the case of New Zealand shows that aggressively dismantling subsidies may not be as disastrous as is conventionally believed.[3]

[1] Macleod, C. and Moller, H. (2006) Intensification and diversification of New Zealand agriculture since 1960: an evaluation of current indicators of land use change. *Agriculture, Ecosystems & Environment* 115:201-208.

[2] Arnold, W. (2007) *Surviving without subsidies.* The New York Times, 2 August 2007. Available: http://www.nytimes.com/2007/08/02/business/worldbusiness/02farm.html?pagewanted=all. Last accessed: January 11, 2014.

[3] Macleod, C. and Moller, H. (2006) Intensification and diversification of New Zealand agriculture since 1960: an evaluation of current indicators of land use change. *Agriculture, Ecosystems & Environment* 115:201-208.

Implementation Plans are essential elements for assessing policy and management strategies and identifying priority activities to meet the requirements of the Stockholm Convention. As countries submit updates to their Plans, including actions on newly listed POPs, future EPIs will continue to track actions countries take to ban or restrict chemicals listed in the Convention.

Unfortunately, neither indicator in this category is a direct measurement of agricultural environmental performance. Instead, they are both proxies related to policy intent. Globally comparable measures to assess agricultural sustainability or impacts simply do not exist. Measures of soil quality and erosion, agricultural water-use intensity, and desertification are all important issues related to agricultural sustainability. While there are a few efforts to develop comparable measures for these concerns (see Box: Toward Improved Indicators of Agricultural Sustainability – the OECD Agri-Environmental Indicators), they are limited in scope and scale. International agreements such as the Stockholm Convention have future plans to provide more country-level data on POPs (see Box: International Data Collection of POPs Emissions).

Data permitting, future EPIs will most likely see the Agricultural Subsidies indicator replaced by something more policy-relevant and reflective of current research. We hope to follow the lead of the scientific community, which has begun to shift its attention toward landscape-scale assessments of agriculture and its impacts. Taking a landscape perspective better corresponds to relevant conditions of geography, climate, biodiversity, and governance than viewing farms as separate from non-working lands or assessing agriculture at national or regional scales.[78] Improved management and planning are the intended goals of agricultural indicators.

[78] Scherr S. and J McNeely. (2008) Biodiversity conservation and agricultural sustainability: towards a new paradigm of 'ecoagriculture' landscapes. *Philosophical Transactions of The Royal Society B* 363:477-494.

INTERNATIONAL DATA COLLECTION OF POPS EMISSIONS

Monitoring the implementation and progress toward goals established through international environmental agreements is arguably just as important as their adoption. However, this qualitative information is often difficult to measure, and instead performance data acts as a key tool for assessing country- and global-level actions.

International data collection has proven beneficial for understanding progress toward the goals of conventions, and in essence its implementation. In 2006 the Convention on Biological Diversity adopted the International Union for Conservation of Nature Red List Index to help measure progress toward the 2010 Biodiversity Target, which was included in the Millennium Development Goals.[1,2] This target aimed to significantly reduce the current rate of biodiversity loss at global, regional, and national levels. Although this target was not met, the Red List data provided valuable information, such as the conservation status (i.e., extinct, endangered, vulnerable, etc.) and distribution of plants and animals, to understand progress and determine where actions were needed.

Likewise, the Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs was created to help facilitate implementation of the Stockholm Convention.[3] Countries can use the toolkit to examine release inventories of Annex C chemicals (i.e., unintentional POPs) and compare management techniques with peer countries. This Toolkit is part of the Convention's larger effort to understand country-level progress and identify best practices for moving toward a POPs-free future.

The Convention is also collecting emissions data as part of a Global Monitoring Plan, which is an effort to compile comparable monitoring data on POPs from all regions to identify changes in emissions over time and understand the regional and global environmental transport of these chemicals.[4] Although this database is not yet comprehensive, the information guides the Conference of the Parties to the Stockholm Convention and helps decisionmakers identify how to better manage these chemicals.

While further progress is needed to better understand the global situation on POPs, great strides are being made on a regional basis. The European Environment Agency, for example, collects data on national air pollutant emissions, including a detailed and specified analysis of dioxins and furans.[5] The data are then submitted to the Long-Range Transboundary Air Pollution Convention – a global agreement that has had considerable success regulating air pollution. Although the data only include emissions from European countries, it will be helpful in distinguishing performance among European countries, which is an important first step and a model for other regions.

[1] Royal Botanic Gardens, Kew. (2013) *IUCN Red List & SRLI explained*. Surrey, United Kingdom. Available: http://www.kew.org/science-conservation/search-rescue/mapping-plants/plants-at-risk/iucn-srli-explained/. Last accessed: January 9, 2014.

[2] Convention on Biological Diversity. (2013) *About the 2010 Biodiversity Target*. Available: http://www.cbd.int/2010-target/about.shtml. Last accessed: January 9, 2014.

[3] Stockholm Convention. (2008) *Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs (Toolkit)*. Available: http://chm.pops.int/Overview/tabid/372/Default.aspx. Last accessed: January 9, 2014.

[4] Stockholm Convention on Persistent Organic Pollutants. (2014) *POPs GMP data visualization and analysis, Global Monitoring Plan on Persistent Organic Pollutants*. Available: http://www.pops-gmp.org/. Last accessed: January 9, 2014.

[5] European Environment Agency. (2013) *National emissions reported to the Convention on Long-range Transboundary Air Pollution (LRTAP Convention)*. Available: http://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-convention-on-long-range-transboundary-air-pollution-lrtap-convention-7. Last accessed: January 11, 2014.

ISSUE PROFILE

Forests

What It Measures

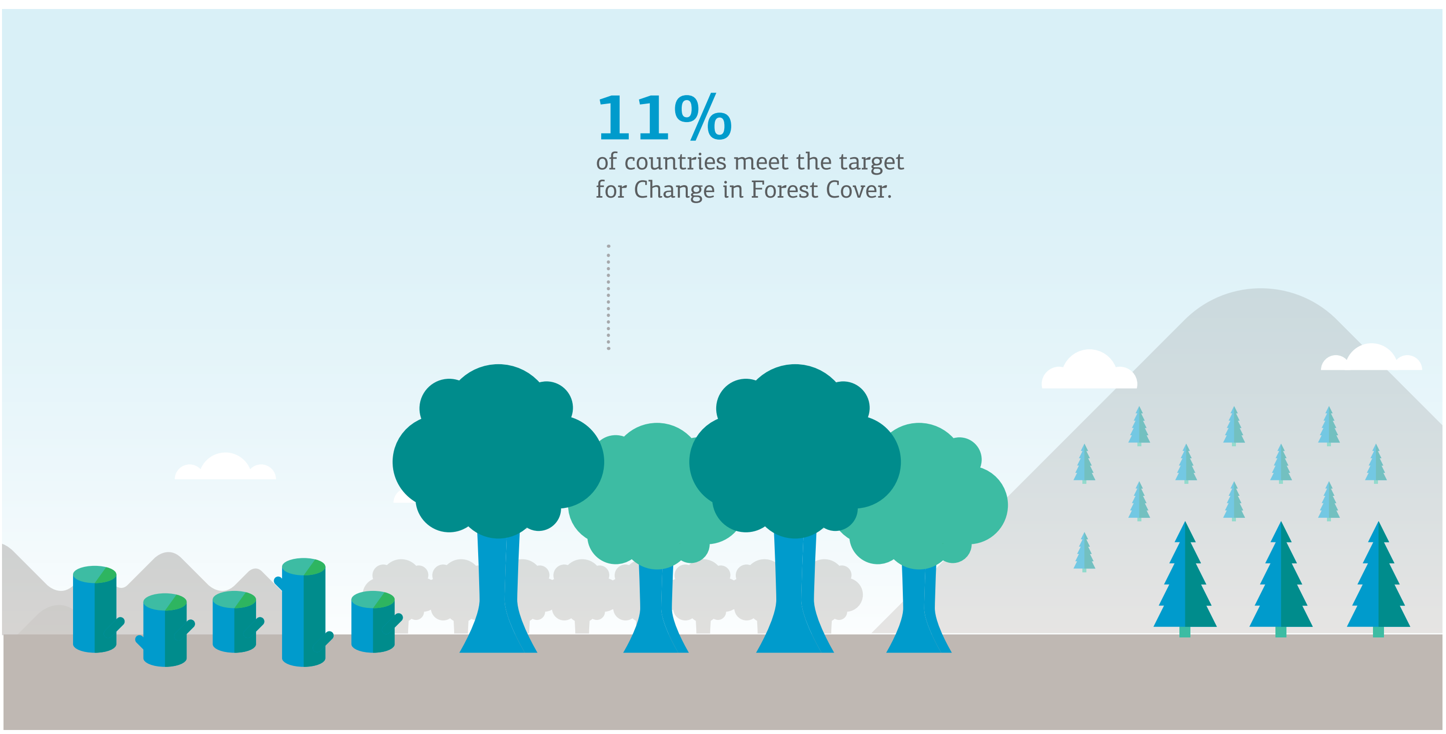
The Change in Forest Cover indicator measures the percent change in forest cover between 2000 and 2012 in areas with greater than 50 percent tree cover. It factors in areas of deforestation (forest loss), reforestation (forest restoration or replanting) and afforestation (conversion of bare or cultivated land into forest).

Why We Include It

Reduction in the extent of forest cover has significant negative implications for ecosystem services and habitat protection.

Where The Data Come From

M.C. Hansen, P.V. Potapov, R. Moore, M. Hancher, et al. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 15: 342 (6160), 850-853.



DESCRIPTION

Forests are dynamic ecosystems vital to sustaining natural life cycles, biodiversity, and the prosperity of humankind. Approximately 31 percent of the world's total land area – around 4.033 billion hectares – is covered by forests, of which 93 percent are natural and the other 7 percent are planted.[79] Forests play a critical role in mitigating the effects of climate change and providing integral ecosystem services and products.[80] Policymakers increasingly acknowledge the significance of forest ecosystems as scientists place greater emphasis on the role of forests as carbon sinks to combat global climate change and in regulating the hydrological system.

Forests are threatened by factors such as timber harvesting, urbanization, cattle ranching, and agricultural development. According to Hansen et al. (2013), there was a net loss of 115,400 square kilometers (11.5 million hectares) of forests per year since 2000.[81] Although forests are in jeopardy around the world, deforestation is most pronounced in tropical countries such as Brazil, Indonesia, Thailand, the Democratic Republic of Congo, other parts of Africa, and parts of Eastern Europe.[82]

In the previous versions of the EPI, the primary source of global data on forest cover change was the FAO Forest Resource Assessment (FRA), but these data have many limitations.[83]

The UN and FAO have identified several principal areas of concern to measure forest sustainability, but because only a few countries have forest monitoring systems sophisticated enough to produce meaningful reports on these criteria, there is a lack of uniformity in reporting on the global scale.

For example, some countries count land as "forest land" based on land use categories regardless of whether or not the land has any tree cover. In the case of forest growing stock change, there are inconsistencies in measurement owing to differences in data collection methods and frequency of assessments. Furthermore, the FAO generally accepts values reported by countries without an independent verification mechanism.[84]

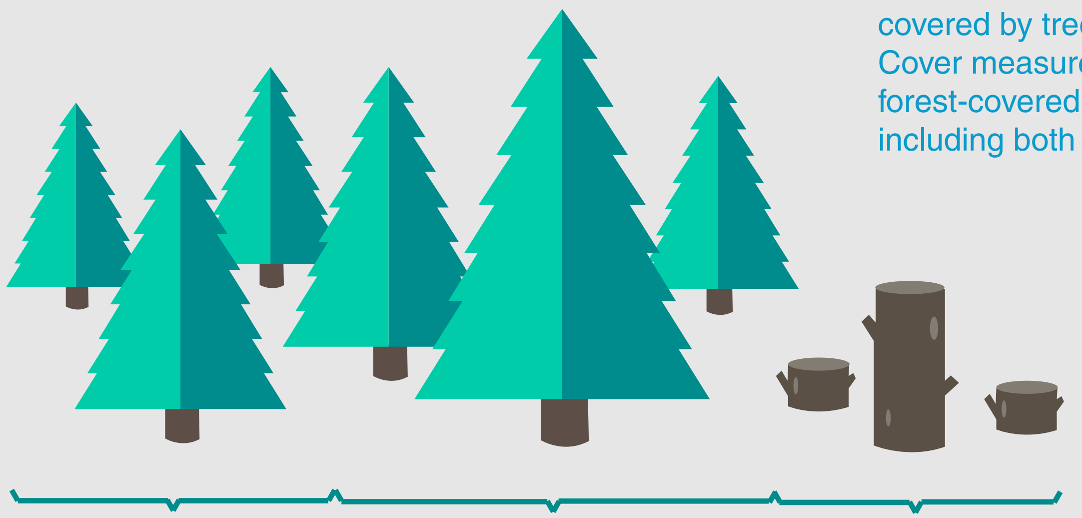
Partially to compensate for these limitations, the 2014 EPI includes a metric of forest change derived from satellite remote sensing data. Over the past two years, the methodology for collecting this data has been substantially improved and associated estimates of forest gain have been developed.[85] With these advancements, satellite-derived estimates represent a marked improvement over the FAO FRA data. Furthermore, the authors of the dataset have a commitment to provide annual updates, providing more regular appraisals than the FRA, which is only updated on a five-year cycle. These data will therefore provide more timely estimates of forest change than the ground-level conducted surveys.

To produce these data, a research team from the University of Maryland collaborated with Google Earth to create a new high-resolution map of forest loss and gain.[86] The "Global Forest Change" project is an interactive mapping tool that uses Google Earth Engine's enormous archive of Landsat 7 images to calculate change in forest cover from 2000 to 2012. The project required 650,000 Landsat 7 images. This map, according to Hansen, "is the first map of forest change that is globally consistent and locally relevant."[87] The satellite-derived map shows that the world lost 2.3 million square kilometers (km^2) of tree cover between 2000 and 2012, but gained

[79] Food and Agricultural Organization. (2010) *FAO forestry fact sheet: managing forests for the future*. Rome, Italy. Available: http://www.fao.org/docrep/014/am859e/am859e08.pdf. Last accessed: January 7, 2014.
[80] *Ibid.*
[81] Hansen, M. C., Potapov, P. V., Moore, R., et al. (2013) High-resolution global maps of 21st-century forest cover change. *Science* 342:850-853.
[82] Food and Agricultural Organization. (2012) *State of the World's Forests*. Rome, Italy. Available: http://www.fao.org/docrep/016/i3010e/i3010e.pdf
[83] Hansen, M. C., Potapov, P. V., Moore, R., et al. (2013) High-resolution global maps of 21st-century forest cover change. *Science* 342:850-853.
[84] A review of time series data show that many countries repeat the same number for forest growing stock over 5-10 year time periods, which seems improbable.
[85] Hansen, M. C., Potapov, P. V., Moore, R., et al. (2013) High-resolution global maps of 21st-century forest cover change. *Science* 342:850-853.
[86] *Ibid.*
[87] Miller, S. (2013) *Google, researchers create first detailed map of global forest change*. Virginia, United States. Available: http://gcn.com/Articles/2013/11/20/hi-res-global-forest-map.aspx?Page=2. Last accessed: January 7, 2014.

What is Change in Forest Cover?

Forest cover refers to land that is mostly covered by trees. The Change in Forest Cover measures the percent change in forest-covered land from 2000 to 2012, including both gains and losses.



Forest Cover Gain

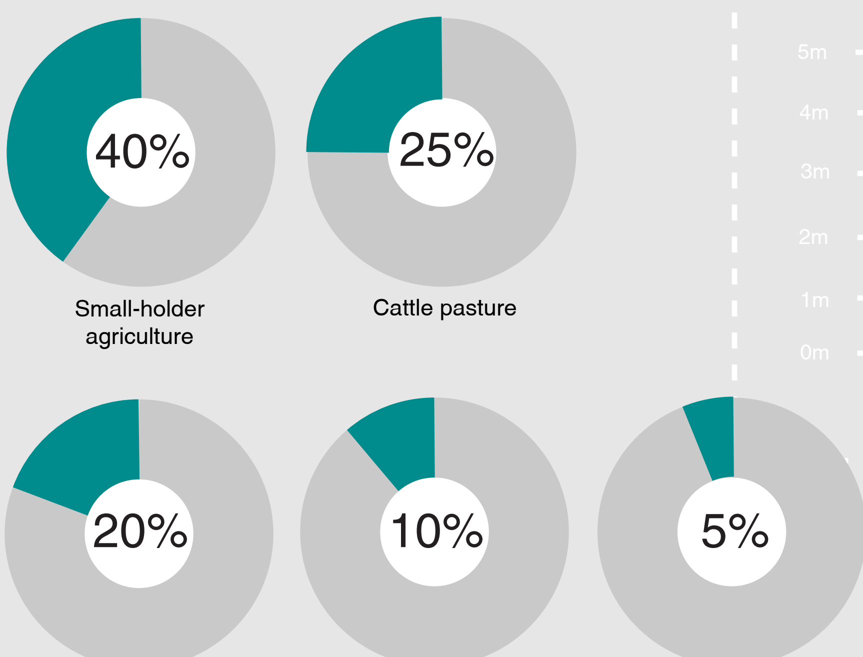
including Reforestation (where there was forest) and Afforestation (where there was not forest)

EPI Target No Change

Forest Cover Loss

mostly due to Agricultural Expansion

Drivers of Deforestation



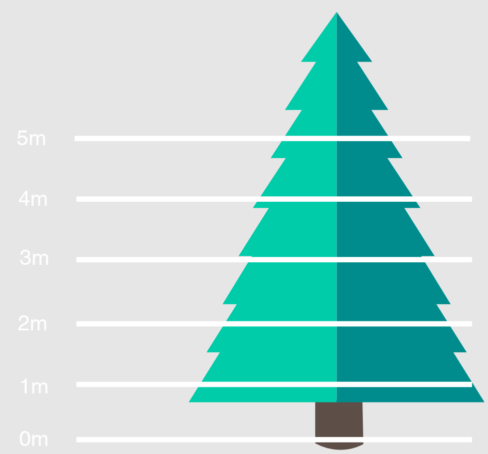
Small-holder agriculture — 40%

Cattle pasture — 25%

Large-scale agriculture — 20%

Logging operations — 10%

Other causes — 5%

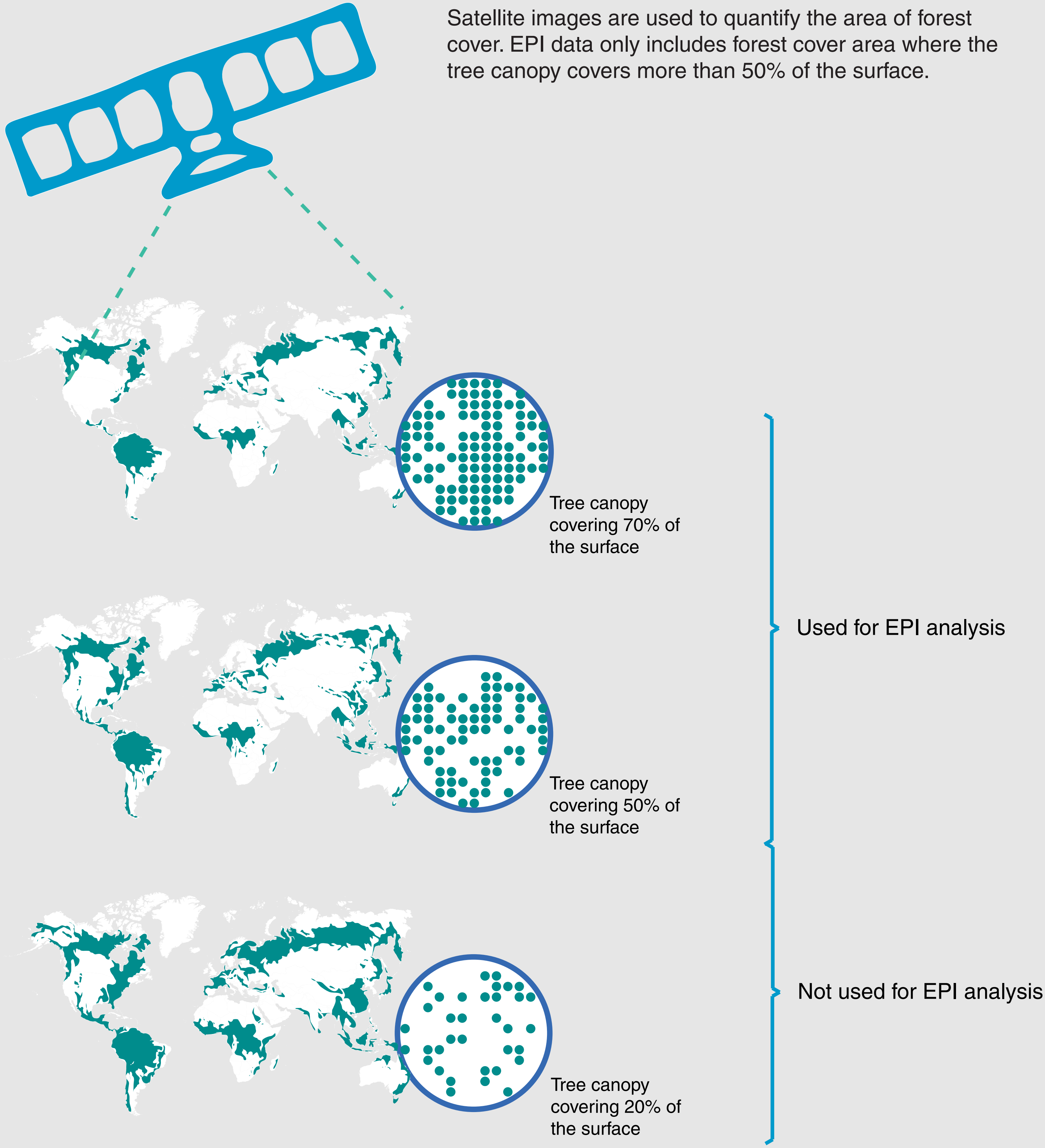


Height Requirement

“Trees” are defined as all forest cover over 5m tall

How do we know?

Satellite images are used to quantify the area of forest cover. EPI data only includes forest cover area where the tree canopy covers more than 50% of the surface.



Countries with less than 200 sq. km. of >50% tree cover in 2000 were not given a score for this category. These countries include: Benin, Botswana, Burkina Faso, Cape Verde, Chad, Djibouti, Egypt, Eritrea, The Gambia, Iceland, Iraq, Israel, Jordan, Kuwait, Lesotho, Libya, Mali, Mauritania, Namibia, Niger, Oman, Qatar, Saudi Arabia, Senegal, Somalia, Sudan, Tajikistan, Turkmenistan, United Arab

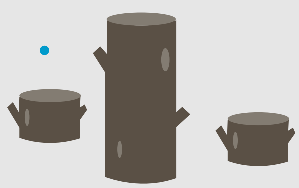
Why does it matter?

A reduction in the extent of forest cover has a range of negative impacts to the ecosystem:

Climate Regulation | Carbon Storage | Water Supplies | Biodiversity Richness

2,200 - 6,600
metric tons of CO_2

Deforestation accounts for 4 to 14% of global CO2 emissions per year.



Between 2000 and 2012, 2.3 million sq. km. of tree cover was lost globally due to land conversion for agriculture, logging, fire, disease or storms. This was slightly offset by a gain of 800,000 sq km of new forest, meaning that the net loss was 1.5m sq. km. in total.

Best Improvement

Brazil

Brazil showed the best improvement of any country, cutting annual forest loss in half from 2003 to 2011.

Largest Deforestation Increase

Indonesia

Indonesia had the largest increase in forest loss, doubling its annual loss to nearly 20,000 sq. km. per year from 2011 to 2012.

High Forest Loss

Paraguay, Malaysia, and Cambodia

Paraguay, Malaysia, and Cambodia also experienced high forest loss between 2000 and 2012.

References

- “Addressing drivers of deforestation”, United Nations Framework Convention on Climate Change (UNFCCC), http://unfccc.int/resource/docs/2012/smsn/igo/70.pdf
- “Deforestation Emissions”, Climate Change, Agriculture and Food Security (CGIAR), http://ccafs.cgiar.org/bigfacts/deforestation-emissions/
- “Forest Definition and Extent”, United Nations Environment Programme (UNEP), http://www.unep.org/vitalforest/Report/VFG-01-Forest-definition-and-extent.PDF
- M.C. Hansen, P.V. Potapov, R. Moore, M. Hancher, et al. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 15: 342 (6160), 850-853.

Sign posts in a forest demonstrate that it is sustainably managed. (Credit: Wikimedia Commons / Cherubino)

MEASURES OF STEWARDSHIP

Forest Certification Schemes

Are forests being managed sustainably, and how can we tell? These questions have proven to be difficult to answer with global data, given the absence of global agreements and scientific consensus for what terms these agreements might contain. The EPI has considered and, in the past, used data on forest certification schemes as indicators of good forest stewardship. Forest certification involves a system of inspection and tracking timber, pulp and other forest products to ensure their harvest is according to a set of strict guidelines that span environmental standards as well as the social and economic well-being of communities and workers.[2]

Brought into prominence in the early 1990s to address the degradation of global forests, forest certification schemes are among the primary means by which the international community sets forest-management standards. In fact, they are a basis for every other certification scheme in the environmental realm, from fisheries management to green building, and they continue to be a site of innovation. This has much to do with the variety of and competition between schemes available, from the conservation-oriented Forest Stewardship Council's (FSC) to more producer-backed schemes, like the Program for the Endorsement of Forest Certification (PEFC). This preponderance of options, however, is also the main drawback of using certification schemes to develop environmental indicators.

Schemes like FSC, which are not managed by industry groups, maintain more stringent standards. The FSC also has added benefits: the records it keeps are meticulous, and ecosystem and social functions are weighted more heavily than economic ones. However, this stringency leads to slower uptake of efforts like FSC and its peers. FSC is seen to favor wealthier, industrial producers who have the means to adapt, and FSC certification is often criticized for drowning out voices of on-the-ground forest managers. While producer-backed schemes may have faster and wider uptake, major compromises and risks are embedded in their reduced stringency and predictable conflicts of interest.

Largely owing to the diversity of, and lack of consistency between, forest certification schemes, the EPI is not prepared to use them. The fact is, while certification schemes can provide more grounded accounts of reforestation and conservation of existing forests, they do not provide a full picture of ecosystem function. For that, certification schemes would have to look at larger scales—not just the forest, but the wider landscape. In fact, many wildlife biologists have complained that the race for certification has been detrimental to biodiversity, as relevant criteria for conservation of all species have not been prioritized as much as forest extraction. Perhaps even more troubling than that, some countries that pursue certification schemes with gusto—Sweden, Canada, the United States, for example—are also the countries not currently experiencing forest loss, while others, including Brazil and Russia, are experiencing major forest loss. In other words, having a lot of certified area is not yet a good indicator of national performance on forest conservation.

[1] Except where otherwise cited, all information in this box from Auld, G., Gulbrandsen, L. and McDermott, C. (2008) Certification schemes and the impacts on Forests and Forestry. *Annual Review of Environment and Resources* 33:187-211.

[2] World Wildlife Fund (WWF). *Forest certification*. Washington, D.C. Available: http://wwf.panda.org/what_we_do/footprint/forestry/certification/. Last accessed: January 10, 2014.

ACCOUNTING FOR DEFORESTATION IN NATIONAL CLIMATE EMISSIONS INVENTORY

The quantification of emissions from forest cover change has become increasingly important in the context of climate change, as forests act as important sources and sinks for carbon. When trees are deforested or removed, the carbon is released back into the atmosphere. The amount of carbon released from land-use change and forestry is not well understood,[1] though its range is somewhere between 4 to 14 percent of global carbon emissions.[2] Countries do not systematically assess emissions from land-use change and forestry.[3] While the UN Food and Agriculture Organization reports emissions from net conversion, it does not include the full set of anthropogenic activities related to land-use, land-use change, and forestry. Uncertainty in the Food and Agriculture Organization data can have significant impacts on overall emission estimates that include land-use change and forestry, particularly for countries with higher deforestation rates. For example, Indonesia, a country with some of the highest deforestation rates in the world, becomes the seventh largest emitter of greenhouse gases when these emissions are included in a national GHG inventory.[4]

[1] Houghton, R. A. (2003) Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management 1850–2000. Tellus B 55:378–390.

[2] van der Werf G.R., Morton D.C., DeFries R.S., et al. (2009) CO2 emissions from forest loss. Nature Geoscience 2:738-739.

[3] Climate Analysis Indicator Tool. (2013) Frequently asked questions. Available: http://cait2.wri.org/faq.html. Last accessed: November 22, 2013.

[4] Ibid.

800,000 km^2 of new forest during the same time period. The map also reveals that, although tropical forest loss is increasing by 2,101 km^2 per year, Brazil shows the best improvement of any country, cutting annual forest loss in half from 2003 to 2004 and 2010 to 2011. By largely removing the uncertainties contained in prior data sources, these estimates are of tremendous value for assessing the effectiveness of country-level forest management programs. However, this is not to say that the Hansen et al. (2013) data are also not without their challenges (see Box: Towards Ideal Forest Indicators).

The new satellite-derived data on global forest loss uncover a number of significant findings in comparison to prior FRA reports. Both Canada and the United States show much higher levels of deforestation than what were previously reported in the FRA, since both countries assessed forest cover change only on officially defined forest lands. China and India officially report significant forest gains that are not readily apparent in time-series satellite imagery. While discrepancies are typically fairly high at the country level, some regions fare much better. The region with the highest correlation between FRA and Landsat-derived net change is Latin America, while European data have the least correlation of the regions examined.[88]

Prevailing discussions point to policy failure as the main driver of deforestation.

In many nations with high rates of forest loss, economic development goals tend to override social and environmental concerns associated with deforestation. Subsidies for agriculture, allowing the invasion of forest lands to avoid land reform elsewhere, lax enforcement of logging concessions, and corruption in the forest sector all contribute to high rates of land clearing.[89] In other areas, it appears as if policy and monitoring are far ahead of operational capabilities. For example, the UN Framework Convention on Climate Change (UNFCCC) Reducing Emissions from Deforestation and Forest Degradation (REDD) program does not have institutional investment and scientific capacity to begin implementing a program that can utilize a global observational record.[90]

[88] Hansen, M. C., Potapov, P. V., Moore, R., et al. (2013) High-resolution global maps of 21st-century forest cover change. *Science* 342:850-853.

[89] Food and Agricultural Organization. (2012) *State of the World's Forests*. Rome, Italy. Available: http://www.fao.org/docrep/016/i3010e/i3010e.pdf. Last accessed: January 7, 2014.

[90] Hansen, M. C., Potapov, P. V., Moore, R., et al. (2013) High-resolution global maps of 21st-century forest cover change. *Science* 342:850-853.

Given the global importance of forests, it is imperative that countries strive to curb deforestation and bolster protection of these valuable ecosystems. It is only through a widespread and concerted global effort to reduce the loss of these ecosystems that the future of forests can be ensured.

MEASURING DEFORESTATION IN REAL TIME

Clear-cutting is one of the most destructive environmental practices on forest ecosystems. (Credit: Timothy Epp / iStock-Thinkstock)

Global Forest Watch

Forest health and deforestation have been staples of modern environmental politics and actions, and for good reason. Forests are critical, their ecosystem services range from the cycling of nitrogen and oxygen, to carbon storage, to housing the bulk of the earth's terrestrial biodiversity and biomass. And that is only to name a few. So why are current global datasets and assessments of the state of the world's forests so woefully incomplete?

The current standard reference for forest resource information, the UN Food and Agriculture Organization's Forest Resource Assessment (FRA), is a Herculean effort at collecting and aggregating data for 233 countries across about 90 different variables, ranging from condition of forests to uses of forest products. Such a massive project takes time, so the FRA is only updated every five years. And its reliance on national reports makes the FRA and its conclusions vulnerable to differences in critical definitions, methods, and capacity for data collection between countries and even regions. It is a worthy catalog of the scope of the world's forests and uses, but perhaps that is all it is, an overview, too slow and general to allow for responsive policy or management practices.

Soon, however, the World Resources

Institute, along with its partners, will launch Global Forest Watch, a new initiative combining satellite technology with open and crowd-sourced data to monitor forests in near real time. Whereas it used to take months to analyze satellite imagery to understand trends in deforestation, Global Forest Watch will create a system to detect patterns that point at deforestation as it occurs on the ground, often in dense forest that cannot be effectively patrolled otherwise.

A key piece of the project is a forest clearing alert system, updated every 16 days. Based on a dataset from Forest Monitoring for Action the alert system compares data gathered daily by satellite with the Normalized Difference Vegetation Index, a measure of vegetation greenness. The alerts will indicate where deforestation may be occurring within a 500-meter x 500-meter area across the world's humid tropical forest biome. Upcoming upgrades will improve the resolution to 250-meters x 250-meters and expand coverage to the rest of the tropics and eventually, to other biomes.

"For the first time, not only will governments and land managers be able to see how forests are changing, but the entire world will be," said World Resources Institute Communications Officer James Anderson, in a recent interview with the Yale Center for Environmental Law & Policy.

"This will change how businesses buy major agricultural commodities, how governments police protected areas, and how traditional communities manage their land."

Testers of the Global Forest Watch beta site are already using the data to help inform criminal investigations and prioritize the efforts of local law enforcement networks, said Anderson. Several business leaders have expressed interest in using Global Forest Watch to help monitor concessions in their commodity supply chains. Soon, rather than just monitoring palm oil futures, traders on the Chicago Board of Trade will be able to monitor forest coverage data for the places where their palm oil is sourced.

"Data-rich projects like [Global Forest Watch] and the EPI help drive a virtuous cycle of information disclosure and transparency," said Anderson. "As high-quality data becomes public on these platforms, researchers and the public are able to develop policy innovations. This leads to calls for greater data availability and transparency. This drives strong, evidence-based policy."

To learn more about GFW, visit http://www.wri.org/our-work/project/global-forest-watch.

Satellite data now provide a clearer picture of how the U.S. has managed its forests compared to the world (Credit: NASA/Robert Simmon)

TOWARD IDEAL FOREST INDICATORS

Although the Forest Loss indicator in the 2014 EPI is a step toward better understanding changes in forest cover over the last decade, it is still far from perfect. Hypothetically, what would a set of ideal indicators for forests look like?

As with any issue, ideal forest indicators would be broadly measurable, reflective of performance, and relevant to policymakers. An ideal national-level measure would be in some ways scalable to local forests while encompassing the wide range of forest management objectives, from biodiversity, to carbon sequestration, to cultural and economic uses, and beyond. Another ideal measure would assess differences in forest species composition and richness – both prerequisites for sustaining a range of ecosystem services.[1] Ideal indicators would also recognize that forest ecosystems are not isolated from other ecosystems but connected to them in form and function.

The use of satellite-derived data from Hansen et. al. (2013) to create a first-of-its-kind, high-resolution global map of forest extent, loss, and gain represents a step in the right direction. As mentioned in the Issue Profile: Forests, data for forest growing stock and forest cover change in past EPIs came from the UN Food and Agriculture Organization's Forest Resource Assessment (FRA), which is primarily informed by country-reported data and is known to be plagued with inconsistencies across countries.[2] Such disparities are exacerbated by various country definitions of what constitutes "forested land," which in many cases is primarily determined by land use, or the ways forested areas are used by people.

A forest land-use definition might ignore certain types of disturbances that an analysis of forest cover might reveal. For instance, North American subtropical forests, which experience short-cycle planting and harvesting for lumber,

[1] Chapin III, F. S., Zavaleta, E. S., Eviner, V. T., et al. (2000) Consequences of changing biodiversity. *Nature*, 405:234-242.
[2] The Food and Agriculture Organization of the United Nations. (2008) *Global Forest Resources Assessment 2010: Guidelines for country reporting for 2010*. Available: http://www.fao.org/forestry/14097-0a8d9580c21c82a81175207120544e2b8.pdf. Last accessed: January 13, 2014.

underwent disturbances at nearly four times the rate of South American rainforests between 2000 and 2012. During that time, more than 31 percent of forest cover in the southeastern United States was lost or regrown. The resulting biophysical changes in form and function of those forests are ignored by the FRA's land-use analysis. However, satellite data were able to capture it.[3]

A similar situation arises with respect to deforestation. A land-use methodology has significant implications for the measurement of deforestation. Huge changes in forest cover can be ignored if the reporting country does not list changes in use. This discrepancy was noted in the divergence in data between Canada and Indonesia, both of which clear natural forests without converting the land to non-forest land uses. However, because cleared forest that is left for "natural recovery" or listed as "managed forest" does not count as deforestation under the FRA's guidelines, Canada's loss of forest cover can go uncounted, while Indonesia's is tallied.[4]

However, the Hansen et. al. (2013) analysis is not immune to definitional challenges, either. Because it tracks tree cover and is not yet fine-grained enough to differentiate between types of tree cover or the biophysical function of those trees, the Hansen et. al (2013) data cannot differentiate between reforestation—or the replanting of forest land—and afforestation, which may in fact have no direct biophysical function. This means Malaysia, with its numerous palm oil plantations, still receives credit for afforestation, even if these plantations are planted in grasslands, or for reforestation, even if those plantations replace natural growth forests. The Hansen et. al (2013) satellite-based mapping system of global forest change would benefit from differentiating between forest use practices to properly measuring global forest change. It is possible, however, that no satellite will ever be able to fully capture such practical, grounded realities.

The EPI's assessment of forest management would also benefit from the inclusion of other governance-based measures, such as whether countries make efforts to ensure the sustainable harvest and sale of timber and wood products (see Box: Measures of Stewardship – Forest Certification Schemes). Nonetheless, globally available data to assess more qualitative aspects of forest performance are sparse.

[3] Hansen, M., Potapov, P. V., Moore, R., et. al. (2013) High-resolution global maps of 21st-century forest cover change. *Science*, 342:850-853.

[4] Hansen, M., Potapov, P. V., Moore, R., et. al. (2013) Supplementary Materials for High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, 342:850-853.

IRAQ DESIGNATES FIRST NATIONAL PARK

Some people believe that Iraq's Central Marshes, formed by the Tigris and Euphrates watersheds, are the location of the biblical Garden of Eden. A rare example of a huge wetland ecosystem in arid – even desert – conditions, the Central Marshes are a vital stopover for migratory birds, a site of unique and beautiful habitats, and, since the time of the Sumerians, home to the indigenous Ma'Dan people, known as the Marsh Arabs. In the last decades of the 20th century, the marshes were drained and burned, most prominently by the regime of Saddam Hussein in an effort to destroy possible hiding places and food sources for insurgents. Dam construction in Turkey at the Tigris and Euphrates headwaters exacerbated the devastation. In 2003 the United Nations Environment Programme estimated that 93 percent of the marshlands had disappeared.[1] Through great effort on the part of Iraqi conservationists, in cooperation with international organizations, Iraq's marshes are finally recovering.

On July 23, 2013, Iraq made a remarkable announcement: 400 square miles of the Central Marshes are now protected as Iraq's first national park. Restoration has been ongoing for nearly a decade already, with scientists conjecturing that 70 to 75 percent of the marshes could recover.[2] Thanks to the efforts of Nature Iraq, the Ministry of Water Resources, the Ministry of Environment, and the National Park Committee, this ecosystem is now under legal protection as it undergoes the recovery process.

Nature Iraq has identified the locations richest in biodiversity in anticipation of increasing the amount of protected lands and waters in other regions of Iraq.[3] The initial designation has taken almost a decade. Now, the nonprofit has a plan for 10 more national parks that will protect about 17 percent of the land.[4] Iraq ranked last in the 2012 EPI, but has seen a slight improvement in its performance over the past decade. Efforts like these will boost biodiversity and habitat and will help the nation continue to improve its environmental performance.

[1] United Nations Environment Programme (UNEP). (2003) *"Garden of Eden" in southern Iraq likely to disappear completely in five years unless urgent action taken."* Nairobi, Kenya. Available: http://www.unep.org/Documents.Multilingual/Default.asp?ArticleID=3920&DocumentID=298. Last accessed: January 11, 2014.

[2] Al-Ansari, N., Knutsson, S., Ali, A. A. (2012) Restoring the Garden of Eden, Iraq. *Journal of Earth Sciences and Geotechnical Engineering*, 2:53-88.

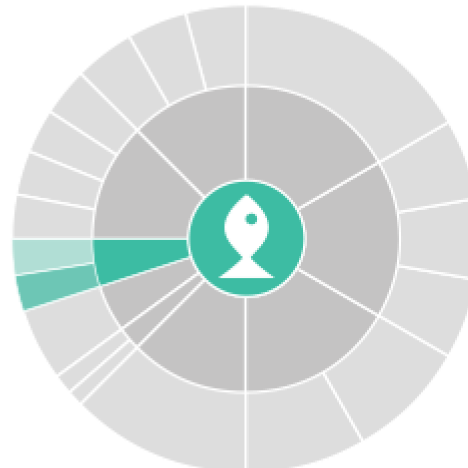
[3] Nature Iraq. (2013) *Key biodiversity areas of Iraq*. Available: http://www.natureiraq.org/maps.html. Last accessed: January 11, 2014.

[4] Schwartz, A. (2013) *This is Iraq's first national park*. Fast Company. Available: http://www.natureiraq.org/maps.html. Last accessed: January 11, 2014

Fisheries

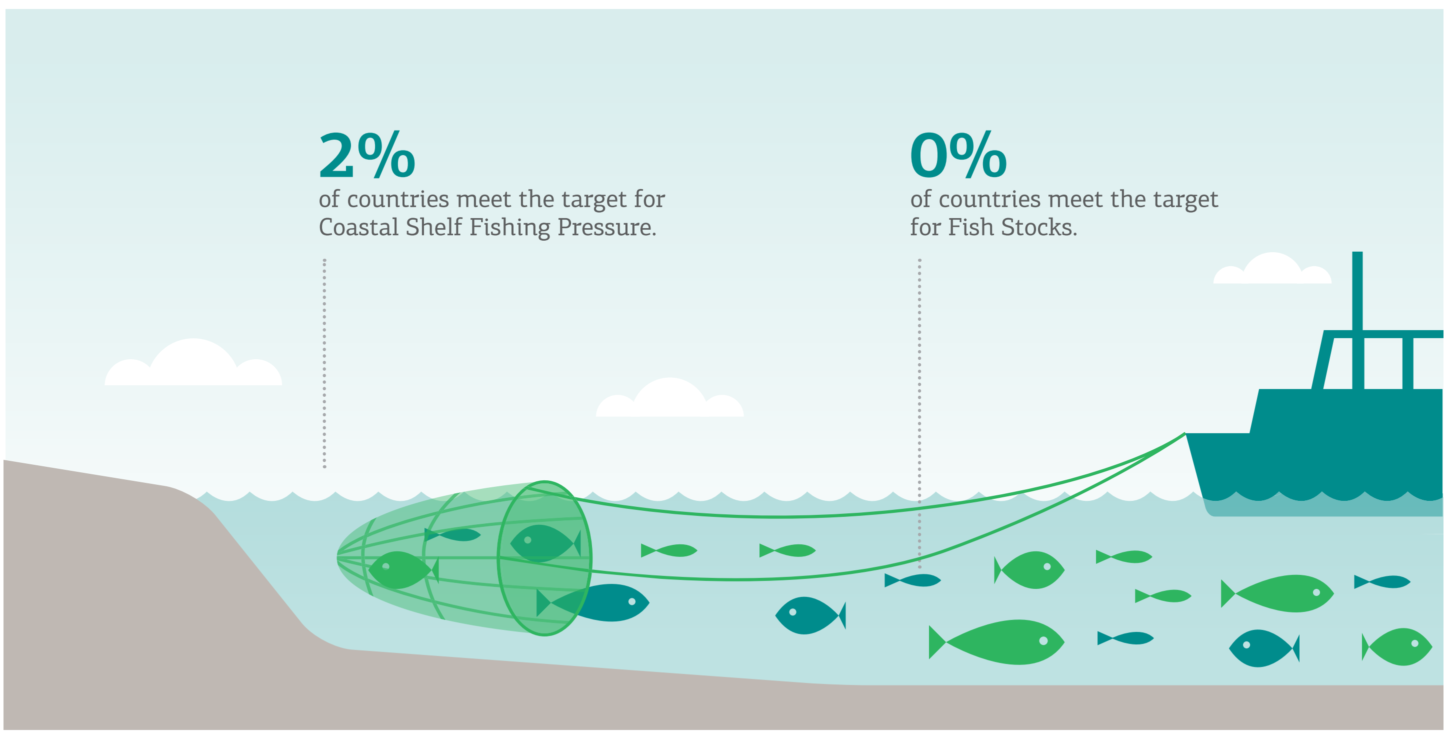
What It Measures

The Fish Stocks indicator measures the percentage of a country's total catch — within its exclusive economic zone — that is comprised of species listed as overexploited or collapsed. The Coastal Shelf Fishing Pressure indicator assesses the total catch from trawling and dredging equipment divided by the total area of each country's exclusive economic zone.



Why We Include It

This category reflects overall fishery health by showing whether countries are harvesting fish and invertebrates at unsustainable rates or through practices that significantly harm the coastal shelf ecosystem. These two indicators reveal the level of fishing pressure within each coastal country's exclusive economic zone.



Where the data come from

The data are compiled and analyzed by the Sea Around Us Project, University of British Columbia Fisheries Centre. The Sea Around Us bases its information on data from the FAO, the International Council for the Exploration of the Seas (ICES), the STATLANT database, the Northwest Atlantic Fisheries Organization (NAFO), and data provided from Canada, the United States, and other governments.[91]

DESCRIPTION

The collapse of the cod population off the northeastern coast of North America is an oft-told cautionary tale of rapid decline. A fishery once so robust that legend told of people walking across the water on the backs of fish, it went from the primary source of an entire region's economy to desolation almost overnight. Beyond its suddenness, what made the collapse of the cod fishery so shocking was that at the time it was believed to be among the best managed in the world, protected by Canadian and American policies that pushed out foreign fleets, and fiercely guarded by the communities who worked there. By 1992, when the number of northern cod in the fishery was estimated to be about one percent of what it had once been, conventional wisdom about proper management went out the window.[92]

Fisheries across the planet have experienced their own collapses, overfished to the point where recovery may be impossible. Some have fallen apart despite protections and policy advancement, as the case of the North American cod illustrates. Some have been obliterated by lack of regulation and wasteful practices that include the willful capture and disposal of unintended species, known as bycatch. In either case, major problems in fisheries management have been exposed. Regulation and advanced technology do not necessarily ensure sustainability; signs that sudden collapse is imminent might not be clear; and a full understanding of the ecological dynamics that govern the sustainability of fisheries has not been achieved.

Fisheries management tends to depend upon setting exploitation levels within a range at which species can replace their numbers through reproduction.[93] The metrics for calculating these levels, however, are still a work in progress. In many cases, scientific understanding of how to calculate sustainable yields has not developed as quickly as fishing technology.[94] Since World War II, technology-driven productivity has enabled exponential increases in the number of fish harvested by a single ship in a single day. Overfishing first came to international prominence during the 1970s, and it remains a critical environmental problem throughout much of the world, especially where countries perceive fishing as necessary for food security, a means to development, or a key economic asset.

Exclusive economic zones (often called EEZs), formally adopted in 1982, are a key tool in effective fisheries management. An exclusive economic zone stretches 200 nautical miles outward from a country's coastline. There, the state has special rights over the exploration and use of marine resources, allowing it to enforce domestic policies on sustainable fishing practices by limiting or eliminating fishing by other countries. Namibia's fisheries, for example, have significantly benefited from the creation of an exclusive economic zone. Prior to its establishment in 1990, Namibian fishermen caught less than five percent of the total fish caught off Namibia's coast. Instead, South African, Spanish, Russian, and Ukrainian fishing boats dominated Namibia's waters. By the 1980s, approximately 90 percent of the country's

[91] The Sea Around Us Project. (2013) Available: http://www.seaaroundus.org/. Last accessed: January 10, 2014.

[92] Myers, R., Hutchings, J., and Barrowman, N. (1997) Why do fish stocks collapse? The example of cod in Atlantic Canada. *Ecological Applications* 7:91-106.

[93] Ricker, W. E. (1975) Computation and interpretation of biological statistics of fish populations. *Bulletin. Fisheries Research Board of Canada* 191:1-382.

[94] Grainger, R. J. R. (1999) *Global trends in fisheries and aquaculture*. In: Trends and future challenges for U.S. national ocean and coastal policy: proceedings of a workshop organized by the National Ocean Service, NOAA, Center for the Study of Marine Policy at the University of Delaware, The Ocean Governance Group on 22 January 1999 in Washington, D.C. Available: http://oceanservice.noaa.gov/websites/retiredsites/natdia_pdf/ctrends_proceed.pdf. Last accessed: January 10, 2014.

What is Coastal Shelf Fishing Pressure?

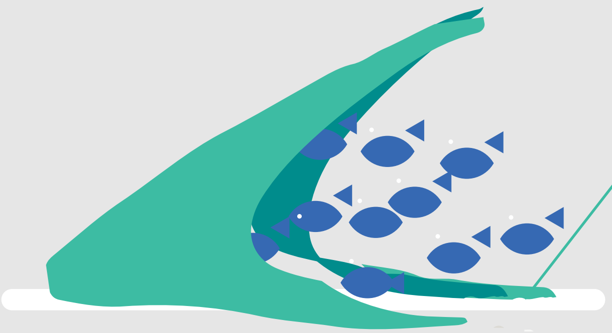
The Coastal Shelf Fishing Pressure indicator measures the intensity of gears such as trawlers that operate on the shelf.

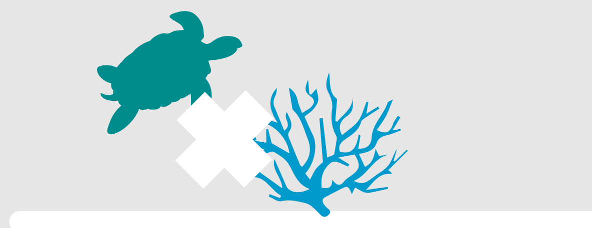
Benthic Trawling

A fishing method that targets fish and invertebrates that inhabit ocean floor (or benthic) ecosystems.

Trawler

A fishing vessel equipped with large heavy nets that are dragged across the living seafloor.

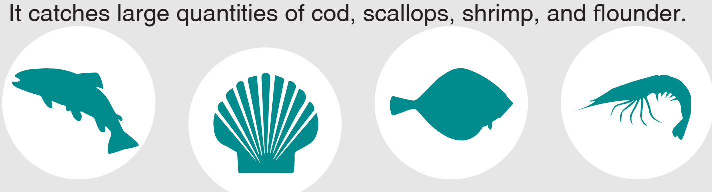




Seafloor/Shelf

Effective

It catches large quantities of cod, scallops, shrimp, and flounder.



Destructive

This fishing method is considered one of the most destructive fishing gear in use today. It breaks 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.

How do we know?

Data Collection

The Sea Around Us spatial database is based on several major data sources, such as:

- Food and Agriculture Organization of the United Nations (FAO) capture fisheries and its regional bodies
- the International Council for the Exploration of the Seas (ICES)
- STATLANT database
- the Northwest Atlantic Fisheries Organization (NAFO)
- data provided by Canada, the United States, and other governments

Calculation Method

Catch from Trawling and Dredging Gear

The catches in each spatial cell are associated with the appropriate fishing gear code to determine the catch from trawling and dredging gear.

EEZ Area by Country by Year

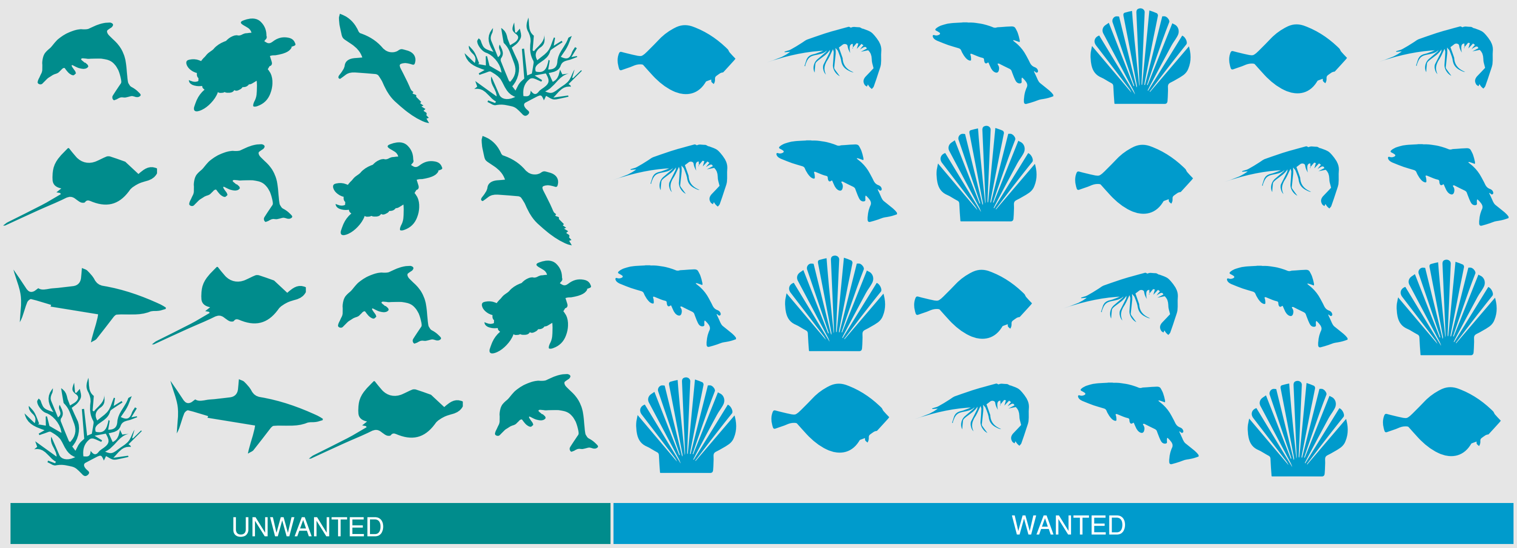
An Exclusive Economic Zone (EEZ) is a seazone prescribed by the United Nations Convention on the Law & the Sea over which a state has special rights over its marine resources within 200 nautical miles from its coast. In some cases, countries have rights to their continental shelf if it extends beyond those 200 nautical miles.

The Coastal Shelf Fishing Pressure Indicator

The 2014 EPI calculates the score for every country and ranks countries based on the scores.

Why does it matter?

Intensive practices like seafloor trawling affect many species and their habitats.



40% It's estimated that 40.4 percent of all global catches are bycatch, the unwanted sea life that gets caught in fisheries operations.

10:1 In some areas, juvenile 'trash fish' can outweigh the catch of targeted shrimp by more than 10 to 1 in shrimp fisheries.

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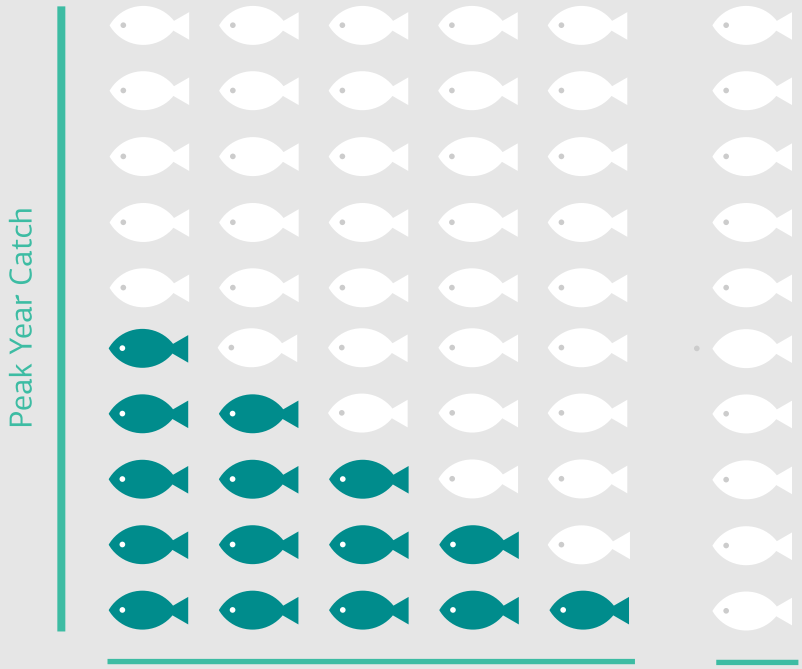
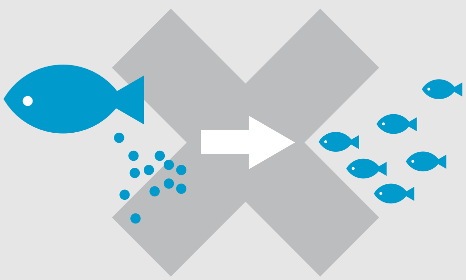
• Sea Around Us Project. http://www.seaaroundus.org/
• Davies, R.W.D., Cripps S.J., Nickson A., & G. Porter (2009). “Defining and Estimating Global Marine Fisheries Bycatch. Marine Policy 33, 661-672
• Tackling fisheries bycatch. World Wildlife Fund (WWF). http://wwf.panda.org/what_we_do/where_we_work/coraltriangle/solutions/tackling_fisheries_bycatch/

What is Fish Stocks?

Fish Stocks uses catch data to identify species being exploited above a sustainable level, risking stock depletion.



Dangers to Fish Reproduction & Growth



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.

Overexploited (10-50%)

For a given species, stock that are caught after the year of peak catch and total 10 percent to 50 percent of the peak catch are considered overexploited.

Collapsed (<10%)

For a given species, stock that are caught after the year of peak catch and total less than 10 percent of the peak catch are considered

How do we know?

This indicator calculates thenumber of overexploited and collapsed fish stocks divided by the total numbers of stocks per EEZ.

1 Clearly define a local fish stock.

Sea Around Us (SAU) defines a stock to be a taxon 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 1,000 metric tons.

2 Assess the catch of the stock, relative to the peak catch.

Second, SAU asseses the catch of the stock for every year, relative to the peak catch. SAU defines five states of stock status for a catch times series.

The EEZ Area by Country by Year

An Exclusive Economic Zone (EEZ) is a seazone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights over its marine resources within 200 nautical miles from its coast. In some cases, countries have rights to their continental shelf if it extends beyond those 200 nautical miles.

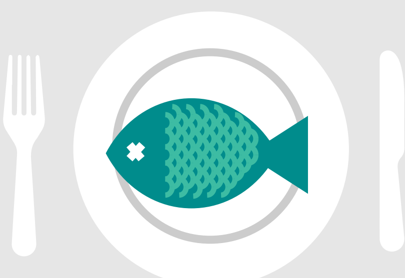
3 Determine the number of stocks and their percentages for each state.

SAU creates a plot number of stocks by status by tallying the number of stocks in a particular state in a given year, and presenting these as percentages.

4 Sum all stocks and present as a percentage in catch.

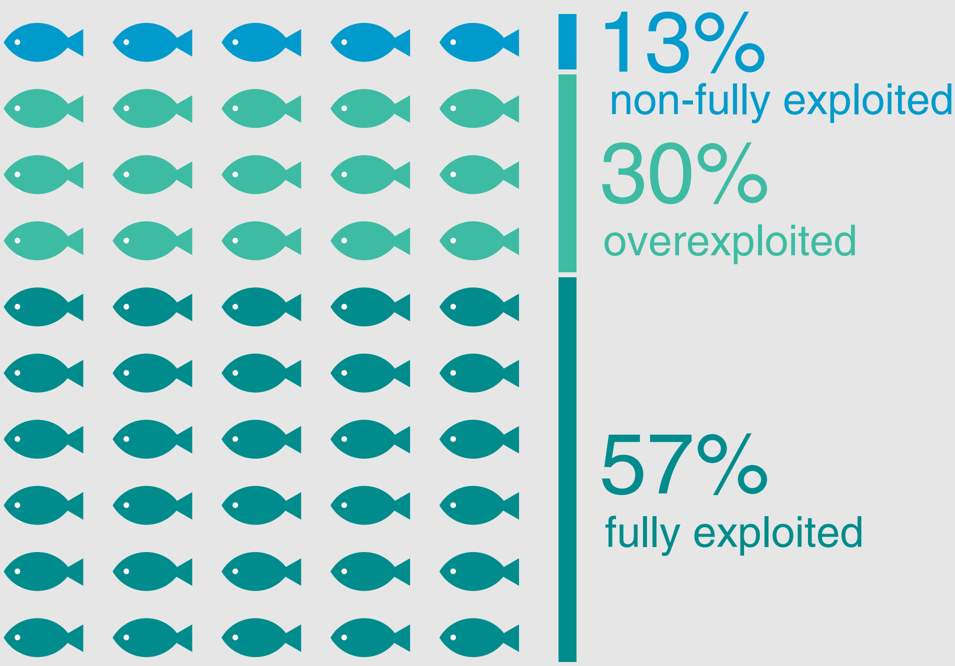
Finally, the cumulative catch of stock by status in a given year is summed over all stocks and presented as a percentage in the catch by stock status graph.

How is the world doing?



Fish as Major Food Sources

Today, intensive fishing remains a critical environmental problem throughout much of the world, especially where countries perceive fishing as necessary for food security, a means to development, or a key economic asset.



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Illegal fishing equipment is so extensive that it can be seen from outer space. (Credit: Rob Bouman / iStock-Thinkstock)

GOOGLE EARTH USED TO CAPTURE UNDERREPORTING IN ANNUAL FISH CATCH

When excavators dug what would become subway tunnels beneath Boston in 1915, they found thousands of wooden stakes, remnants of an ancient, stationary fishing trap known as a weir. This one was huge, installed to corral hundreds of thousands of fish as they attempted to swim to deeper waters during the ebb tide. And it was not just old – it was a fixture of life. Carbon dating revealed the trap, now known as the Boylston Street Fishweir, was first installed 5,700 years ago, and that it was used and maintained over a period of 1,500 years.

As technology goes, fish weirs are among humanity's oldest, and, judging by their continued worldwide use, most irreplaceable. So it is a little ironic that one of the newest technologies – satellite imagery – was used to expose the present-day use of weirs to overharvest commercial fish species. In a recent study published online in the ICES Journal of Marine Science in November 2013, researchers employed Google Earth to count the number of fishing weirs sited off of six Persian Gulf nations: Kuwait, Bahrain, UAE, Iran, Saudi Arabia, and Qatar.[1] Using Google Earth images, local and regional data on catch volumes, and data about types of fish caught, the researchers created a model for the likely yearly catches at the studied weirs. What they found may have been fit for a detective novel – mismatches between officially reported catch data and estimates including fish catches using weirs.

Across all six countries, the study estimated that 31,433 tons of fish were caught in weirs in 2005. This number was six times higher than the 5,260 tons reported to the Food and Agriculture Organization. The researchers estimated that in Bahrain alone, catch volume from weirs was 142 percent greater than the total volume that country reported for all types of fishing. Perhaps even more striking, Iran reported that no fish were caught in weirs in 2005, while the study estimated 12,000 tons of fish were caught in Iranian weirs that year.

While the study's methods are novel and limited in geographic scope, they have the potential to be applied on a much broader basis to provide greater insight as to the true sustainability of fishing practices, and to shed new light on the health of global fisheries. The authors stress that the six countries studied are not alone in their negligence. The study, they assert, is just representative of a larger global misreporting problem. Satellite data is a new tool – similar to the way the fishing industry has used technology like Fishfinders and GPS Chartplotters to target catches – to monitor fisheries, particularly in areas that were previously considered too remote or expensive to patrol, according to the authors. With satellite technology comes expanded capacity to monitor fisheries, forests, and land-use in ways that complement the old tools.

[1] Al-Abdulrazzak, D. and Pauly, D. (2013) Managing fisheries from space: Google Earth improves estimates of distant fish catches. *ICES Journal of Marine Science*, published online, 25 November 2013, doi: 10.1093/icesjms/fst178.

fish stock was overexploited or collapsed. Since 1990, however, the fishery has recovered by more than 30 percent.[95]

Volume of fish caught is not the only potential risk to fisheries. Ocean ecosystems are significantly affected by the way in which aquatic species are harvested.

Bottom or benthic trawling and dredging, which leave widespread, lasting damage, are used heavily in fisheries.[96] Respectively, these methods employ either a large net or a mechanical arm dragged along the ocean floor, hollowing out deep furrows. Aimed primarily at collecting benthic species like rockfish, cod, flounder, shrimp, and scallops, dredging and trawling break off brittle bottom flora and fauna such as sponges and corals and catch unintended marine species. Bycatch often includes sea turtles, which are particularly slow to reproduce.[97] The EPI's Coastal Shelf Fishing Pressure indicator measures the degree to which intensive and destructive fishing equipment, like trawlers and dredgers, operates within a country's exclusive economic zone.

An assessment of countries' catch data is paired with the Coastal Shelf Pressure indicator. Fish stocks, or the estimated sub-populations of given species, are becoming easier to track. As with most environmental concerns, monitoring is the primary condition of successful fisheries management. Fish stocks are listed as undeveloped, developing, fully exploited, overfished, or collapsed, according to the size of catch relative to the historical peak catch. The Sea Around Us Project, which contributed the data for this indicator, created an additional category — "recovering"— to account for fisheries where populations have begun to rebound as a result of effective management.

In calculating data for the Fish Stocks indicator, Sea Around Us determined that the reporting of low or erroneous catch data by a number of countries has led to misrepresentation of the real performance of their fisheries. For this group of 57 countries, Sea Around Us did not calculate stock status plots, which comprise the data used to determine the proportion of fish stocks overexploited or collapsed. This discrepancy was stark for Haiti, which achieved the first rank in this category in the 2012 EPI. Haiti may have reported its catch of commercial species, but its reporting in respect to destructive fishing practices and bycatch was lacking. Haitian reefs are near collapse, and the country's fishery is among the most heavily depleted in the world.[98] Many other countries have had issues with questionable data that do not allow assessment of the status of fish stocks. Some countries penalized in the 2014 EPI include Belgium, Monaco, Slovenia, Israel, Eritrea, Benin, Belize, and Singapore.

[95] Levy, M. (2012) *Seeking the signal in the noise of environmental performance metrics*. Yale Center for Environmental Law and Policy: Connecticut, United States. Available: http://environment.yale.edu/envirocenter/post/seeking-the-signal-in-the-noise-of-environmental-performance-metrics/. Last accessed: January 10, 2014.

[96] Watson, R., Hoshino, E., Beblow, J., et al. (2004) *Fishing gear associated with global marine catches*. Fisheries Centre, University of British Columbia, Vancouver, Canada. Available: http://www.ecomarres.com/downloads/12-6.pdf. Last accessed: January 10, 2014.

[97] de Quevedo, I. A., Cardona, L., De Haro, A., et. al. (2010) Sources of bycatch of loggerhead turtles in the western Mediterranean other than drifting longlines. *ICES Journal of Marine Science* 67:677-685.

[98] Battaglia, N. (2013) The Status of Haiti's Fisheries: When Numbers Don't Match Reality. Environmental Performance Index: Connecticut, United States. Available: http://epi.yale.edu/community/blog/2013/08/13/status-haiti-s-fisheries-when-numbers-don-t-match-reality. Last accessed: January 10, 2014.

The means for holding countries accountable for bad reporting are gradually emerging. Recently a group of researchers used Google Earth mapping to expose potential underreporting of fish catch in Iran, Saudi Arabia, and Qatar (see Box: Google Earth Used to Capture Underreporting in Annual Fish Catch). They used satellite images of fishing weirs - a type of large, stationary trap - to estimate real catch sizes and found that they exceeded reported catches by as much as 600 percent.[99] Another major cause of misreporting is the tracking of catch quantities solely for commercial species, which disregards the volume of bycatch.

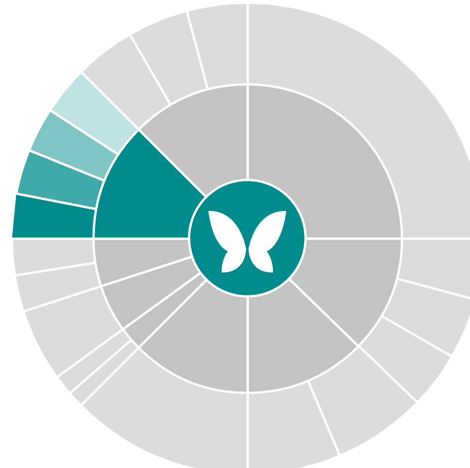
Sadly, incomplete or inconsistent reporting, deliberate underreporting, and poor monitoring of fisheries is common. The 2014 EPI is sensitive to this unacceptable global trend.

It penalizes a total of 57 countries by scoring them with the lowest observed indicator scores for both the Fish Stocks and Coastal Shelf Fishing Pressure indicators. Countries who report bad data for one or more EEZ were also penalized and given the worst observed value. The countries that fall into this category include Australia, France, the Netherlands, Russia, South Africa, Saudi Arabia, the United Kingdom, and the United States. By penalizing these countries, the 2014 EPI aims to encourage them to pursue better monitoring and reporting of both their exclusive economic zones and their fish stocks.

[99] Al-Abdulrazzak, D., and Pauly, D. (2013) Managing fisheries from space: Google Earth improves estimates of distant fish catches. *ICES Journal of Marine Science* published online 25 November 2013. DOI:10.1093/icesjms/fst178.

ISSUE PROFILE

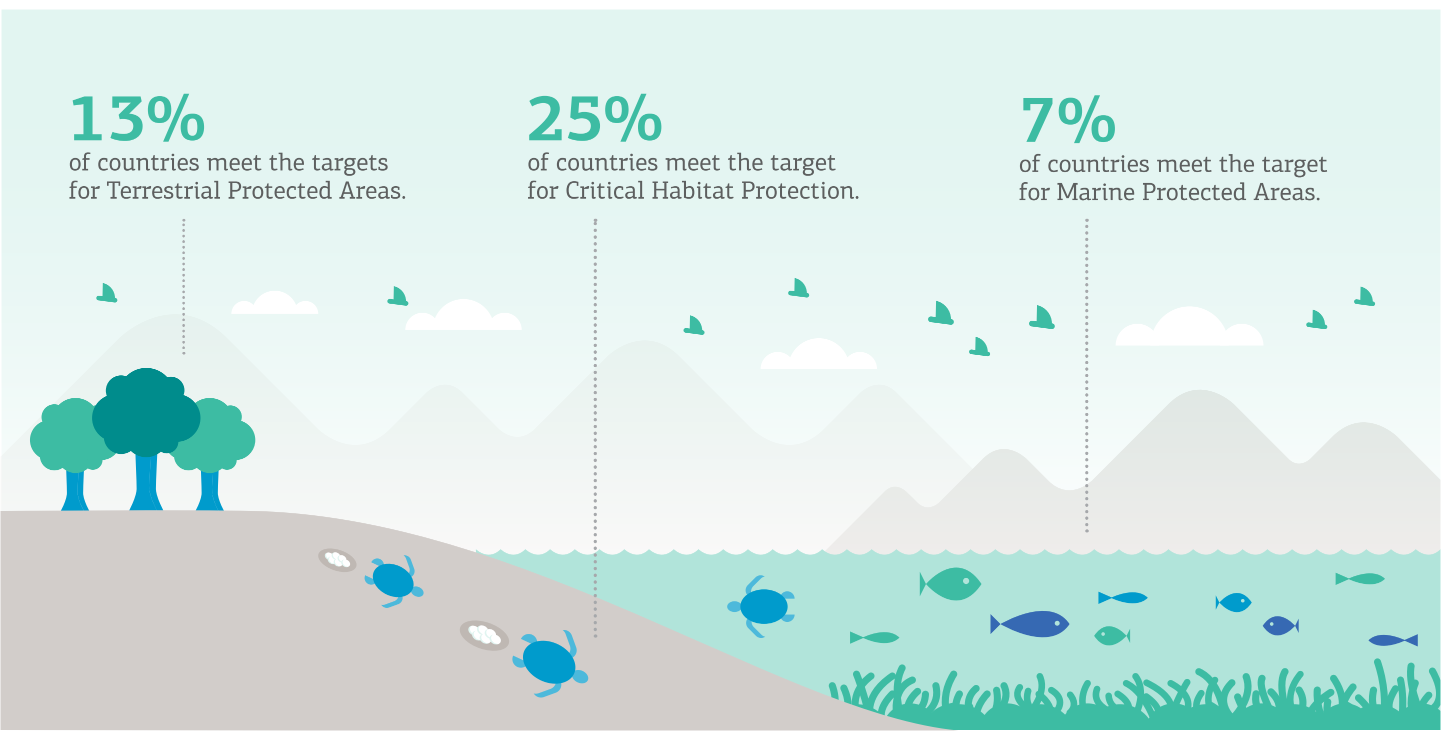
Biodiversity & Habitat



What It Measures

The Biodiversity and Habitat category includes four indicators: Critical Habitat Protection, Terrestrial Protected Areas (National Biome Weight), Terrestrial Protected Areas (Global Biome Weight), and Marine Protected Areas.

The Critical Habitat Protection indicator measures the percent of sites identified by the Alliance for Zero Extinction (AZE) that have partial or complete protection. The AZE is a collaborative network of conservation organizations working to identify irreplaceable habitats for highly endangered species. AZE sites are places where 95 percent or more of the entire known population of an endangered or critically endangered species (as defined by the International Union for Conservation of Nature (IUCN) 2004 Red List) occurs. Although 2010 site data are available, the 2014 EPI indicator uses the 2005 data on the basis that countries need at least five years to plan for the establishment of a protected area that encompasses the AZE biodiversity sites. Because not all countries have AZE sites, we have scores for 91 countries.



Terrestrial Protected Areas are broken into two indicators that weight the percentage of biomes under protected status. The Terrestrial Protected Areas (National Biome Weight) indicator assesses the protection of biomes weighted by the proportion of a country's territory the biome occupies. The Terrestrial Protected Areas (Global Biome Weight) reflects the protection of biomes weighted by their globally proportional abundance. These two weightings reflect different contributions of biodiversity conservation efforts at national and global scales. While understanding biome protection at a national scale is useful, it is also helpful to know the global context of these protection efforts.

Marine Protected Areas measures the percentage of country's exclusive economic zone (EEZ) that is under protection. Although the majority of marine protected areas lies within territorial waters (0 to12 nautical miles from land), it is important to include EEZs (12 to 200 nautical miles) in this measure because several types of valuable marine habitats exist only in EEZs, including deep-sea trenches, submarine canyons, and seamounts.[100] Additionally, nations have sovereign rights within EEZs for exploration, exploitation, and conservation, so it is important to understand how well they are managing these areas.[101] Protected areas in both terrestrial and marine realms are defined as nationally designated IUCN category I-VI protected areas.

Why We Include It

Habitat protection is a necessary but not sufficient condition for the conservation of biodiversity and ecosystem services that are critical to sustain human life and well-being.[102] The Critical Habitat Protection indicator examines the extent of protection of the last remaining habitats for endangered or critically endangered species (according to the IUCN criteria). The EPI's measurement of terrestrial and marine protected areas stems from the targets set by the Convention on Biological Diversity (CBD), which established protection goals of 17 percent of terrestrial and inland water areas and 10 percent of marine and coastal areas.

Where The Data Come From

All four indicators build on data from the World Database on Protected Areas (WDPA) maintained by the United Nations Environment Programme (UNEP) World Conservation Monitoring Centre (WCMC). More specifically: Critical Habitat Protection is drawn from the AZE and the WDPA. Terrestrial Protected Areas uses data from the World Wildlife Fund Ecoregions of the World and the WDPA. Marine Protected Areas is built with data from the Flanders Marine Institute (VLIZ) Maritime Boundaries Database and the WDPA.

DESCRIPTION

Humans rely on natural resources to serve the most basic of our needs—including food, water, clothing, and shelter. Yet our collective impact on the planet's ecosystems threatens the very resources that have allowed us to thrive as a species. In 2010, the 168 Parties of the CBD adopted the Nagoya Protocol, agreeing to the Strategic Plan for Biodiversity 2011-2020 and a series of goals known as the Aichi targets.[103]

The targets seek to protect the Earth's biological diversity and promote the sustainable use of natural resources and the equitable sharing of the benefits we derive from ecosystem services. The EPI charts each country's progress in achieving these goals through three indicators - Terrestrial Protected Areas (National Biome Weight), Terrestrial

100 Corrigan, C. and Kershaw, F. (2008) *Working Toward High Seas Marine Protected Areas: An Assessment of Progress Made and Recommendations for Collaboration*. United Nations Environment Programme World Conservation Monitoring Centre. Cambridge, United Kingdom. Available: http://www.cbd.int/doc/meetings/mar/ewbcsima-01/other/ewbcsima-01-unep-wcmc-en.pdf. Last accessed: January 11, 2014.

101 *Ibid.*

102 Additional indicators such as the effectiveness of protected area management, trends in species abundance, enforcement of wildlife trafficking laws, and quality of landscape conservation efforts would be desirable, but sufficient internationally comparative data are not available at this time.

103 Convention on Biological Diversity. *Strategic plan for biodiversity 2011–2020 and the Aichi Targets*. Available: http://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf. Last accessed: January 2014

What are Terrestrial Protected Areas?

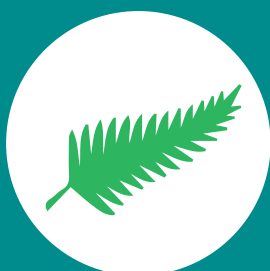
Two Terrestrial Protected Areas indicators measure the percentage of terrestrial habitat under protected status.

Habitat Conservation

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.

15 Different Biomes of Terrestrial Protected Areas

Forests



Tropical & Subtropical Moist Broadleaf Forests

Tropical & Subtropical Dry Broadleaf Forests

Tropical & Subtropical Coniferous Forests

Temperate Broadleaf and Mixed Forests

Temperate Conifer Forests

Boreal Forests and Taiga

Mediterranean Forests, Woodlands and Scrub

Grasslands, Savannas & Shrublands

Tropical & Subtropical Grasslands, Savannas and Shrublands

Temperate Grasslands, Savannas and Shrublands

Flooded Grasslands and Savannas

Montagne Grasslands and Shrublands

Others

Tundra

Deserts and
Xeric Shrublands

Mangrove

Snow and Ice

Target Set by the Convention on Biological Diversity

The EPI's measurement of Terrestrial Protected Areas stems from the targets set by Convention for Biological Diversity, which establishes a conservation goal of 17 percent of terrestrial and inland water areas by 2020.

17% of terrestrial and inland water under protection

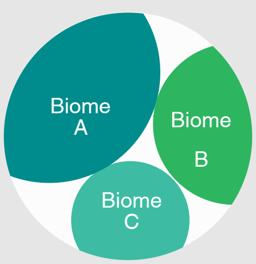
How do we know?

Two Kinds of Weighting: National & Global

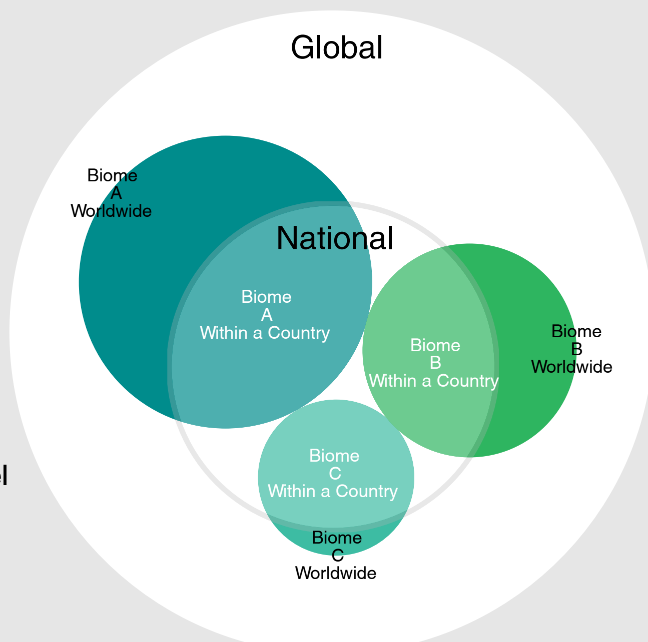
EPI measures both the national and global contribution of a country's biome protection.

National Weight

The percentage a particular biome comprises out of a country's total biomes.

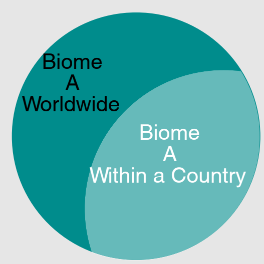


Biome A on the national level



Global Weight

The percentage a particular biome within a country comprises at the global level.



Biome A on the global level

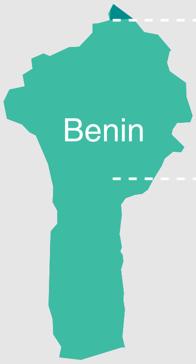
We Weight Both Ways Because Not All Protection Efforts Are Equal

Nationally

The degree to which a tiny sliver is protected may matter less than degree to which a large area is, depending on the biome.

Globally

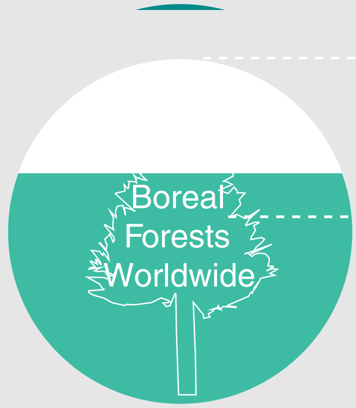
The degree to which a country protects a biome that is rare outside its borders may matter more than protecting a biome that is plentiful elsewhere.



1%
Tropical/Subtropical Moist Broadleaf Forests

99%
Tropical/Subtropical Grasslands/Savannas

It matters more that Benin protects its forests than grasslands.

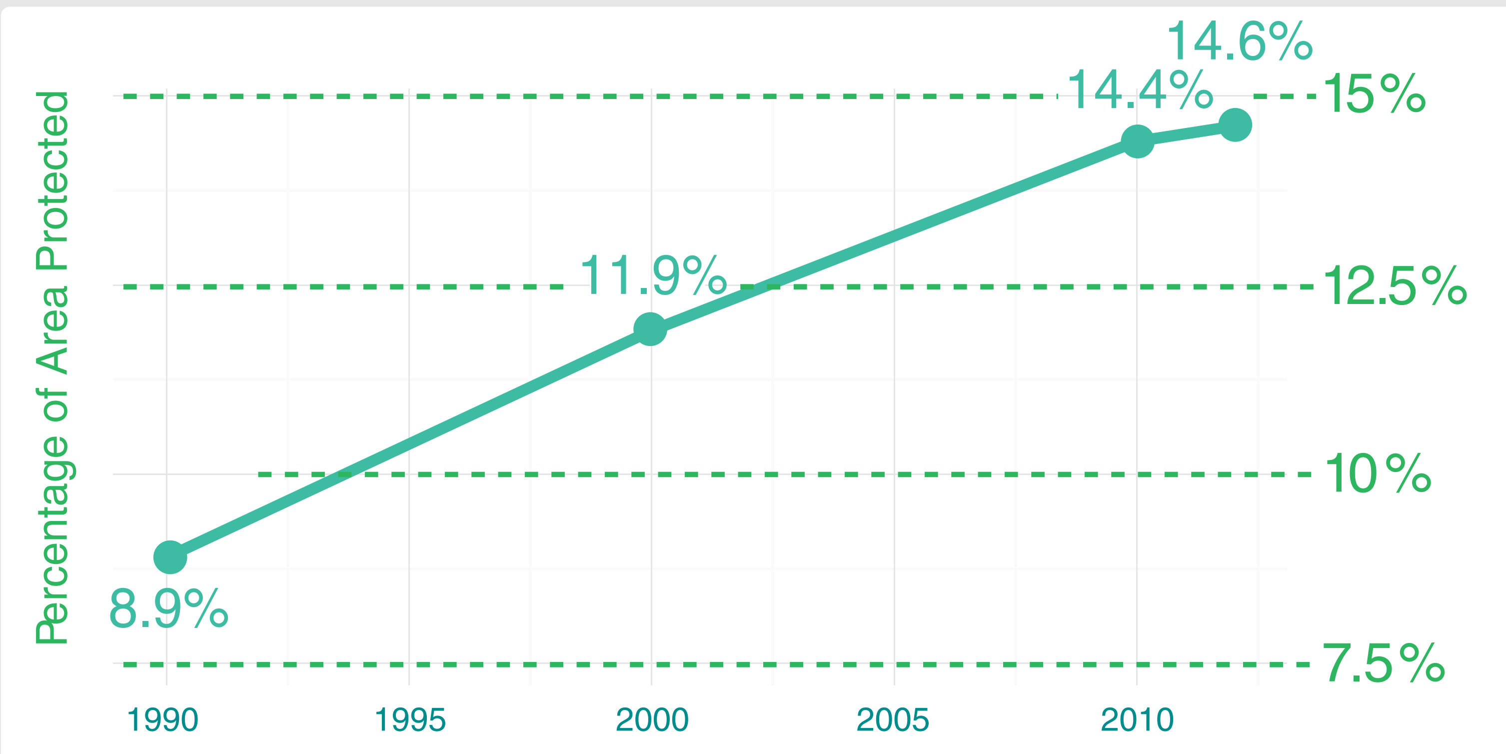


0.26%
Mongolia only has 0.26% of the world's boreal forests.

65%
Russia has 65% of the world's boreal forests.

Russia slipping in protecting its boreal forests may have more dire consequences.

How is the world doing?



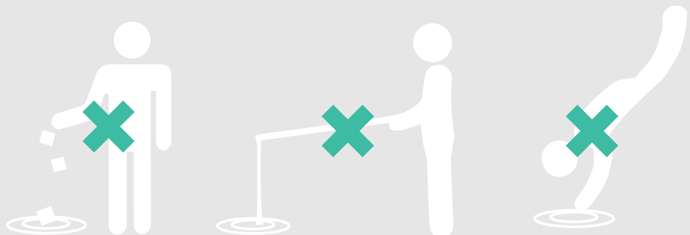
References

• University of California Museum of Paleontology. (2006). The World's Biomes. Available: http://www.ucmp.berkeley.edu/glossary/-gloss5/biome/
• The World Wildlife Fund Global. (2013). Major biomes of the world. Available: http://wwf.panda.org/about_our_earth/teacher_resources/web-fieldtrips/major_biomes/
• World Wildlife Fund Global. (2013). Selection of terrestrial ecoregions. Available: http://wwf.panda.org/about_our_earth/ecore-gions/about/habitat_types/selecting_terrestrial_ecoregions/

What are Marine Protected Areas?

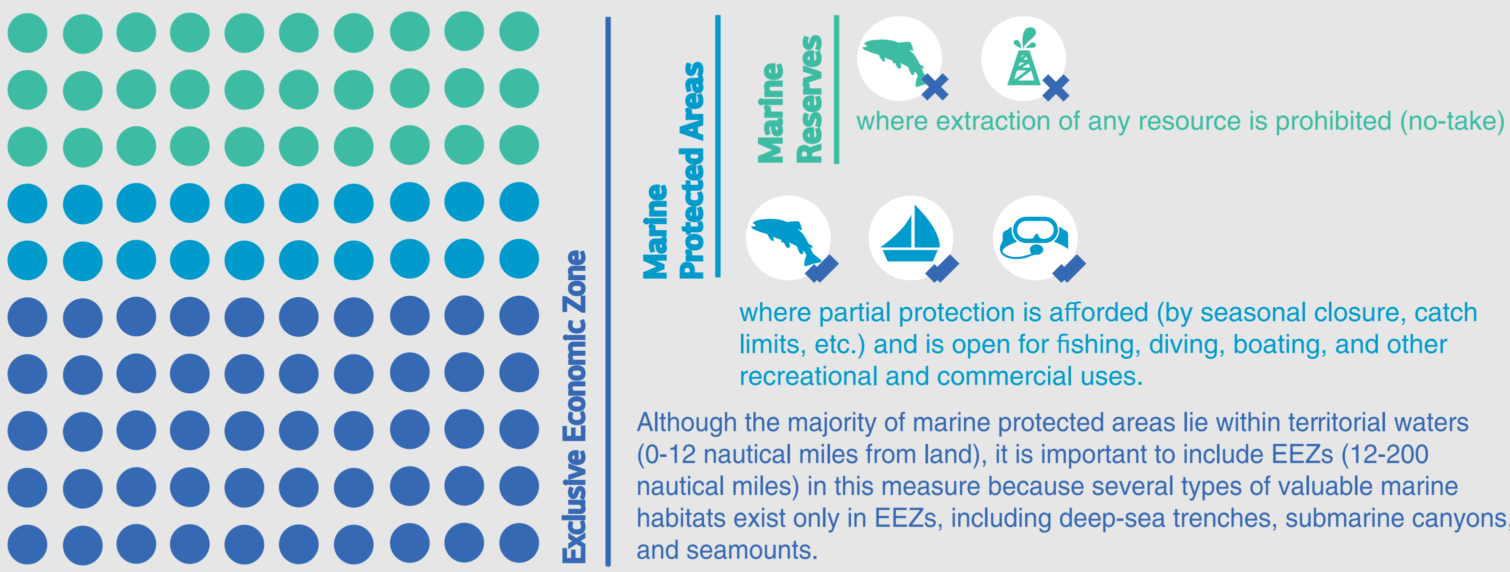
The Marine Protected Areas indicator measures the percentage of a country's exclusive economic zone (EEZ) that is under protection. A marine protected area is essentially a space in the ocean where human activities are more strictly regulated than the surrounding waters - similar to parks we have on land, for the protection of historical and natural resources.

Certain human activities are strictly regulated



For the sake of protecting

Marine Reserves, Marine Protected Areas & Exclusive Economic Zone



Although the majority of marine protected areas lie within territorial waters (0-12 nautical miles from land), it is important to include EEZs (12-200 nautical miles) in this measure because several types of valuable marine habitats exist only in EEZs, including deep-sea trenches, submarine canyons, and seamounts.

Managing MPAs through Prohibitions and Limitations

2 Categories

Prohibition

Yes/No?

Absolute prohibition of access to a prescribed area is the simplest form of regulation.

Prohibition of certain activities within a prescribed area is another prohibitive technique.

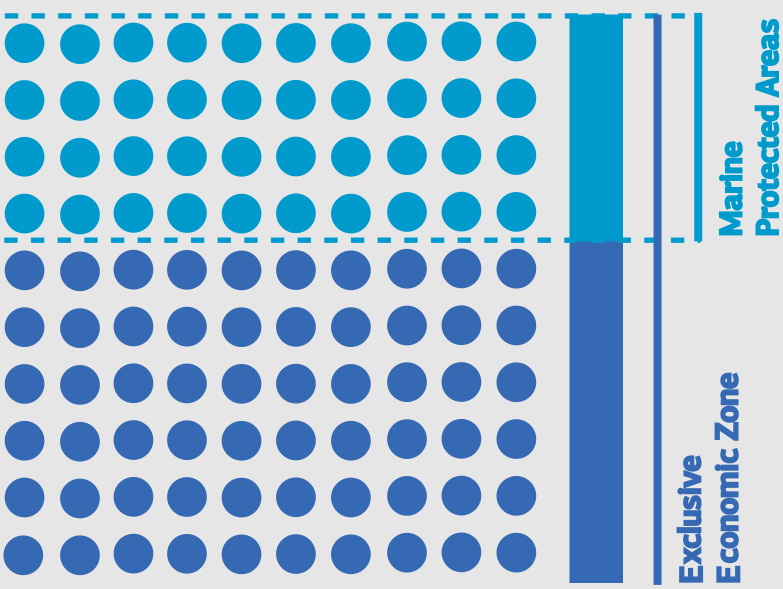
Limitation

Marine protected areas around the world often allow some level of human activity, especially if it involves recreation, nature appreciation, education, or research.

Limitation includes

- Zonal Management
- Temporal Control
- Equipment Restriction
- Permits
- Quotas

How do we know?

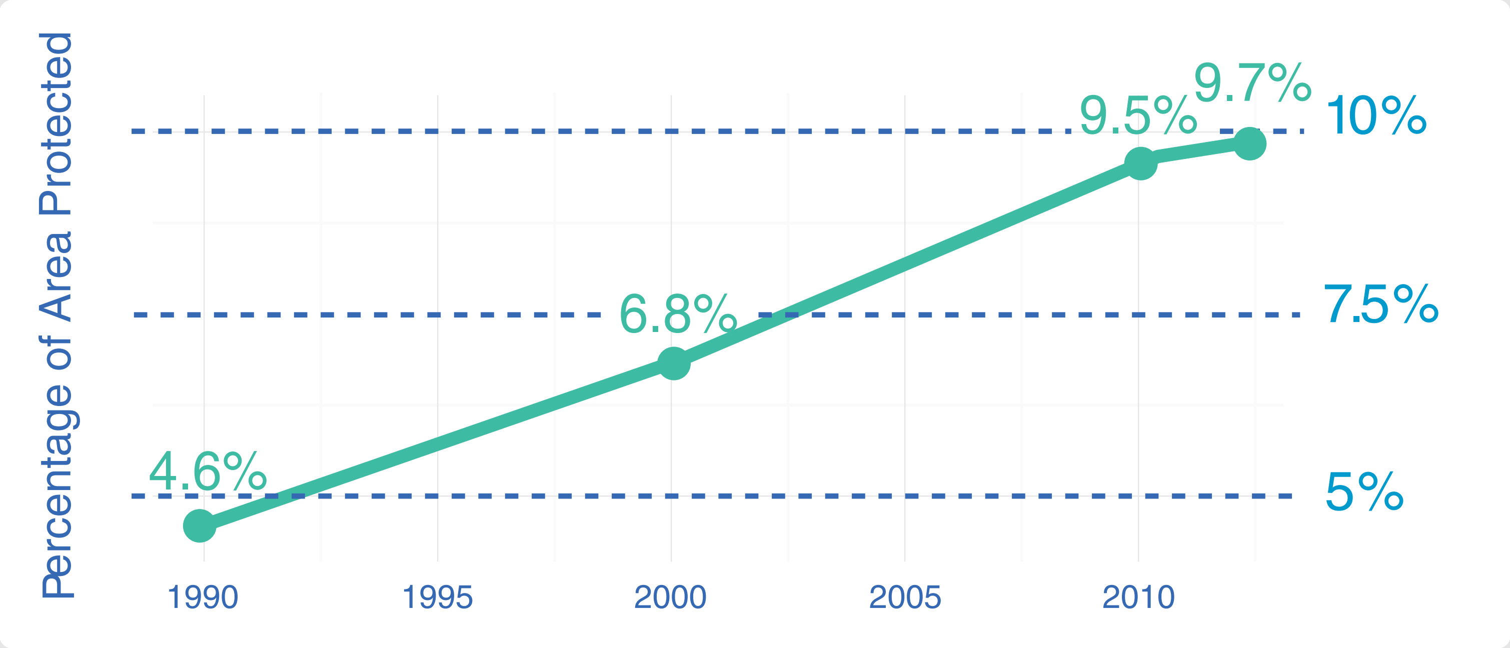


The Marine Protected Areas indicator measures the percentage of country's exclusive economic zone (EEZ) that is under protection.

Targets Set by Convention for Biological Diversity **10%**

The EPI's measurement of Marine Protected Areas stems from targets set by Convention for Biological Diversity, which establishes a conservation goal of 10 percent of marine and coastal areas by 2020.

How is the world doing?



References

• "Protect Planet Ocean Is About Marine Conservation", Protect Planet Ocean: http://www.protectplanetocean.org/introduction/introbox/m-pas/introduction-item.html

What is Critical Habitat Protection?

The Critical Habitat Protection indicator for the 2014 EPI measures the percentage of the key sites recognized by the Alliance for Zero Extinction (AZE) that are located in protected areas.

What Qualifies as an AZE Site?

The Alliance for Zero Extinction , a joint initiative of biodiversity conservation organizations from around the world, aims to prevent extinctions by identifying and safeguarding key sites, each one of which is the last remaining refuge of one or more Endangered or Critically Endangered species.

1 Endangerment

EN — Endangered (EN)

or

CR — Critically Endangered (EN)

An AZE site must contain at least one Endangered (EN) or Critically Endangered (CR) species, as listed on the International Union for the Conservation of Nature (IUCN) Red List.

2 Irreplaceability

≥95%

More than 95% known resident population

or

More than 95% known resident population for one life segment

An AZE site should only be designated if it is the sole area where an EN or CR species occurs, contains the overwhelmingly significant known resident population (>95%) of the EN or CR species, or contains the overwhelmingly significant known population (>95%) for one life history segment (e.g. breeding or wintering) of the EN or CR species.

3 Discreteness

Habitats

Biological Communities

Management Issues

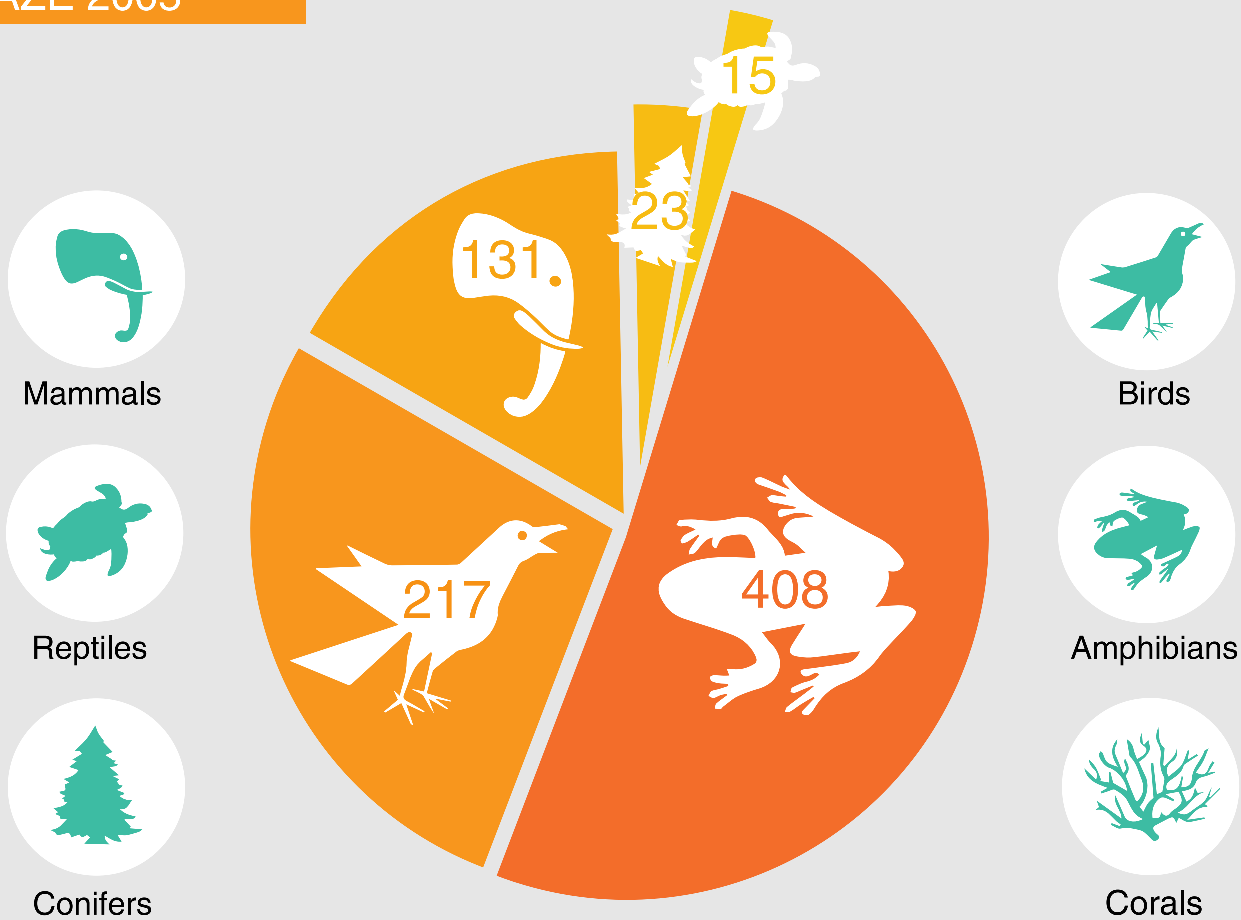
The area must have a definable boundary within which the character of habitats, biological communities, and/or management issues have more in common with each other than they do with those in adjacent areas.

595 SITES

794 SPECIES

AZE 2005

AZE scientists working in collaboration with an international network of experts identified 595 sites that must be effectively protected to prevent the extinction of 794 of the world's most threatened species. Many sites contain more than one AZE "trigger species."



AZE Species by Taxonomic Group

How do we know?

595 SITES

794 SPECIES

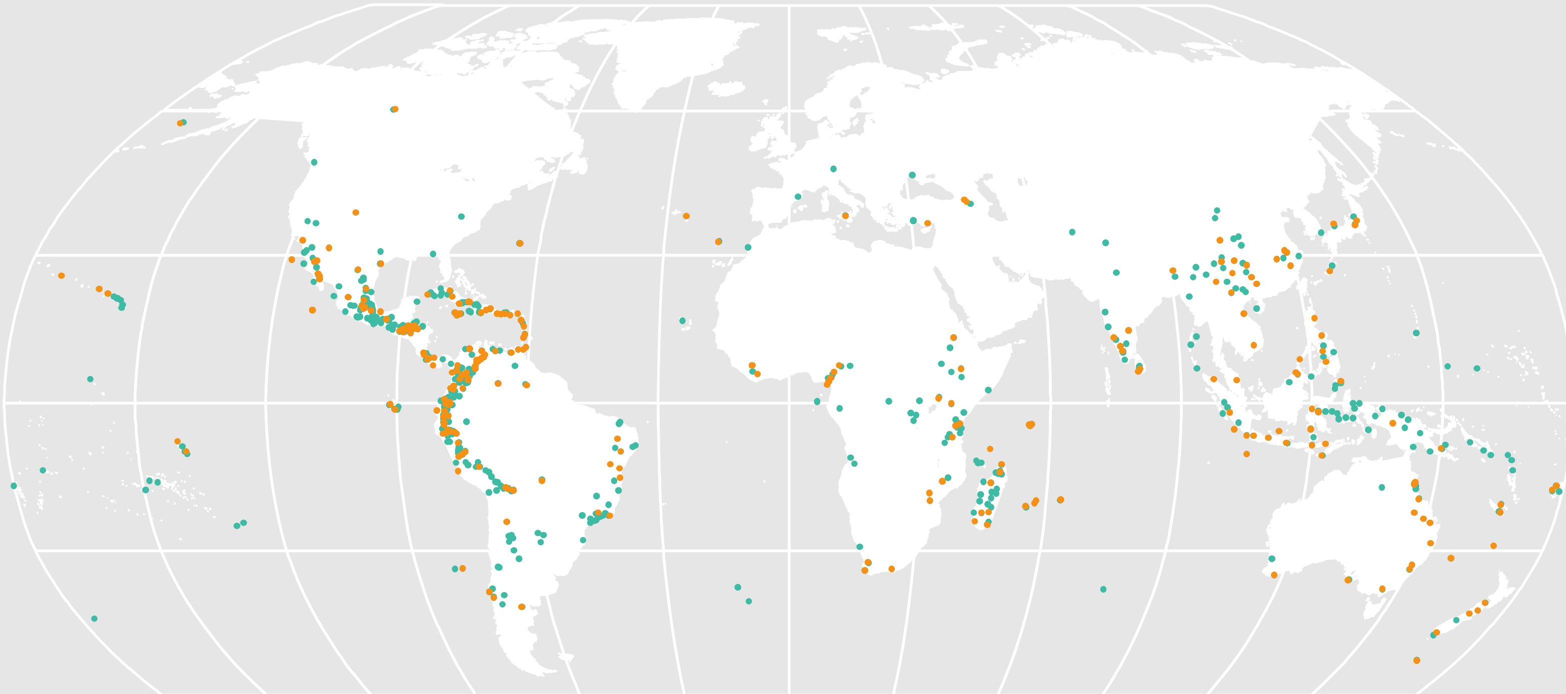
AZE 2005

587 SITES

920 SPECIES

AZE 2010

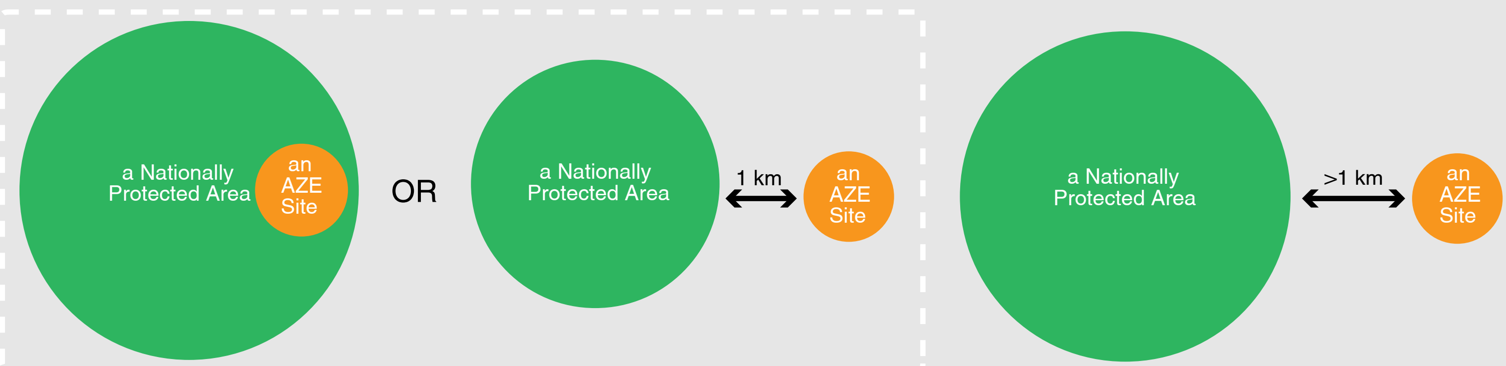
The AZE last updated its site list, totaling 587 sites and 920 species in 2010. The 2014 EPI uses the 2005 AZE sites to give countries time to establish protected areas and other conservation actions to protect these endangered species.



The AZE Sites Worldwide

AZE 2005 Sites
AZE 2010 Sites

Protected vs Unprotected AZE Sites



Protected AZE Sites

Unprotected AZE Sites

For a country

$$\text{AZE indicator} = \frac{\text{Protected AZE Sites}}{\text{Unprotected AZE Sites}}$$

The 2014 EPI uses the 2005 AZE site designations to create a percentage, within a 1-km radius of a protected area, of the number of sites that fall within the protected area. So if an AZE area is within 1 km of a protected area, we give its status as "protected."

References

- "AZE Overview", Alliance for Zero Extinction, http://www.zeroextinction.org/overviewofaze.htm

CRITICAL HABITAT PROTECTION IN PERU

The Peruvian rainforest is home to numerous species, some of which are threatened from climate change and human activities. (Source: Wikimedia Commons)

Peru contains the second largest portion of the Amazon rainforest, and with it, a spectacular range of biodiversity. It harbors 25,000 plant species and 2,000 species of fish, both of which account for 10 percent of the world total in their respective categories. It is also home to 1,736 species of birds.[1] Currently, Peru's forests are home to a total of 222 endangered species. Thirty-one of these face extinction. Eighty-nine are categorized as vulnerable. Twenty-two are rare species, and 80 have an indefinite status.[2] Because of anthropogenic threats like climate change and deforestation, conservation of the Peruvian Amazon has become increasingly important.

Peru has taken heed, and the 2014 EPI rewards it for its performance. Peru is the only country to have demonstrated improvement on the Critical Habitat conservation indicator. Although improvements in the conservation of critical habitats can be attributed to many factors, a primary driver has been the Peruvian government's determination to protect its own environment and biodiversity.

In June 2010 the Peruvian government bolstered habitat protection for endangered birds such as the Ash-breasted Tit-Tyrant, the White-browed Tit-Spinetail, and the Royal Cinclodes.[3] It announced the creation of several new community-owned private conservation areas: Choquecaca, Mantanay, and Sele. These will significantly enhance ongoing efforts to protect habitat for endangered bird species in the country.[4]

In July 2010, Peru's Ministry of the Environment further emphasized its commitment to biodiversity conservation by creating the National Program for the Conservation of Forests and Mitigation of Climate Change. The initiative strives to preserve 54 of the 72 million hectares of the Amazon rainforest within 10 years.[5]

[1] Convention on Biological Diversity. (2013) *Peru-country profile*. Available: https://www.cbd.int/countries/profile/default.shtml?country=pe. Last accessed: November 22, 2013.
[2] *Ibid.*
[3] American Bird Conservancy (2010) *Bird Calls: Peruvian habitat ramps up habitat protection for endangered birds*. Available: http://www.abcbirds.org/newsandreports/birdcalls_pdf/bc10jun.pdf. Last accessed: January 11, 2014.
[4] *Ibid.*
[5] El Peruano (2010) *Normas Legales*. Available: http://www.bdlaw.com/assets/attachments/Peru%20-%20National%20Program%20for%20Forest%20Conservation%20to%20Mitigate%20Climate%20Change.pdf. Last accessed: January 11, 2014.

Researchers will identify and map areas to conserve, and on-the-ground initiatives will promote the development of sustainable forest-based products and improvement of forest protection capabilities within regional and local governments, farming communities, and indigenous groups.[6]

The creation of the program followed through on Environment Minister Antonio Brack's pledge that Peru would conserve 54 million hectares of forest by reducing logging rates and forest fires to 0 by 2020 to reduce the country's greenhouse gas contributions.[7] By reducing deforestation, this program has directly contributed to biodiversity conservation.

In 2012, the Peruvian government continued its habitat conservation trend by creating three new protected areas in the northern Amazon territory of Loreto, spanning nearly 600,000 hectares.[8] Protection of these areas, collectively a world hotspot of biological and cultural diversity, consolidated the Putumayo Trinational Conservation Corridor, a joint effort at regional-style management by the governments of Peru, Ecuador, and Colombia.[9]

The efforts undertaken by the Peruvian government to protect those habitats critical for biodiversity conservation within its boundaries represent a success on both a national and global scale. Although Peru's ranking in the issue category of Biodiversity and Habitat is not as strong as some others, it is important to recognize Peru as one of the few countries that has improved at conserving critical habitats, particularly at a time when others have either remained flat or declined.

[6] Block, B. (2010) *Peru forms a national forest conservation program for the mitigation of climate change*. REDD Block. Available: https://sites.google.com/site/reddblock/blog/peruformsanationalforestconservationprogramforthemitigationofclimatechange. Last accessed: January 11, 2014.
[7] *Ibid*.
[8] World Wildlife Fund. (2012) *Peru creates three more protected areas*. Available: http://wwf.panda.org/?206543/Peru-creates-three-new-Amazon-protected-areas. Last accessed: January 11, 2014.
[9] *Ibid*.

Protected Areas (Global Biome Weight), and Marine Protected Areas - in the biodiversity and habitat issue area.

Since the Nagoya Protocol, biodiversity has continued to gain attention in international conservation and development arenas.

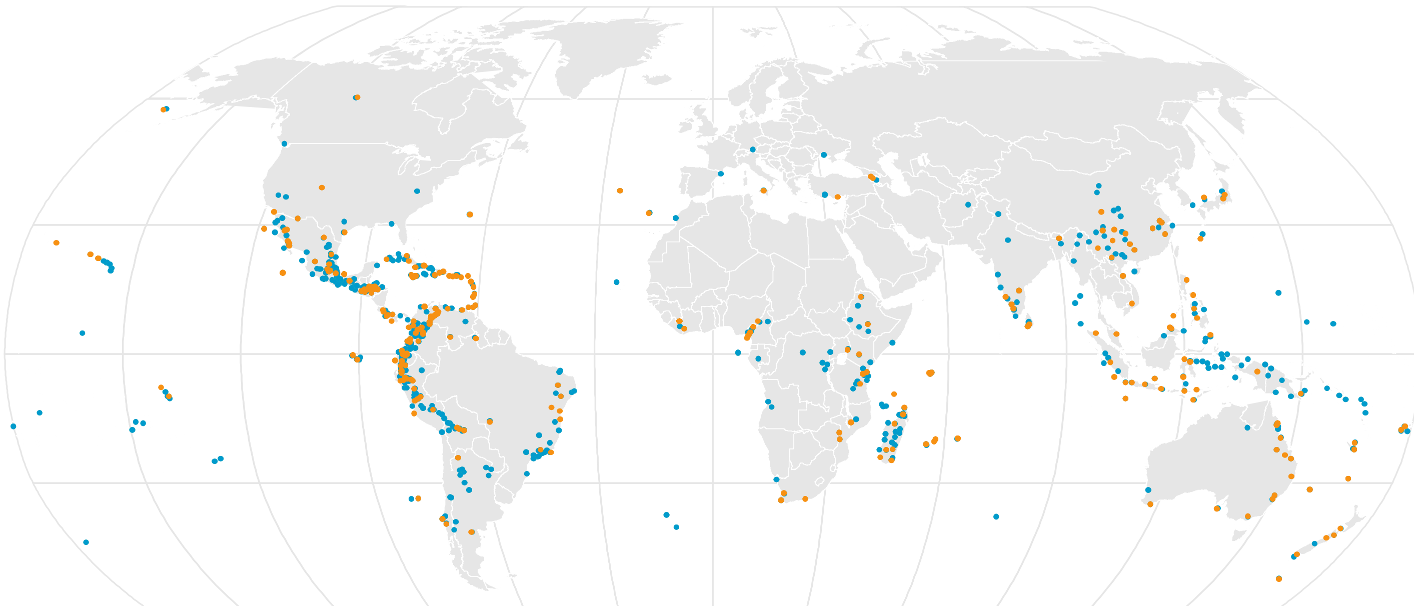
The UN designated 2011 to 2020 as the Decade of Biodiversity, indicating the increasing concern within the global community.[104]

The 2014 EPI shows global progress in terms of the increase of terrestrial and marine protected areas, largely due to national efforts to meet targets set through the CBD. Other analyses, such as the UN MDGs Report,[105] similarly show modest improvements in reducing the rate of loss of some species.

With the realization that ecological wealth can translate into economic health, policymakers and business leaders worldwide have begun to understand the value of protecting ecosystems and biodiversity. The CBD reports that 45 percent of business leaders in Africa, 53 percent in Latin America, 34 percent in Asia-Pacific, and 18 percent in Western Europe consider biodiversity loss to be a threat to economic growth.[106] The same report estimates that the cost of inaction on biodiversity will amount to US$2.0 to US$4.5 trillion per year over the next 50 years. These numbers are significant, and leaders are more frequently taking ecosystem services into account when calculating their nations' assets. In February 2012, the UN developed the System of Environmental-Economic Accounting, making it possible for countries to include "natural capital" in their accounting to support sustainable development.[107] Twenty-four countries are already using natural capital accounting.[108] The quantification of natural capital and the heightened awareness of its value should aid countries in taking action to protect biodiversity.

Despite these signs of progress, much remains to be done to reduce global rates of biodiversity loss and ecosystem degradation. The MDGs 2012 Report shows that even with increased protected areas, biodiversity is still being lost and key sites remain unprotected. UNEP-WCMC's Protected Planet 2012 Report reveals that only 33 percent of terrestrial ecoregions, 13 percent of marine ecoregions, and 22 percent of AZE sites reach target levels of protection.[109] Importantly, these targets only measure the area under legal protection, but this does not necessarily translate into effective conservation of biodiversity or prevention of species loss.

[104] United Nations Resolution 65/161. (2011). *Convention on biological diversity*. Resolution adopted by the General Assembly on 11 March 2011. Available: http://www.cbd.int/undb/goals/undb-unresolution.pdf. Last accessed: January 11, 2014.
[105] United Nations. (2012) *The millennium development goals report 2012*. New York, New York. Available: http://www.un.org/millenniumgoals/pdf/MDG%20Report%202012.pdf. Last accessed: January 11, 2014.
[106] Convention on Biological Diversity. *Biodiversity for Development and Eradication of Poverty*. Available: https://www.cbd.int/undb/media/factsheets/undb-factsheet-development-en.pdf. Last accessed: January 11, 2014.
[107] United Nations. *System of Environmental-Economic Accounting*. Available: http://unstats.un.org/unsd/envaccounting/seea.asp. Last accessed: January 11, 2014.
[108] The World Bank. (2012) *Moving beyond GDP: how to factor natural capital into economic decision making*. Washington, D.C. Available: https://www.wavespartnership.org/sites/waves/files/images/Moving_Beyond_GDP.pdf. Last accessed: January 11, 2014.
[109] Bertzky, B., Corrigan, C., Kemsey, J., et al. (2012) *Protected planet report 2012: tracking progress towards global targets for protected areas*. Available: http://www.unep-wcmc.org/medialibrary/2012/09/14/eb3bb854/PPR2012_en.pdf. Last accessed: January 11, 2014.



The AZE Sites Worldwide

The Alliance for Zero Extinction (AZE) presents the world's critical sites for biodiversity conservation. Although the surveyed sites changed between 2005 and 2010 (above) and were changed from simple points to more complex polygons, the EPI makes use of 2005 data to give countries a chance for their conservation policies to take effect. (Credit: Malanding Jaiteh, Center for International Earth Science Information Network)

Successfully reducing the threats to biodiversity and improving the status of degraded ecosystems requires concerted action on multiple fronts and scales. Land use and climate change, invasive species, and overexploitation remain the principal threats to global biodiversity. Protected areas by themselves are not sufficient to combat the effects of these threats. Biodiversity conservation must also be included in comprehensive strategies that incorporate sustainable use and allow for economic development. The more leaders and societies value ecosystem conservation on its own merits and for the services that ecosystems provide, the brighter the prospects for biodiversity conservation.[110]

[110] United Nations Environment Programme. *Ecosystems and Their Services*. Nairobi, Kenya. Available: http://www.unep.org/maweb/documents/document.300.aspx.pdf. Last accessed: January 11, 2014.

Toad species are often invasive to many kinds of habitats.
(Credit: Wikimedia Commons / Sam Fraser-Smith)

INVASIVE SPECIES – A MAJOR THREAT TO BIODIVERSITY CONSERVATION

One of the greatest—though lesser-known—environmental threats is the spread of non-native invasive species. A non-native species is one that humans transport from its home range into a new environment far from its native home. When a non-native species adapts to its new habitat, and spreads away from the place where it was originally introduced, it can cause harm to the economy, public health, or the environment. It is termed an "invasive species."[1]

Non-native species arrive when humans transport them accidentally or intentionally, through shipping, for ornamental plants, food, pets, or any other reason.[2] Rats have infested islands across the world because boats arrived with the rodents as stowaways. The plant Japanese knotweed is eliminating plant life along streams in the United States because people wanted it for their ornamental gardens. White nose syndrome is devastating bat populations because a cave explorer brushed against a fungus in a European cave and unknowingly transported it back to the United States.[3]

Invasive species have dramatic impact on critical habitats across the globe. According to the National Wildlife Federation, invasive species are the primary threat to nearly half of the threatened or endangered species in the United States.[4] Dutch Elm Disease, an invasive fungus, has driven the iconic American Elm tree to near extinction. In South Africa, pine and Acacia trees introduced for plantations have invaded the fynbos shrublands, harming important economic plants such as rooibus and honeybush. The Cane Toad, brought to Australia to control sugar cane pests, is devastating ground-dwelling animals, including birds, reptiles, and amphibians.

If policymakers want to assure ecosystem and habitat vitality, policies must go beyond merely limiting human activity in a designated area. Governments must also actively manage habitats to protect them from threats like invasive species, which don't stop at the borders of protected areas.

[1] Richardson, D.M., Pysek, P., Carlton, J.T. (2011) *A Compendium of Essential Concepts and Terminology in Invasion Ecology*. In Richardson, D.M. (ed.), Fifty Years of Invasion Ecology: The Legacy of Charles Elton (409-420). Oxford, U.K.: Wiley-Blackwell. Available: http://www.ibot.cas.cz/personal/pysek/pdf/Richardson,_Pysek,_Carlton-Concepts_In_Elton_book_Wiley2011.pdf. Last visited: January 11, 2014.

[2] *Ibid*.

[3] Center for Biological Diversity. *White-nose syndrome: questions and answers*. Arizona, United States. Available: http://www.biologicaldiversity.org/campaigns/bat_crisis_white-nose_syndrome/Q_and_A.html. Last accessed: January 13, 2014.

[4] National Wildlife Federation. *Invasive Species*. Virginia, United States. Available: http://www.nwf.org/wildlife/threats-to-wildlife/invasive-species.aspx. Last accessed: January 11, 2014.

INTERNATIONAL VERSUS NATIONAL PROTECTED AREAS

As significant hotspots of biodiversity and unique ecosystems, protected areas serve as a benchmark of conservation. They represent national and international cooperation, the best of conservation science, and collaboration between governments and people on the ground to preserve habitats and their resources from exploitation.

There is staggering variety between types of protected areas: some allow few visitors, others welcome them in throngs; some are based around the conservation of cultural heritage, others the conservation of a single species; some are tiny, some span multiple countries. Protected areas also serve a broad range of functions, which the International Union for Conservation of Nature (ICUN) breaks down into six categories: strict nature reserves, wilderness areas, national parks, habitat monuments/features, protected landscape/seascape, and protected area with sustainable use of natural resources.[1] The EPI recognizes all of these designations, despite major conservation-related differences among them.

Significant among these differences is that some are designated by national governments, others through international agreements, like UNESCO World Heritage Sites, the Ramsar Convention, and the Convention on Biodiversity. Functionally, this divergence has important implications on the ground. Nationally designated protected areas necessarily come with guidelines and mandates for protection under the legal framework of the host country. Internationally designated areas are not necessarily subject to national legal structures and may be, therefore, less protected.

There is a great deal of overlap between internationally designated protected areas and nationally designated ones, and many areas are listed as both. However, there are exceptions. Virtually all World Heritage sites are now required to have a conservation regime in place, although these requirements were imposed after the establishment of the program. Some currently listed World Heritage Sites do not have stringent enough protections to qualify. Similarly, under the Ramsar Convention, listed wetlands are required to be used "wisely." This measure was put in place to encourage countries to sign the Convention, so there is no obligation for stringent protection. Again, although most Ramsar sites are protected areas, being designated as such is no guarantee.[2]

Many of the great national parks of the United States, including Olympic, Yellowstone, Grand Canyon, Great Smoky Mountains, and Yosemite are included on the list of UNESCO World Heritage Sites. While the UNESCO status does offer some protection under the Geneva Convention and certainly increases the prestige of these sites, it is their status as national parks within the United States, based on federal legislation, that provides the most easily and consistently enforceable legal protection.

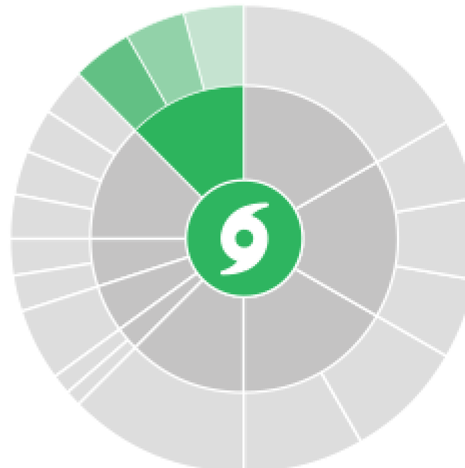
While countries are certainly not penalized for participating in international conservation efforts, the EPI seeks to gauge national governments' efforts for protecting their own domestic habitats. For that reason, and because of the lack of consistent enforcement of internationally designated protected areas, only national designations are recognized.

[1] Dudley, N. (ed.) (2008) *Guidelines for applying protected area management categories*. International Union for the Conservation of Nature: Gland, Switzerland. Available: http://data.iucn.org/dbtw-wpd/edocs/PAPS-016.pdf. Last accessed: January 11, 2014.

[2] *Ibid*.

ISSUE PROFILE

Climate & Energy



What It Measures

Whereas other indicator scores reflect the degree to which a target has been met, there are no globally agreed-upon targets for CO_2 reductions. Therefore the EPI Climate and Energy indicators should not be interpreted as a proximity-to-target, but rather a relative position globally. These indicators measure countries' ability to reduce the intensity of carbon emissions over time. They are sensitive to countries' differing policy obligations and take into consideration both economic and industrial development. Scores for three of the indicators include weightings tied to Gross National Income (GNI) per capita, as determined by the World Bank's country classifications.[111]

90%
of high-income countries are reducing their Trend in Carbon Intensity.

55%
of middle-income countries are reducing their Change in Trend of Carbon Intensity.

43%
of countries are reducing their Trend in CO_2 Emissions per kWh.

- For wealthy countries (GNI per capita greater than US$12,616), scores are primarily comprised of an indicator measuring the Trend in Carbon Intensity, as the burden of climate mitigation lies firmly with them.
- For middle-income countries (GNP per capita between US$1,036 and US$12,615), the primary measure is the rate at which their carbon intensity growth has slowed. These countries must develop while gradually moving toward more sustainable energy sectors.
- Least Developed Countries (LDCs) are not scored on emissions indicators, since they have historically contributed less significant amounts of carbon dioxide (CO_2) to the atmosphere. Emissions are not as important as transitioning people to more sustainable forms of energy. Therefore, no score is given to LDCs for Climate and Energy. Instead, an indicator of Access to Electricity is presented but not calculated in the EPI score.

A third indicator in this category is the Trend in CO_2 Emissions per kilowatt hour (kWh) of electricity produced, determined for most countries as a trend from 2000 to 2010. For those countries that already perform at the lowest levels of carbon intensity per kWh of electricity produced, a score is calculated as an absolute level of CO_2 emissions per kWh of electricity and heat produced, divided by the total amount of electricity and heat production.

Why We Include It

Climate change is among the direst environmental challenges. Still, too little progress has been made to mitigate its effects, aid vulnerable populations to adapt, account for loss and damage already experienced, or to move the policy conversation toward consensus on the problem's scope, origins, or potential solutions. These indicators are intended to rank progress in reducing the carbon intensity of emissions over roughly the last decade (2000 to 2010).

Where The Data Come From

Carbon dioxide (CO_2) emissions data come from the Climate Analysis Indicators Tool (CAIT) 2.0 database provided by the World Resources Institute. Data for the Access to Electricity indicator are from the Sustainable Energy for All Initiative, a joint effort by the World Bank and the International Energy Agency (IEA). The Trend in CO_2 Emissions per kWh of electricity generation indicator is developed from data provided by the IEA.

DESCRIPTION

In 2007 UN Secretary-General Ban Ki Moon called climate change "the defining issue of our era."[112] Since then global greenhouse gas emissions have increased and accelerated.[113] Our understanding of the underlying science of climate change has improved vastly, but the data and indicators we used to measure and track policy response to it has lagged. Most of the climate data are based on levels of primary CO_2 emissions, due to the near linear relationship between carbon dioxide and global temperature rise.[114] However, although emissions-based indicators may be a proxy for climate change performance, they are also a proxy for level of economic development. Countries such as Mozambique and the Democratic Republic of Congo may not emit much in comparison to the United States, but that has less to do with outright climate policy than economic underdevelopment.

The 2014 EPI takes a new approach to climate and energy. In past iterations of the EPI, the primary goal was to develop indicators that, when statistically transformed and normalized, allowed for absolute comparability among countries. The 2014 EPI acknowledges that generally applying the same targets to every country provides little insight into policy. We agree with international climate Frameworks like the United Nations Framework Convention on Climate

[111] World Bank. (2013) *How we classify countries*. Available: http://data.worldbank.org/about/country-classifications. Last accessed: December 30, 2013.

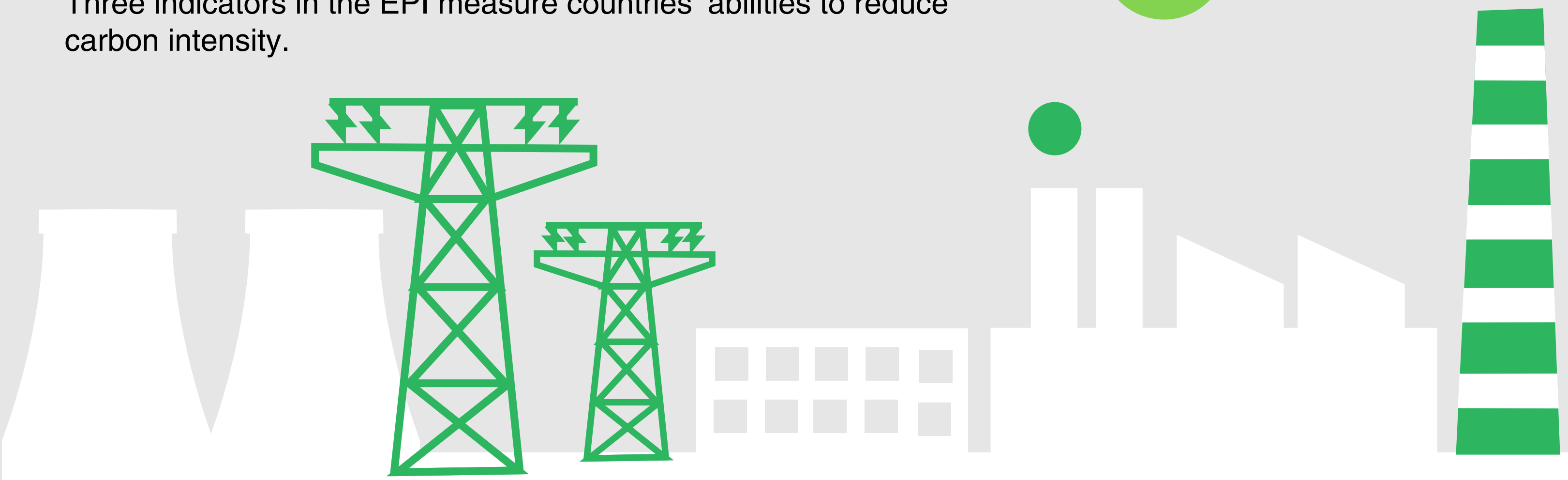
[112] United Nations. (2007) *Climate change 'defining issue of our era,' says Ban Ki-moon, hailing G8 action*. Available: http://www.un.org/apps/news/story.asp?NewsID=22836&Cr=climate&Cr1=change#.Un6s9pRARFI. Last accessed: January 10, 2014.

[113] International Energy Agency. (2013) *Four energy policies can keep the 2°C climate goal alive*. Available: http://www.iea.org/newsroomandevents/pressreleases/2013/june/name,38773,en.html. Last accessed: January 10, 2014.

[114] Intergovernmental Panel on Climate Change. (2013) *Fifth assessment report: working group 1*. Available: http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter01.pdf. Last accessed: December 30, 2013.

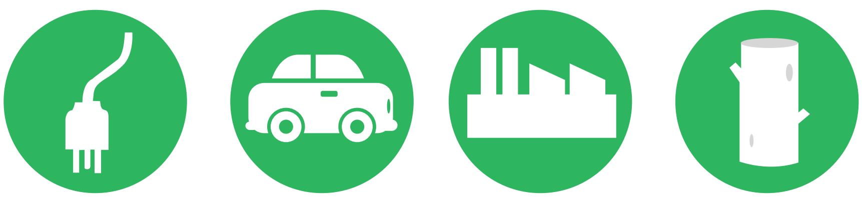
What is Climate and Energy?

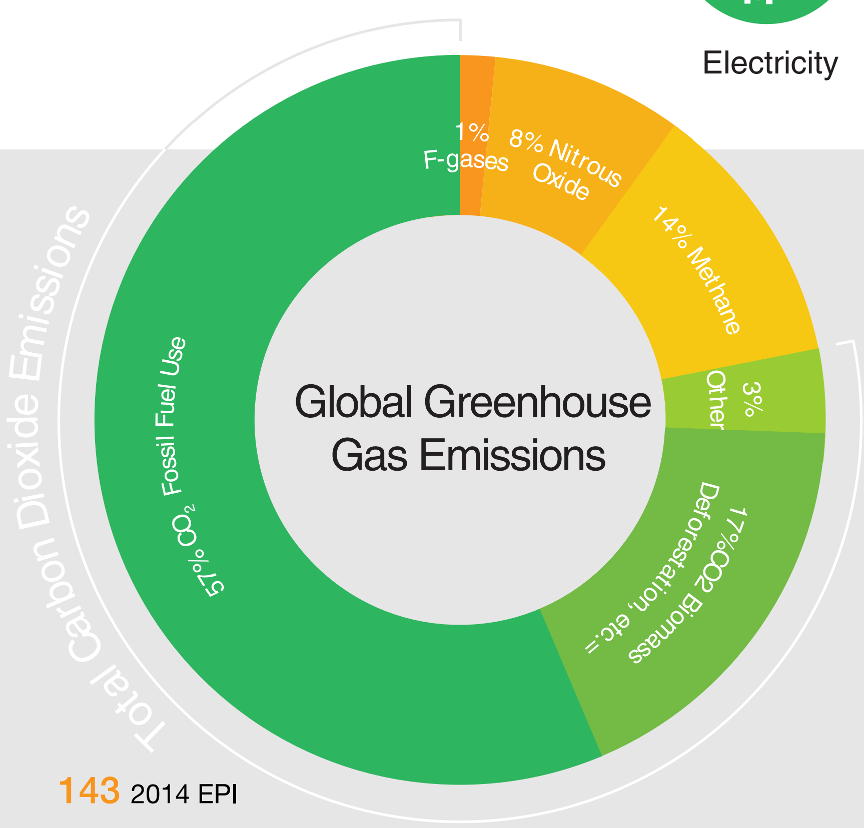
The burning of carbon-based fuels for energy has greatly increased concentrations of atmospheric carbon dioxide (CO2) and other greenhouse gases. The accumulation of these gases in the atmosphere is changing the Earth's climate and is dangerously affecting human health and ecosystems. Three indicators in the EPI measure countries' abilities to reduce carbon intensity.



What generates CO_2?

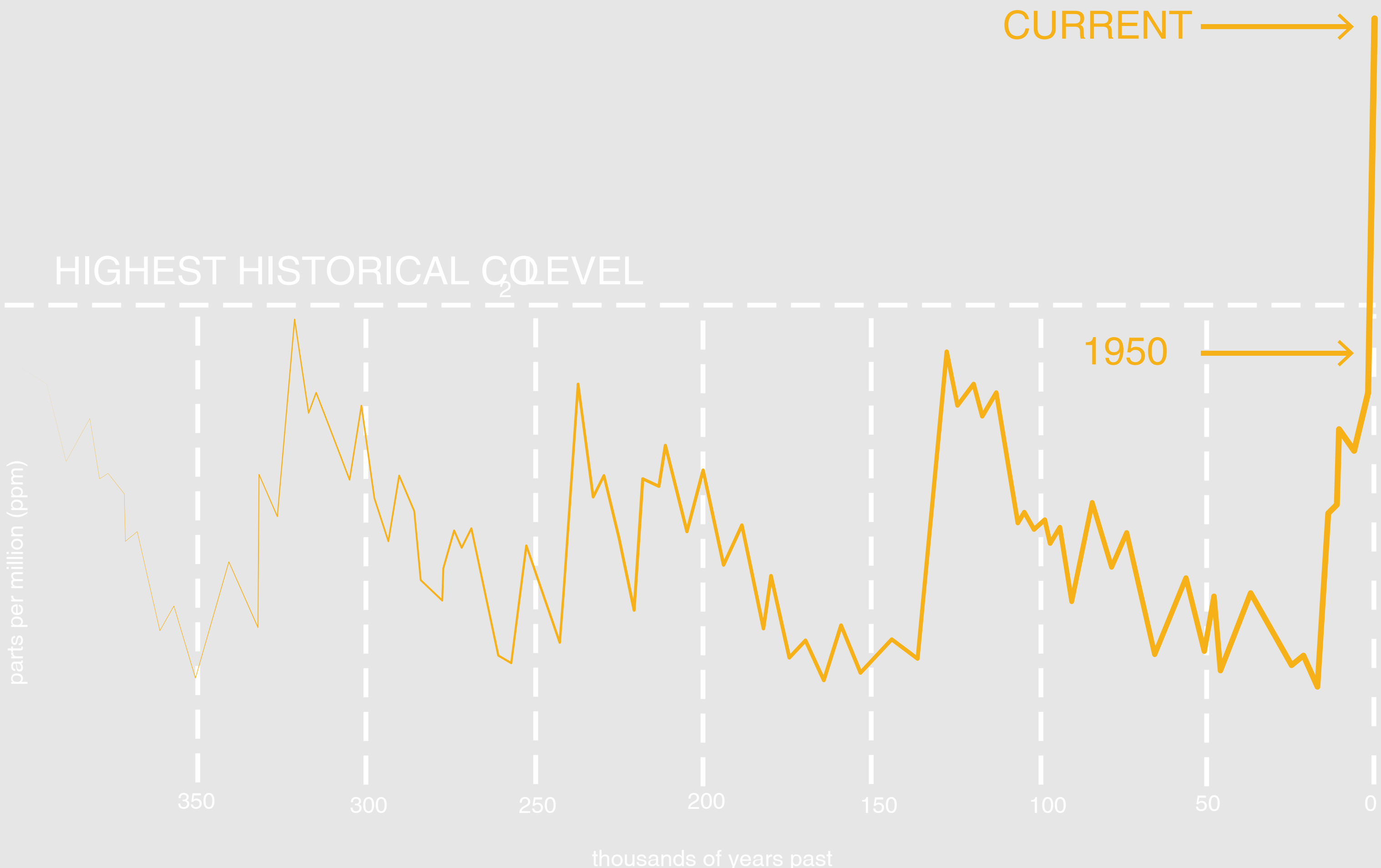
CO_2 is the predominant greenhouse gas. While emissions have a variety of natural sources, the steep increase since the Industrial Revolution is the result of human activity.





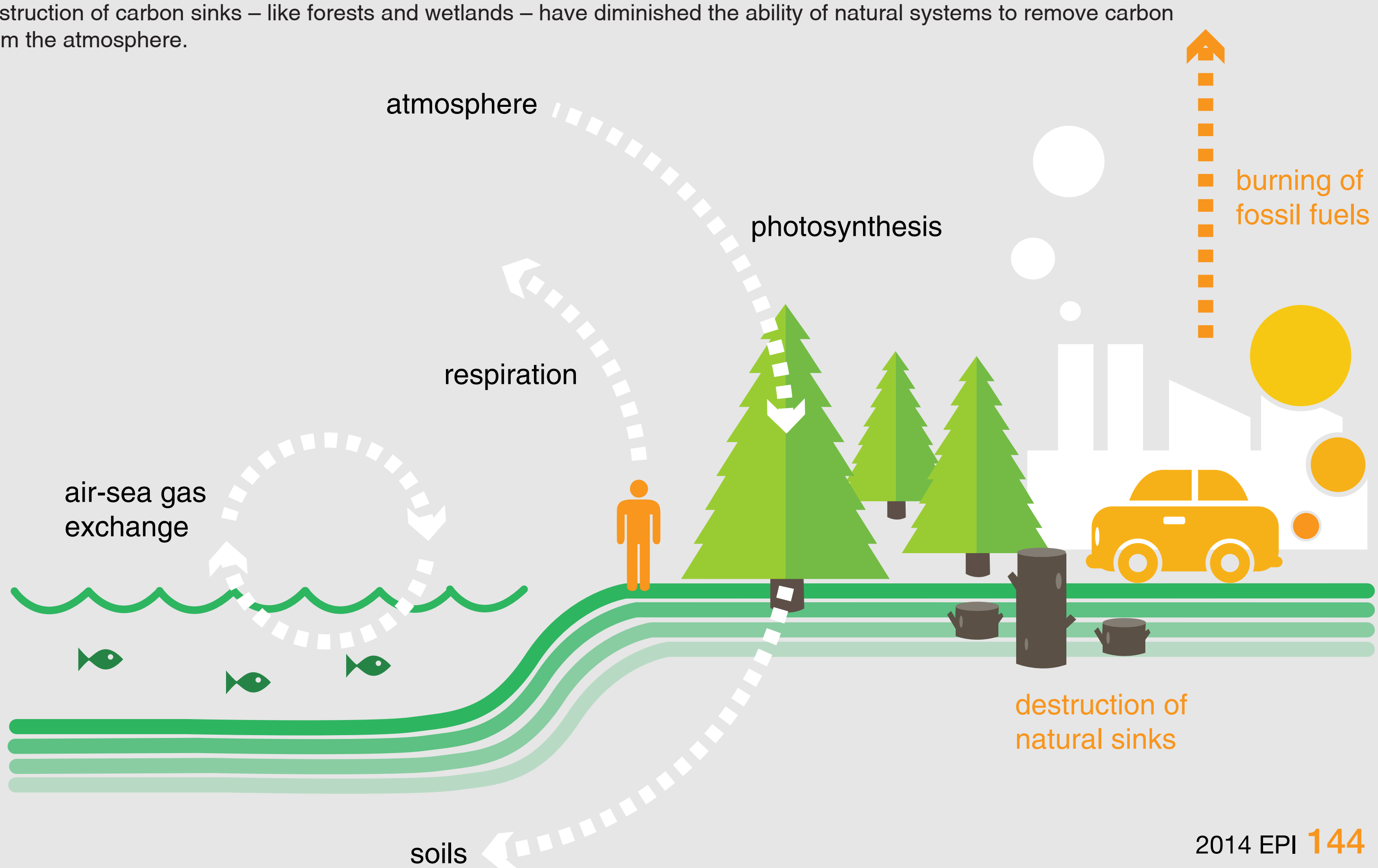
Carbon Dioxide Concentration

Although fluctuations in concentration of atmospheric CO_2 occur naturally between glacial cycles, the present levels appear to be the highest in the last 800,000 years.



Earth's Carbon Cycle

CO_2 is naturally present in the atmosphere, contributing to the circulation of carbon between organisms, the atmosphere, oceans, and soils. Adding carbon is not the only way human activities have altered this carbon cycle. The destruction of carbon sinks – like forests and wetlands – have diminished the ability of natural systems to remove carbon from the atmosphere.



How do we know?

Whereas other indicator scores reflect the degree to which a target has been met, there are no globally agreed-upon targets for CO2 reductions. Therefore, the EPI Climate and Energy indicators should not be interpreted as a proximity-to-target, but rather a relative position globally. The EPI indicators for Climate and Energy are weighted depending on a country's level of economic development. Least-developed countries (LDCs) are not scored on emissions indicators, as their historic contributions of atmospheric CO2 are insignificant.

SCORING

The score for this indicator is based on three trends: Trend in Carbon Intensity, Change of Trend in Carbon Intensity, and Trend in CO2 Emissions per kWh.

The Trend in Carbon Intensity and Change of Trend in Carbon Intensity indicators are weighted according to a country's GDP. Wealthier countries have scores weighted more on Trend in Carbon Intensity (x), while scores for lower-income countries are weighted more on Change of Trend in Carbon Intensity (y).

Trend in CO2 emissions per kWh scores countries based on the change in the carbon intensity of the average unit of electricity and heat produced. A few top performers are scored solely on their CO2 emissions per kWh for the year 2010, as they already perform well enough that there is little room for additional improvement.

Weighting

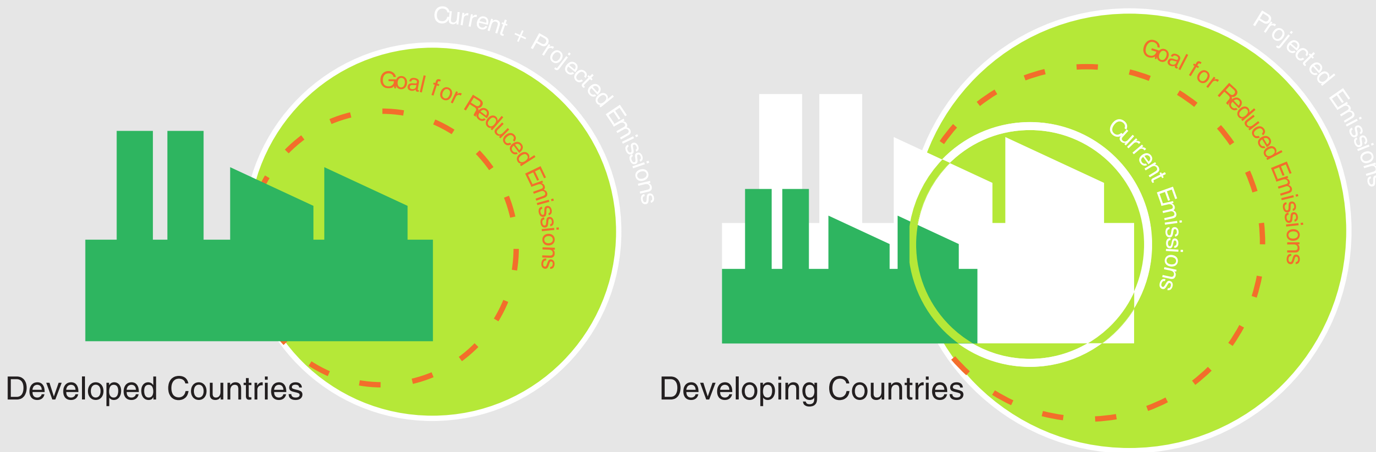
raised for high-income countries

Trend in Carbon Intensity 2000-2010 — *x, where x+y = 100%*

raised for lower-income countries

Change of Trend in Carbon Intensity 2000-2010 — *y, where x+y = 100%*

CO_2 Emissions per kWh 2000-2010 — *100% weighted equally for all countries*



WHY WEIGHT THE INDICATORS?

Climate change is largely the legacy of developed and industrialized countries. These include OECD states in Europe, as well as the U.S., Japan, Australia, and Canada. Expectations under current climate arrangements, including the Kyoto Protocol, are that these countries will reduce their emissions to a baseline (i.e., 1990 levels) by a certain target date. We score this group based on their efforts to reduce emissions.

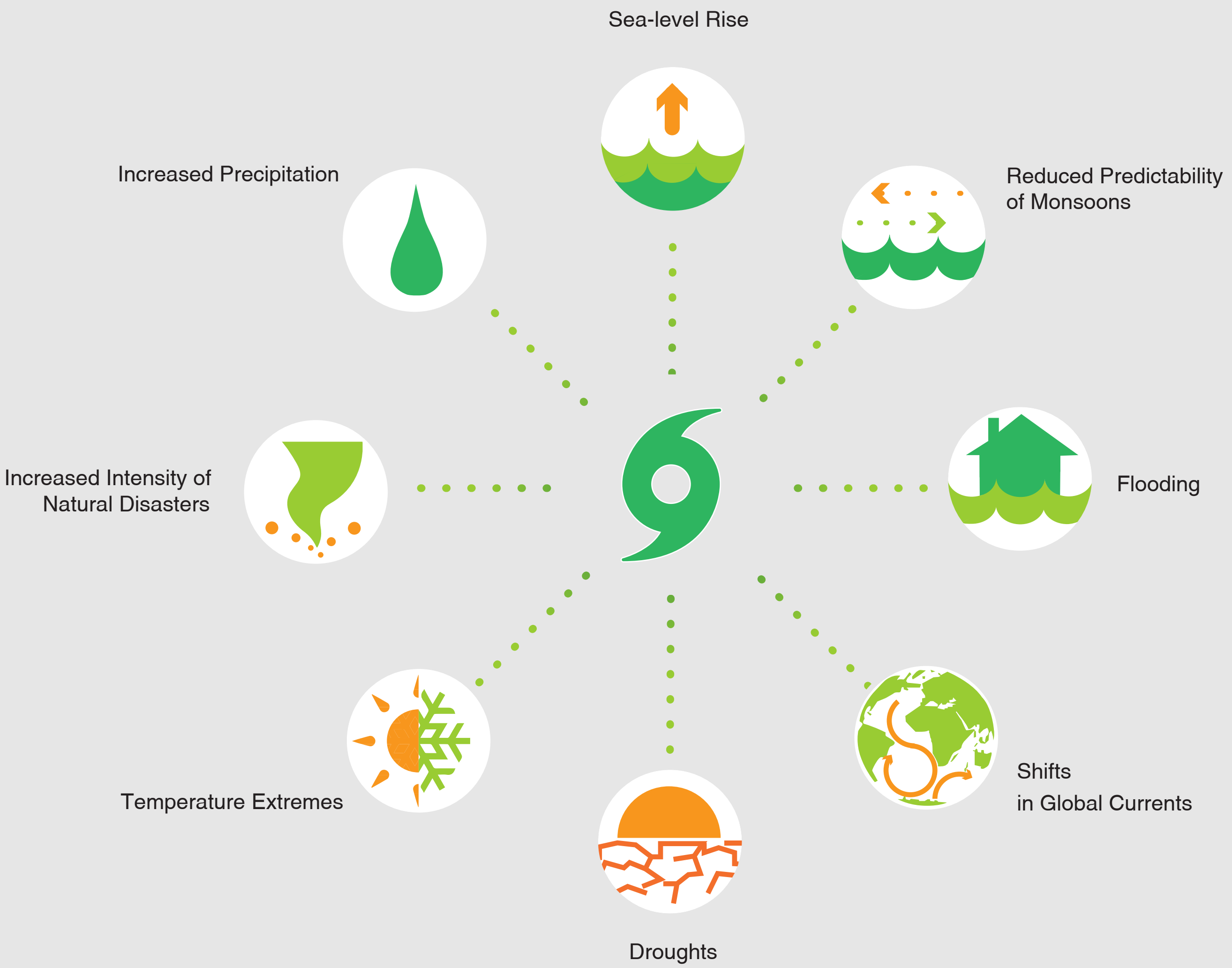
Developing countries, particularly major emerging economies like China and India, are or will be responsible for the majority of future emissions. Still, nobody expects these countries to deliberately stop growing. It is vital that they at least slow the rate at which carbon intensity grows. Our scores for this group emphasize the need for slowed growth in intensity. Countries that slow their rates of emissions growth are scored better than countries that remain steady or are increasing emissions more rapidly than at earlier times.

ACCESS TO ENERGY

For LDCs, emissions are simply not as important as transitioning people to more sustainable and accessible forms of energy. No score is given to LDCs for Climate and Energy. Instead, an indicator showing Access to Electricity is presented but not calculated in the overall EPI score.

Why does it matter?

Global temperature rise as a result of climate change has been shown to be correlated with a number of natural phenomena, including:



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• "Climate Change," The World Bank: http://www.worldbank.org/en/topic/climatechange
• Houser, Trevor. (2010). "Copenhagen, the Accord, and the Way Forward", Peterson Institute for International Economics: http://www.iie.com/-publications/pb/pb10-05.pdf
• "Overview of Greenhouse Gases", United States Environmental Protection Agency (EPA): http://www.epa.gov/climatechange/ghgemissions/gases/co2.html
• Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, "Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change", Intergovernmental Panel on Climate Change (IPCC): http://www.ipcc.ch/
• "What are the Main Sources of Carbon Dioxide Emissions?", What's Your Impact (WYI): http://www.whatsyourimpact.org/co2-sources.php

World leaders have put out a call to increase the world's energy efficiency and renewable supply by 2030. (Credit: Chalabala / iStock-Thinkstock)

STRIVING TOWARD SUSTAINABLE ENERGY FOR ALL

Three billion people lack access to clean energy to heat their homes and cook their food. For more than a billion people who do have access, it is precarious and inconsistent. In and of themselves, these are major environmental problems.

Where electrical grids cannot be accessed, people tend instead to burn biomass, which not only comes with greater carbon intensity, but also a myriad of localized health problems. Transitioning from burning biomass inside the home to having stable electrical grids and access to electricity is therefore a vital first step to sustainable development, the meeting of the Millennium Development Goals (MDGs), and adaptation to impending climate crises.

With this in mind, the United Nations (UN) General Assembly established 2012 as the 'International Year of Sustainable Energy for All.'[1] The initiative instituted three goals: to ensure universal access to modern energy services (including electricity and clean, modern cooking solutions), to double to global rate of improvement in energy efficiency, and to double the share of renewable energy in the global energy mix – all with a 2030 deadline. Already, around 70 countries have formally accepted the initiative, which includes plans to enhance partnerships between governments and the private sector to share best practices, finance infrastructure and innovation, and develop policies.[2] By the UN's estimate, carbon emissions resulting from increasing electricity access to 100 kilowatt-hour per person, per year—the International Energy Agency's recommendation—can be neutralized through energy efficiency initiatives and the use of low-carbon fuels, including the already occurring shift from coal to natural gas.[3]

[1] Sustainable Energy for All Initiative. (2013) *Global Tracking Framework*. World Bank and International Energy Agency. Available: http://www.worldbank.org/en/topic/energy/publication/Global-Tracking-Framework-Report. Last accessed: December 29, 2013.

[2] *Ibid.*

[3] The United Nations. (2010) *Energy for a sustainable future: Summary report and recommendations*. Available: http://www.un.org/wcm/webdav/site/climatechange/shared/Documents/AGECC%20summary%20report%5B1%5D.pdf. Last accessed: January 2, 2014.

Change (UNFCCC) that emphasize the significant differences between developed and developing countries. For the first time, the EPI scores countries using emissions-based measures that account for differences in economic development.

In doing so, the 2014 EPI aims to provide a blueprint for climate and energy indicators that do not hold countries with different needs and capacities to a monolithic set of metrics.

It introduces a tiered set of expectations. Wealthier nations are gauged according to reduced emissions per unit Gross Domestic Product (GDP) (carbon intensity) from 2000 to 2010. Countries within this tier include Annex I parties to the UNFCCC who have taken on emission reduction commitments, a group that includes the European Union and other wealthy countries who have pledged mitigation actions through the Copenhagen Accord, including the United States, Japan, and Canada.[115] The United States, for example, has committed to reduce emissions by 17 percent of 2005 levels by the year 2020. This indicator is an effort to measure the progress of that commitment, which is by no means legally binding or guaranteed.

Denmark, whose government has framed a commitment to reduce emissions to 40 percent of 1990 levels by 2020, is performing particularly well in this category. Its goal is to phase out fossil fuels by 2050. Yet, like its northern European neighbors, Denmark has already made impressive cuts in both household and industrial carbon emissions, largely through efficiency and renewables initiatives. The country has clearly demonstrated a policy commitment to substantially reduce carbon emissions.[116]

Middle-income countries whose economies are still developing are expected to slow the rate at which the carbon intensity of their economy increases. These countries, including China, India, and Brazil, are judged against a benchmark of a slowed rate of carbon intensity increase. Although ideally they will begin to move toward absolute emission reductions (as in the case of wealthier countries), the tension between industrial growth and populations still struggling with poverty makes it necessary for these countries to continue to grow their economies. The expectation is that they do this as sustainably as possible. For now, the EPI rewards countries that are doing their best to curb the rate of growth in emissions.

China, for example, is the world's largest emitter of greenhouse gases and one of the top energy-consuming countries. It tends to receive heavy criticism for these distinctions. Still, GDP per person in China is very low, with almost 400 million people living on less than US$2 a day. Despite high economic expansion averaging greater than 10 percent annual growth in GDP, China reported a 20-percent decrease in carbon intensity between 2005 and 2010. At the 2009 UN Copenhagen Climate Summit, China committed to reduce carbon intensity an additional 40 to 45 percent of 2005 levels

[115] United Nations Framework Convention on Climate Change. (2009) *Copenhagen Accord*. Available: http://unfccc.int/meetings/copenhagen_dec_2009/items/5262.php. Last accessed: December 30, 2013.
[116] The Danish Government. (2013) *The Danish climate policy plan: toward a low carbon future*. Available: http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/danishclimatepolicyplan_uk.pdf. Last accessed: January 10, 2014.

CHINA'S EFFORTS ON CLIMATE CHANGE & ENERGY

China has recently revised their policies on coal energy to help mitigate their high carbon dioxide emissions. (Credit: Wikimedia Commons / Rob Loftis)

China, the second-largest economy in the world, has seen rapidly increasing carbon dioxide (CO_2) emissions in recent years. In 2007 the country overtook the United States to become the largest global emitter of CO_2, and its emissions continue to grow.[1] These increasing emissions levels have put China under both international and national scrutiny, particularly as 70 percent of China's energy comes from coal – a fossil fuel responsible for a host of other environmental impacts, including poor air quality.[2]

Chinese authorities have recognized the urgency of climate change and energy security. In 2011, the Chinese government launched the 12th Five-Year Plan (2011-2015), the greenest social and economic development blueprint in China to date.[3] For the first time, the Plan established clear targets to reduce carbon intensity by 16 to 17 percent from 2005 baseline levels, with a longer-term goal of 40 to 45 percent reductions by 2020.[4] To ensure the country is on track to meet these goals, China has invested heavily in renewable energy development and has been aggressively rolling out solar and wind generation technologies. In the first 10 months of 2013, renewables accounted for more than a half of all new electricity generation capacity.[5]

In addition to renewable energy development, officials are also exploring market-led mechanisms such as emissions trading. In 2013, China announced and implemented pilot carbon trading schemes in seven regions. The heavily industrialized southeastern city of Shenzhen established its trading market in June, which included a total of 635 industrial facilities and 197 large public buildings.[6] During its first 100 days of operation, the market saw a total of 185 transactions, amounting to 113,000 tons of carbon at a value of nearly 8 million yuan (US$1.3 million).[7] The markets in Shanghai and Beijing were established in November, with the remaining soon to follow.

Although it is too soon to tell how effective these early steps will be, China's performance in the Climate and Energy category demonstrates the tangible results of policies implemented over the last few years that have helped to reduce energy and carbon intensity in the country.

[1] Vidal, J. and Adam, D. (2007) *China overtakes US as world's biggest CO2 emitter*. The Guardian. 19 June 2007. Available: http://www.theguardian.com/environment/2007/jun/19/china.usnews. Last accessed: January 14, 2014.

[2] Energy Information Agency. (2012) *Countries analysis: China*. Washington, D.C. Available: http://www.eia.gov/countries/cab.cfm?fips=CH. Last accessed: November 25, 2013.

[3] National People's Congress. (2011) *Report on the work of the government* (Premier Wen Jiabao). English versions available: http://blogs.wsj.com/chinarealtime/2011/03/05/china-npc-2011-reports-full-text/. Last accessed: March 1, 2012.

[4] Lan, L. (2011) *China to reduce carbon intensity by 17% by 2015*. China Daily. Available: http://www.chinadaily.com.cn/china/2011-07/29/content_13006047.htm. Last accessed: January 14, 2014.

[5] Bloomberg News. (2014) *China Doubles Renewable Energy Capacity Amid Pollution Cut Push*. Bloomberg Business Week. Available: http://www.businessweek.com/news/2013-12-04/china-doubles-renewable-energy-capacity-amid-pollution-cut-push. Last accessed: January 13, 2014.

[6] Swartz, J. (2013) *A Users Guide To Emissions Trading in China. International Emissions Trading Association (IETA)*. Available: http://www.ieta.org/assets/Reports/ieta_emissionstradinginchinauserguide_oct2013.pdf. Last accessed: January 13, 2014.

[7] Hornby, L. (2013) *China tests water for carbon market to discourage emission*. Financial Times. 10 October 2013.

by 2020.[117] Trends in carbon intensity reduction from the past decade demonstrate China's policy achievements.

As low as China's GDP may be, a whole tier of countries ranked in the EPI is even poorer, with a GNI per capita less than US$1,035. These LDCs have, in past iterations of the EPI, dominated the rankings, largely due to low economic development. But because of the less significant contribution of LDCs to overall climate emissions, the 2014 EPI does not score these countries on the Climate and Energy category. Their priority should be building their economies, albeit as sustainably as possible, while developing robust energy infrastructures that ensure access to cleaner forms of energy for their people. In terms of climate change, these countries' primary concerns are vulnerability and adaptation to climate change.

Many countries with high proportions of populations lacking access to electricity currently rely on higher-polluting, less sustainable forms of fuel, including biomass like animal dung, wood, and charcoal.

Switching to less-polluting, non-solid fuels has both climate impacts and household air pollution impacts (see Issue profile: Air Quality). Furthermore, increasing access to electricity provides a range of social and economic benefits for citizens. The 2014 EPI website provides an indicator of Access to Electricity for LDCs, but it does not include the measure when calculating the aggregated score for these countries.

Recognizing these disparate policy goals, the 2014 EPI treats national levels of development as a central determinant of how countries' performance on the Climate and Energy trend indicators are weighted. Instead of scoring countries by their absolute carbon intensity, trends in carbon intensity between 2000 and 2010 are calculated, with weightings between two different indicators— Trend in Carbon Intensity and Change in Trend of Carbon Intensity— gradually blended for countries at ratios based on their GNI per capita. For the high-income group — those countries with a GNI per capita above US$12,616 – the Trend in Carbon Intensity indicator is weighted more heavily. For middle-income countries— those with a GNI per capita between US$1,036 and US $12,615 — the Change in Trend of Carbon Intensity is weighted higher. Essentially, this indicator is a measure of how much countries have slowed their rate of growth in carbon intensity in the recent past. Those that have slowed their rates of emissions growth are scored better than countries that remain steady or are increasing emissions more rapidly than at earlier times. The exact weighting ratios for these two indicators for each country are provided on the EPI website.

The third indicator in the Climate category, Trend in CO_2 Emissions per kWh, measures the carbon intensity of countries' electricity and heat generation sector. While sector-based indicators benchmarked against ambitious carbon emission targets would be ideal, global data on all sectors are not available. The one exception is the power sector, which is responsible for well over half of all global emissions. This indicator therefore assesses the trend in carbon

[117] McKibbin, W. J., Morris, A., and Wilcoxen, P. J. (2010) *Comparing climate commitments: A model-based analysis of the Copenhagen Accord*. Brookings Institution: Washington, D.C.. Available: http://www.brookings.edu/~/media/research/files/papers/2010/5/27%20copenhagen%20mckibbin%20morris%20wilcoxen/0527_climate_committments_mckibbin_morris_wilcoxen.pdf. Last accessed: January 10, 2014.

EVALUATION POLICY PERFORMANCE – THE CLIMATE CHANGE PERFORMANCE INDEX

The Climate Change Performance Index (CCPI) holds countries accountable to global carbon dioxide reduction targets using emissions-based indicators and policy evaluations.[1] Produced by Germanwatch and Climate Action Network Europe, it is released at the annual meetings of the United Nations Framework Convention on Climate Change. Since 2005, the CCPI has been naming and shaming countries as they rise and fall on their list.

The CCPI ranks 58 countries that together represent over 90 percent of global CO_2 emissions. These countries include top emitters like China and the United States, but also other countries like Kazakhstan and Iran. To achieve the top ranks, highest performing countries must be on track toward achieving an under two-degree Celsius temperature rise scenario – the most ambitious emissions pathway possible. So far, no country has ranked in one of the top three slots because, according to the CCPI report, no country is performing well enough to meet the ideal carbon emissions targets.

The Index includes indicator categories that weigh both long- and short-term needed for climate policies to take effect. To do so, the CCPI takes into consideration climate emissions that include both the levels of emissions and the trend of emissions over time.

What is novel about the CCPI is its attempt to not only consider climate emissions as an indicator of performance, but to include perception and survey data on how policies are working within countries. The scores in the climate policy category come from surveys of climate experts around the world. Over 250 experts ranked their nations' domestic climate change policies as well as their leaders' international action on a five-point scale (from "very good" to "very poor"). The national and international climate change policy indicators are both weighted evenly in the indicator; this can have a dramatic effect on countries' ranking on the CCPI. This year Germany dropped out of the top-10 ranking for the first time, mainly because national climate experts gave a negative evaluation of their nation's performance. Their perception: the German government is letting up on some of its prior ambition.

[1] Burck, J., Marten, F. and Bals, C. (2014) *The Climate Change Performance Index Results 2014*. Germanwatch and Climate Action Network Europe. Available: http://germanwatch.org/en/download/8599.pdf. Last accessed: January 11, 2014.

intensity of electricity and heat production from 2000 to 2010. Select countries do not have much room to improve in this category, as they are already performing extremely well. For them, the indicator simply represents the amount of CO_2 emissions per unit of electricity and heat produced.

Iceland is among this very small group of exceptions. Aside from shipping and transportation, all of the country's energy comes from renewable sources, mostly geothermal and hydropower. Although Iceland is endowed with a low population and an optimal mix of resources to achieve that distinction, it would be unwise to think its success is unrelated to policy. Iceland manages its power sector so well that it is able to export energy and still provide clean, reliable electricity to its citizens. A different scenario exists in one of the other exceptions. In Paraguay a massive hydropower system provides the power sector with the bulk—almost 80 percent— of its energy. However, power-outages are frequent, reliability is low, and access to the abundant clean energy is not widespread. In fact, the majority of the electricity produced is exported to Brazil, at bargain-basement prices.[118]

Both countries have tremendous opportunities for innovation: Iceland is on its way to putting its geothermal energy to use for the recycling of CO_2 into usable, exportable fuels.[119] And Paraguay, which imports all of its fossil fuels, is positioned to use its abundant hydropower to foster a robust domestic renewables fuels industry. However the fact that these countries are ranked highly in this important category is no guarantee that they will continue to perform at the same level as conditions change. As is true with all of the EPI's issue categories, even a cursory investigation reinforces the fact that individual indicators only tell a fragment of the story.

These case studies are examples of countries that blend a strategy of natural resources endowments and policy to keep emissions low. When there is little room to improve because of already high performance, incremental performance is even more challenging. Judging small improvements can seem like a penalty. Sadly, such high performance is well outside the norm. For the vast majority of nations, the Trend in CO_2 Emissions per kWh indicator is based on the trend in reduction of carbon intensity in the electricity sector.

Ideally, future measures of climate change and energy performance will be tied more directly to policy actions toward both mitigation of and adaptation to climate effects. For now, the data for such a global-scale venture does not exist (see Box: Evaluating Policy Performance – The Climate Change Performance Index). Until it does, the EPI must make do with existing data, offering imperfect measures at best.

[118] Toledano, P. and Maennling, N. (2013) *Leveraging Paraguay's hydropower for economic development*. Vale Columbia Center on Sustainable International Development: New York, United States. Available: http://www.vcc.columbia.edu/files/vale/content/Leveraging_Paraguays_Hydropower_for_Economic_Development.pdf. Last accessed: January 10, 2014.

[119] Katz, C. (2013) *Iceland seeks to cash in on its abundant renewable energy*. Yale Environment 360. Available: http://e360.yale.edu/feature/iceland_seeks_to_cash_in_on_its_abundant_renewable_energy/2697/. Last accessed: January 10, 2014.

Albania's high use of hydroelectricity contributes to its lower carbon emissions. (Credit: Wikimedia Commons / Idobi)

THE FUTURE OF HYDROELECTRICITY AND COAL CONSUMPTION IN ALBANIA

Albania receives about 90 percent of its energy from a renewable source: hydropower. Like Iceland, Paraguay, and other high-ranking countries in the Trend in CO_2 Emissions per Kilowatt-hour indicator, a heavy reliance on clean electricity gives little room for Albania to improve the current carbon intensity of its power sector—a shortcoming any country would be proud to claim. While it may be hard to fathom a decline from these top levels of performance, given established infrastructure, recent policy changes in Albania signal that the country may decline in performance on this indicator in the future.

Because water availability for Albania's energy sector historically has been unstable, Albania's power sector suffers from frequent outages and shortfalls. The World Bank projects that climate change will only exacerbate existing problems of water availability.[1] However, Albania is keen to maintain the general trend of growth it has experienced since it opened its markets following the fall of communism. To do so requires expanding its power sector. Among the proposed approaches to overcoming Albania's energy shortages is connecting Albania to Kosovo's coal-based electricity grid. A deal was signed in December 2013 to build a 400-kV transmission line linking the two countries.

Another deal has been struck between Albania and an Italian firm to build a large "energy complex" in the area of Porto Romano, the centerpiece of which will be an 800-megawatt coal-fired power plant. With its own coal infrastructure on the horizon, it seems likely that the days of Albania's exceptional record of low-carbon energy are numbered.

EPI methods do not account for future projections of indicator metrics, which is why Albania is still a top performer in Climate and Energy despite impending policies. Taking into consideration current actions that may impact Albania's future climate performance, including the shortfalls of the country's current hydropower system as well as an imminent increase of coal consumption, suggests the country should look to diversify its renewable energy portfolio beyond hydropower if it seeks to continue low-carbon economic growth.

[1] Ebinger, J. (2010) *Albania's Energy Sector: Vulnerable to Climate Change. Europe and Central Asia Knowledge Brief.* The World Bank: Washington, D.C. Available: http://siteresources.worldbank.org/INTECALEA/Resources/ECA_KB_29_Albania_Energy.pdf. Last accessed: December 26, 2013.

2014 EPI Results

ECONOMIC AND POLITICAL GROUP COMPARISONS

G20/Major Economies

Countries included in the G20 group represent around 85 percent of the world's gross domestic product and over two-thirds of the global population.[120] Australia ranks the highest in this group at 3, followed by Germany at 6 and the United Kingdom at 12. Indonesia, China and India are the lowest performers of this group, at 112, 118, and 155, respectively. Overall, the G20 group performs poorly on Fisheries and Forests, with the United States in the bottom of both of these categories. Australia and the United Kingdom perform very well on Air Quality, Health Impacts, and Water and Sanitation. Overall, the G20 scores the highest among other groups for Health Impacts, Water and Sanitation, Biodiversity, Climate and Energy, and Water Resources, and the lowest on Fisheries.

Countries: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, United Kingdom, United States, European Union

BRICS/Emerging Markets

Emerging market countries – those with high rates of industrialization and economic growth – include China, India, Brazil, Russia, and South Africa. These countries are frequently grouped together and known as the BRICS because of their large, rapidly growing economies. They alone have been responsible for 55 percent of global growth from the end of 2009 to 2012.[121] In terms of the 2014 EPI, South Africa ranks the highest in this group at 72, followed by Russia at 73 and Brazil at 77. China and India are among the worst performers at 118 and 155, respectively. They perform relatively worse on Air Quality compared to other country groups, and India and China are the worst performers globally with respect to both Air Pollution indicators – PM2.5 Average Exposure and PM2.5 Exceedance. They are also the worst performers with respect to Fisheries. In particular, South Africa receives a score of 0 on Coastal Shelf Fishing Pressure and has a score of 5.04 on Fish Stocks. The group also performs below the global average on Biodiversity and Habitat protection – India's protection of terrestrial and marine habitats is especially weak. In terms of trends, the BRICS countries demonstrate positive 10-year trends, although with modest improvements over the last decade.

Countries: Brazil, China, India, Russia, South Africa

Least-developed Countries (LDCs)

A least-developed country (LDC) is classified as such if it meets a set of criteria established by the United Nations regarding its poverty, human resource weakness, and economic vulnerability.[122] As of 2014, 49 countries are classified as LDCs. In the EPI, these countries are among the worst-performing. However, some countries, such as Kiribati, which is 59th, rank relatively high. Kiribati's high EPI score islargely driven by its high performance in the Biodiversity and Habitat category, and is likely a reflection of the manageability of its small 811 sq.

[120] Australia 2014. (2014) *About G20*. Available: http://www.g20.org/about_g20/g20_members. Last accessed: January 13, 2014.

[121] World GDP. (2013) *The Economist*. Available: http://www.economist.com/news/economic-and-financial-indicators/21574491-world-gdp. Last accessed: January 12, 2014.

[122] UN Development and Policy Analysis Division. (2013). *LDC information: the criteria for identifying least developed countries*. Available: http://www.un.org/en/development/desa/policy/cdp/ldc/ldc_criteria.shtml. Last accessed: January 12, 2014.

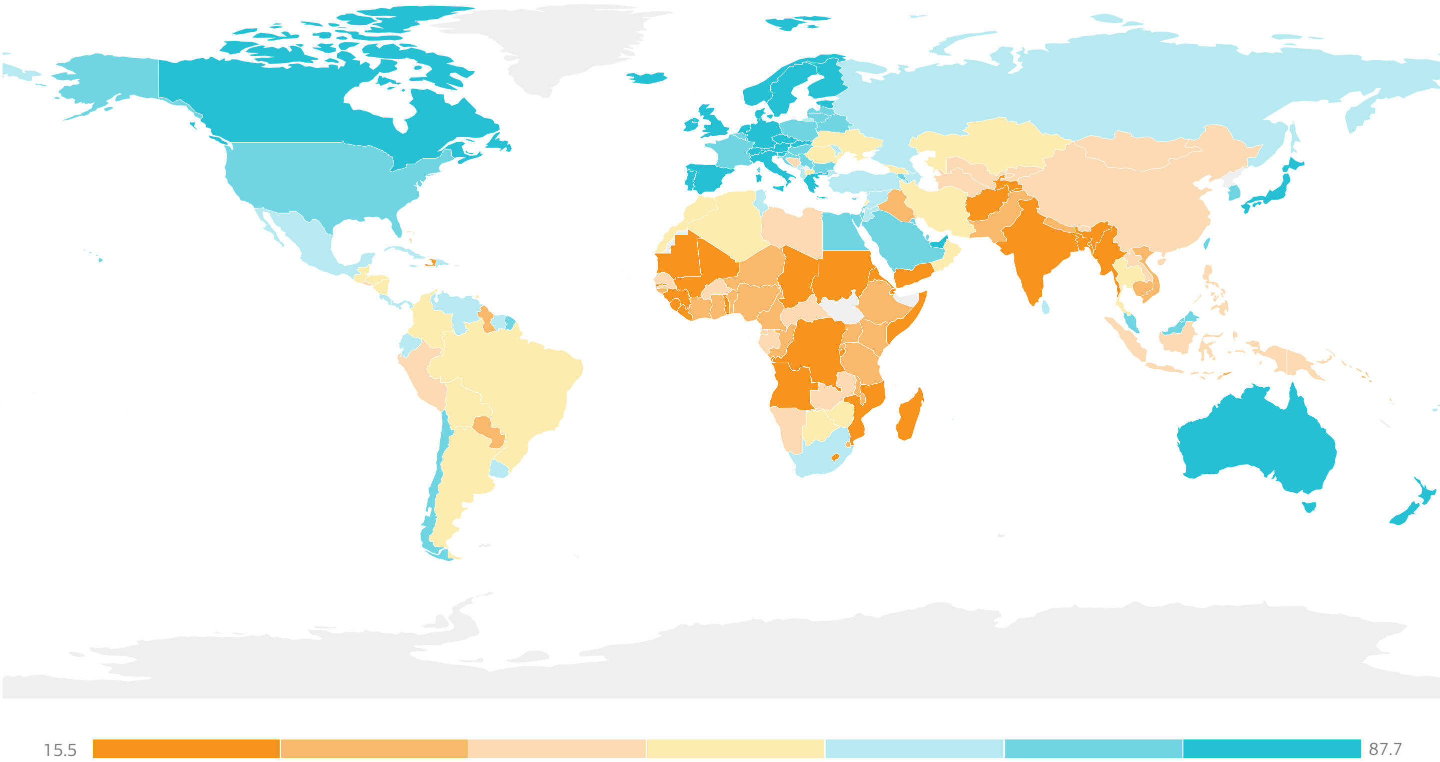

Figure 11. Global map of the 2014 EPI rankings.

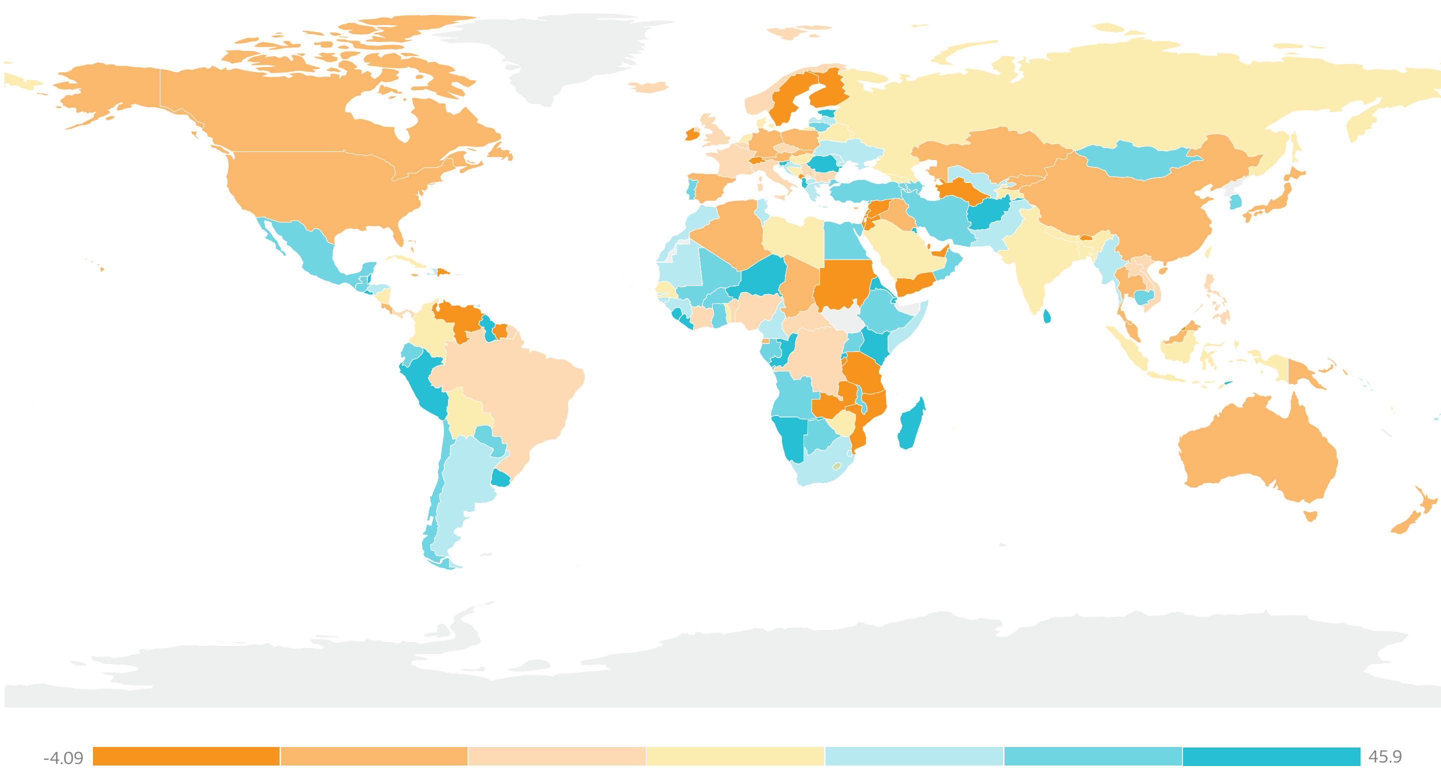

Figure 12. Global map of 10-year change results in EPI performance.

km. land area. In general, the LDCs perform well on Air Quality, a result that is driven more by the outdoor Air Pollution indicators rather than the Household Air Quality, as many LDCs continue to use high percentages of solid-fuels indoors for cooking. Most LDCs, with the exception of Djibouti, which scores an 87, perform the worst on the Household Air Quality indicator. Afghanistan, Lesotho, Haiti, Mali, and Somalia comprise the bottom-five worst performers in the 2014 EPI. Many of these countries have been subject to political instability and natural disasters. The LDCs are also the worst performers on Waste and Sanitation and Water Resources, with average scores of 13.8 and 1.6, respectively. Most LDCs lack infrastructure for wastewater treatment. For the 2014 EPI, LDCs were not scored on climate change mitigation.

Countries: Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Laos, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Samoa, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Sudan, Tanzania, Timor-Leste, Togo, Tuvalu, Uganda, Vanuatu, Yemen, Zambia

Small Island Developing States (SIDS)

Small Island developing states (SIDS) are a group of 52 low-lying coastal countries that have small but growing populations, limited resources, and share common sustainable development challenges, such as vulnerability to natural disasters and climate change.[123] There is some overlap between the SIDS and LDCs, including Kiribati, Vanuatu, Timor-Leste, Guinea-Bissau, Solomon Islands, Comoros, and Haiti. Overall, the SIDs tend to perform well on Air Quality, with almost all countries performing at target for both Air Pollution indicators (PM2.5 – Average Exposure and PM2.5 Exceedance). These countries, however, perform poorly on Water Resources, with most lacking wastewater treatment infrastructure and failing to provide populations with Access to Clean Drinking Water and Access to Improved Sanitation. SIDS also perform low with respect to Climate and Energy, although Jamaica and Fiji are relative standouts, with scores of 76.98 and 65.71, respectively. Despite SIDS being island-countries, they perform slightly better than the global average with respect to Fisheries, with the Solomon Islands performing well on Coastal Shelf Fishing Pressure with a near at-target score of 99.77.

Countries: American Samoa, Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Virgin Islands, Cape Verde, Comoros, Cook Islands, Cuba, Dominica, Dominican Republic, Fiji, French Polynesia, Grenada, Guam, Guinea-Bissau, Guyana, Haiti, Jamaica, Kiribati, Maldives, Marshall Islands, Mauritius, Micronesia, Montserrat, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Seychelles, Singapore, Solomon Islands, Suriname, Timor-Leste, Tonga, Trinidad and Tobago, Tuvalu, United States Virgin Islands, Vanuatu

[123] UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States. (2013) *About the Small Island Developing States*. Available: http://unohrlls.org/about-sids/. Last accessed: January 13, 2014.

RELATIONSHIP BETWEEN GDP & THE EPI

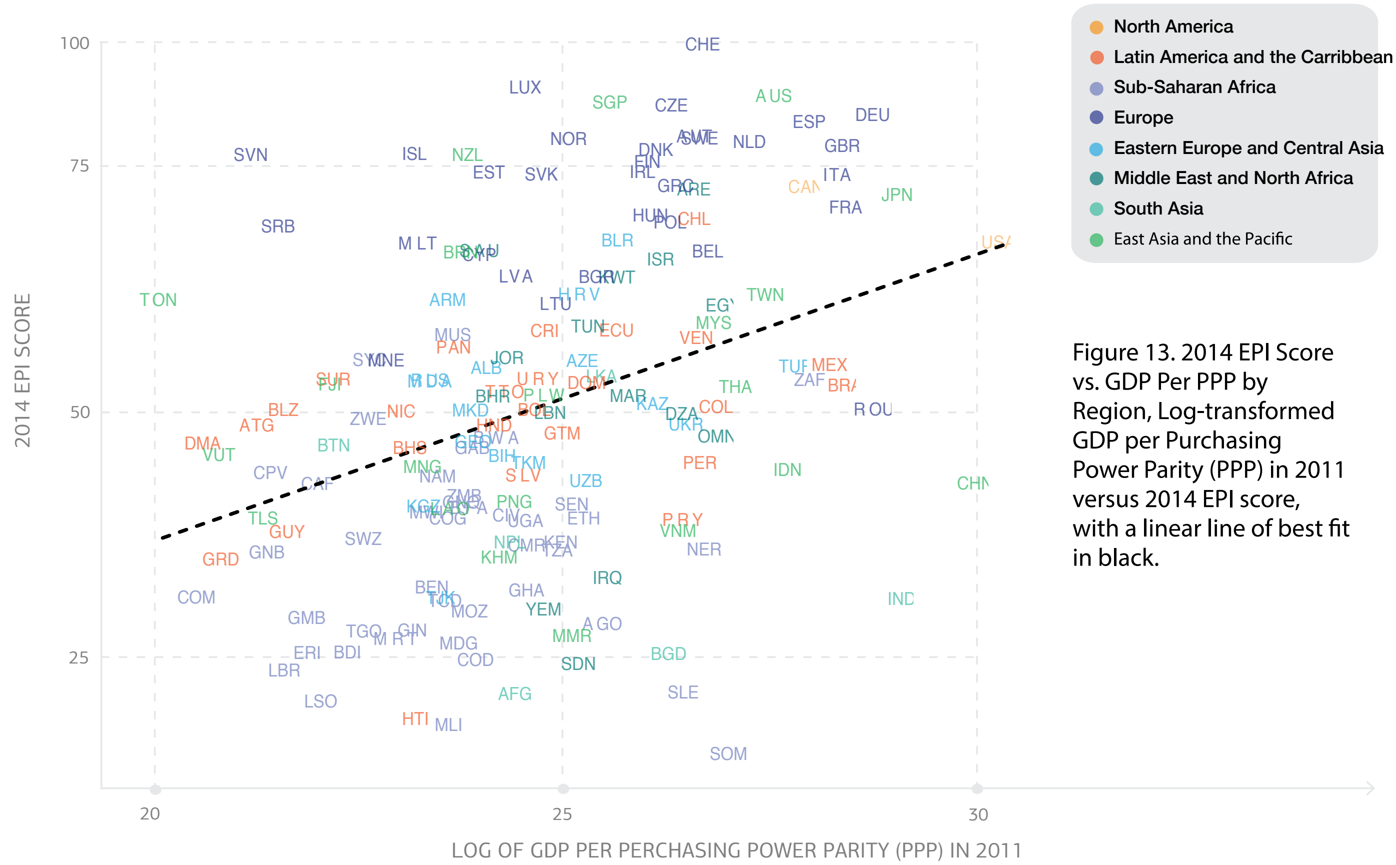

Figure 13. 2014 EPI Score vs. GDP Per PPP by Region, Log-transformed GDP per Purchasing Power Parity (PPP) in 2011 versus 2014 EPI score, with a linear line of best fit in black.

RELATIONSHIP BETWEEN EPI & 10-YEAR PERCENT CHANGE

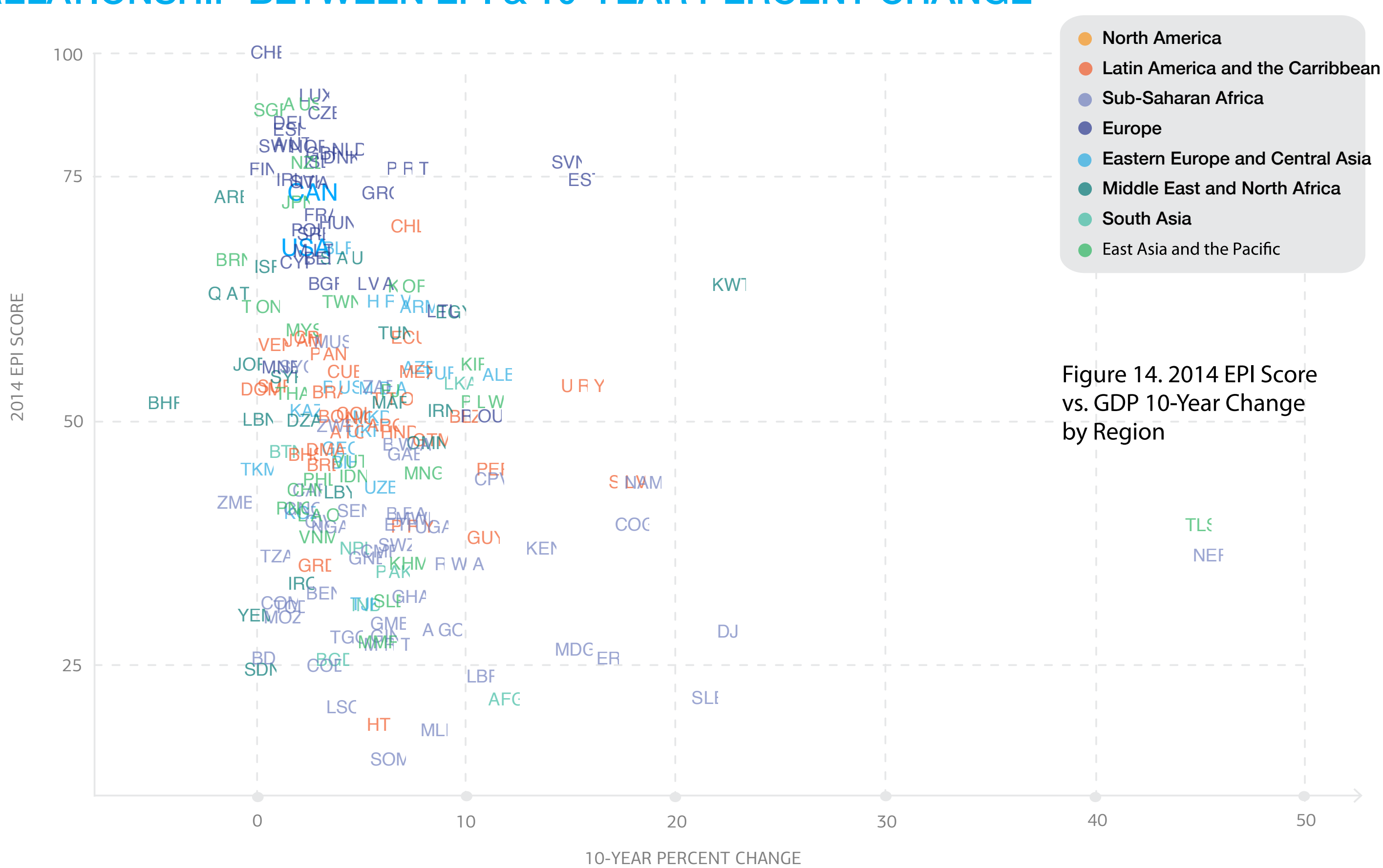

Figure 14. 2014 EPI Score vs. GDP 10-Year Change by Region

Community of Latin American and Caribbean States (CELAC)

The Community of Latin American and Caribbean States (CELAC) is a group of 33 countries created to help advance political dialogue and cooperation for all of the Latin American countries.[124] CELAC performs the highest among all groups for Air Quality, with all countries except Mexico tied as number one for the Air Pollution – Average Exposure to PM2.5 indicator. This group also performs well in Health Impacts and Agriculture, with Argentina and Chile being among the top performers in both categories. These countries, however, are the lowest overall performers for Forests, with large forest losses occurring in Argentina, Belize, Guatemala, Nicaragua, and Paraguay. CELAC also performs low with respect to Fisheries, with 10 countries (e.g., Haiti, Jamaica, Barbados, and Belize), all receiving a score of zero. Fish stocks in many of these countries are overexploited or collapsed, and much of the catch comes from trawling; both of which significantly decrease their category and overall scores.

Countries: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela

Organization of the Petroleum Exporting Countries (OPEC)

The Organization of the Petroleum Exporting Countries (OPEC) was created in 1960, and today includes a total of 12 Member Countries.[125] Among the group, OPEC helps coordinate and unify petroleum policies to manage stable prices, provide stable supplies, and assure fair capital for petroleum providers.[126] This group performs well on Air Quality and is the highest performer among other groups in Agriculture, with Ecuador, Iraq, Venezuela, Algeria, Iran, Nigeria, and Angola tying as the number one performer. Overall, OPEC performs poorly on Fisheries and Forests. Angola, Nigeria, Iran, Ecuador and Iraq have an extremely low range of scores in Water Resources, from 0 to 8.29, respectively. Some of the low-performing countries in this group, such as Angola, Iraq, and Libya, have suffered from recent armed conflict, not surprisingly contributing to their positions in the bottom one-third of all countries including in the EPI.

Countries: Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, Venezuela

From Figure 13, a relationship between countries' EPI performance and economic development emerges. For instance, countries located in Europe (shown in purple), tend to have higher EPI scores in relation to their GDP per PPP compared to other regions, in particular Sub-Saharan Africa, which tends to have the poorest results, incaluding Somalia (SOM). This tendency implies that countries with more financial resources can better implement policies to protect human health and the environment. However, this is not always the case. China (CHN) and India (IND) for instance, both have high GDP per PPP but receive

[124] European Union External Action Service. (2013). *The EU's relations with Latin American and the Caribbean*. Available: http://www.eeas.europa.eu/lac/index_en.htm. Last accessed: January 13, 2014.
[125] Organization of the Petroleum Exporting Countries. (2014). *Brief History*. Available: http://www.opec.org/opec_web/en/about_us/24.htm. Last accessed: January 13, 2014.
[126] *Ibid*.

low scores on the overall EPI. This result suggests the role of something other than economic development alone (e.g., governance or political investments) that may also be critical in achieving environmental results. For example, Tonga (TON) has relatively low economic development and a relatively high EPI score, compared to other countries with similar GDP per PPP.

When comparing countries' performance on the 2014 EPI and their change in performance over the last decade, several trends emerge. First, aside from Slovenia and Estonia, most countries in Europe perform well on the EPI but do not exhibit high percentages of change. This result makes sense – it is difficult for already high-performing countries to incrementally increase their performance. Contrarily, it is much easier for countries that start out performing poorly to improve, such as Timor-Leste and Niger. On the whole, it is easy to see from Figure 14 that most countries cluster between 0 and 10 percent change, which indicates relatively flat trends in performance over the last decade.

REGIONAL RESULTS

East Asia and the Pacific

Rank	Country	Score	10-year % change	Rank	Country	Score	10-year % change
3	Australia	82.4	2.32	80	Palau	51.96	10.84
4	Singapore	81.78	0.94	106	Vanuatu	45.88	4.7
16	New Zealand	76.41	2.58	111	Mongolia	44.67	8.26
26	Japan	72.35	2.17	112	Indonesia	44.36	4.8
37	Brunei Darussalam	66.49	-0.84	114	Philippines	44.02	3.21
43	South Korea	63.79	7.37	118	China	43	2.6
46	Taiwan	62.18	4.33	122	Papua New Guinea	41.09	2.04
47	Tonga	61.68	0.37	127	Laos	40.37	2.96
51	Malaysia	59.31	2.51	132	Timor-Leste	39.41	45.37
59	Kiribati	55.82	10.6	136	Viet Nam	38.17	3.19
76	Fiji	53.08	6.61	145	Cambodia	35.44	7.52
78	Thailand	52.83	1.91	152	Solomon Islands	31.63	6.57

Eastern Europe and Central Asia

Rank	Country	Score	10-year % change	Rank	Country	Score	10-year % change
32	Belarus	67.69	4.17	84	Kazakhstan	51.07	2.57
45	Croatia	62.23	6.34	89	Macedonia	50.41	5.75
48	Armenia	61.67	8.02	95	Ukraine	49.01	5.44
63	Azerbaijan	55.47	7.98	101	Georgia	47.23	4.28
66	Turkey	54.91	9.03	107	Bosnia and Herzegovina	45.79	4.4
67	Albania	54.73	11.79	109	Turkmenistan	45.07	0.33
73	Russia	53.45	4.21	117	Uzbekistan	43.23	6.16
74	Moldova	53.36	6.04	125	Kyrgyzstan	40.63	2.39

Europe

Rank	Country	Score	10-year % change	Rank	Country	Score	10-year % change
1	Switzerland	87.67	0.8	20	Estonia	74.66	15.91
2	Luxembourg	83.29	3.02	21	Slovakia	74.45	2.66
5	Czech Republic	81.47	3.47	22	Italy	74.36	2.72
6	Germany	80.47	1.89	23	Greece	73.28	6.2
7	Spain	79.79	1.82	27	France	71.05	3.29
8	Austria	78.32	1.82	28	Hungary	70.28	4.1
9	Sweden	78.09	1.3	30	Poland	69.53	2.67
10	Norway	78.04	2.79	31	Serbia	69.13	2.99
11	Netherlands	77.75	4.62	34	Malta	67.42	2.7
12	United Kingdom	77.35	3.48	36	Belgium	66.61	3.22
13	Denmark	76.92	4.3	38	Cyprus	66.23	2.18
14	Iceland	76.5	2.99	40	Latvia	64.05	5.69
15	Slovenia	76.43	15.16	41	Bulgaria	64.01	3.59
17	Portugal	75.8	7.23	49	Lithuania	61.26	9.06
18	Finland	75.72	0.45	62	Montenegro	55.52	1.41
19	Ireland	74.67	1.7	86	Romania	50.52	10.91

Latin America and the Caribbean

Rank	Country	Score	10-year % change	Rank	Country	Score	10-year % change
29	Chile	69.93	7.44	88	Belize	50.46	10.17
53	Ecuador	58.54	7.51	90	Nicaragua	50.32	5.14
54	Costa Rica	58.53	2.67	93	Argentina	49.55	6.42
55	Jamaica	58.26	2.37	96	Antigua and Barbuda	48.89	4.51
57	Venezuela	57.8	1.12	97	Honduras	48.87	7.05
58	Panama	56.84	3.53	98	Guatemala	48.06	8.63
64	Cuba	55.07	4.48	102	Dominica	47.08	3.54
65	Mexico	55.03	7.94	105	Bahamas	46.58	2.58
70	Uruguay	53.61	15.61	108	Barbados	45.5	3.46
71	Suriname	53.57	1.13	110	Peru	45.05	11.57
75	Dominican Republic	53.24	0.47	115	El Salvador	43.79	17.75
77	Brazil	52.97	3.72	133	Paraguay	39.25	7.45
79	Trinidad and Tobago	52.28	6.52	137	Guyana	38.07	11.19
85	Colombia	50.77	4.9	147	Grenada	35.24	3.13
87	Bolivia	50.48	4	176	Haiti	19.01	6.08

Middle East and North Africa

Rank	Country	Score	10-year % change	Rank	Country	Score	10-year % change
25	United Arab Emirates	72.91	-0.95	82	Bahrain	51.83	-4.09
35	Saudi Arabia	66.66	4.09	83	Iran	51.08	9.03
39	Israel	65.78	0.7	91	Lebanon	50.15	0.34
42	Kuwait	63.94	22.96	92	Algeria	50.08	2.48
44	Qatar	63.03	-1.33	99	Oman	47.75	8.42
50	Egypt	61.11	9.67	120	Libya	42.72	4.17
52	Tunisia	58.99	6.87	149	Iraq	33.39	2.39
60	Jordan	55.78	-0.07	157	Yemen	30.16	0.2
68	Syria	54.5	1.7	171	Sudan	24.64	0.49
81	Morocco	51.89	6.66				

North America

Rank	Country	Score	10-year % change
24	Canada	73.14	2.58
33	USA	67.52	2.23

South Asia

Rank	Country	Score	10-year % change	Rank	Country	Score	10-year % change
69	Sri Lanka	53.88	9.94	155	India	31.23	5.4
103	Bhutan	46.86	1.63	169	Bangladesh	25.61	3.98
139	Nepal	37	4.96	174	Afghanistan	21.57	12.17
148	Pakistan	34.58	6.66				

Sub-Saharan Africa

Rank	Country	Score	10-year % change	Rank	Country	Score	10-year % change
56	Mauritius	58.09	3.9	143	Tanzania	36.19	1.15
61	Seychelles	55.56	2.15	144	Guinea-Bissau	35.98	5.54
72	South Africa	53.51	6.04	146	Rwanda	35.41	9.7
94	Zimbabwe	49.54	4.05	150	Benin	32.42	3.45
100	Botswana	47.6	7.18	151	Ghana	32.07	7.58
104	Gabon	46.6	7.35	153	Comoros	31.39	1.42
113	Cape Verde	44.07	11.48	156	Chad	31.02	1.87
116	Namibia	43.71	18.74	158	Mozambique	29.97	1.49
119	Central African Republic	42.94	2.75	159	Gambia	29.3	6.62
121	Zambia	41.72	-0.78	160	Angola	28.69	9.09
123	Equatorial Guinea	41.06	2.5	161	Djibouti	28.52	22.77
124	Senegal	40.83	4.91	162	Guinea	28.03	6.34
126	Burkina Faso	40.52	7.17	163	Togo	27.91	4.65
128	Malawi	40.06	7.72	165	Mauritania	27.19	6.25
129	Cote d'Ivoire	39.72	3.14	166	Madagascar	26.7	15.48
130	Congo	39.44	18.33	167	Burundi	25.78	0.59
131	Ethiopia	39.43	7.15	168	Eritrea	25.76	17.09
134	Nigeria	39.2	3.73	170	Dem. Rep. Congo	25.01	3.56
135	Uganda	39.18	8.68	172	Liberia	23.95	11.03
138	Swaziland	37.35	6.96	173	Sierra Leone	21.74	21.79
140	Kenya	36.99	13.96	175	Lesotho	20.81	4.36
141	Cameroon	36.68	6.16	177	Mali	18.43	8.67
142	Niger	36.28	45.88	178	Somalia	15.47	6.62

Conclusion

LOOKING AHEAD TO THE FUTURE OF THE EPI

Despite the ever-increasing media attention and public focus on the importance of environmental protection and sustainability, the 2014 EPI highlights disparities in global environmental performance. While a few major issues show improvement—protection of terrestrial and marine habitats, and the reduction of child mortality and populations lacking access to clean water and improved sanitation, for instance—the 2014 EPI suggests an unevenness of results achieved by both countries and the world. It also provides specific evidence for the importance of incorporating robust indicators and time-bound targets into policy design. When measurement and management align consistently and comprehensively, we see progress at the global and national levels.

For some priority issues, measurement capabilities remain weak. Agriculture is an extreme example of this shortcoming, and the 2014 EPI indicators for agriculture reflect the poor state of the environmental monitoring of farming practices. Both the scientific and policy communities have been very slow to develop a clear direction for assessing the sustainability of agriculture with cross-cutting environmental impacts, including climate change, air quality, and forests. We hope that recent moves toward landscape assessments, food security and safety, and interest by food manufacturers and agro-industry in sustainability measurement begin to offer new directions for agricultural indicators.

Other key areas lacking adequate measurement include human exposure to toxic chemicals, solid waste management, recycling, species protection, freshwater quality, and wetlands protection. Data on these vital categories are so incomplete that the EPI cannot even track them. It seems the issue areas that are fundamentally ecological and systems-oriented tend to be measured least effectively. Failing to manage such systems poses increasing risks, and the need to step up to the measurement challenge is dire and urgent.

Recognizing the relevance of scale when it comes to environmental management is important. While the EPI is primarily focused on the national state, because it is the locus for global policy coordination, we acknowledge the arbitrary nature of national boundaries with respect to global environmental challenges. The global climate system is agnostic with respect to where emissions come from—whether households, cities, or industrial sectors—each unit of carbon released is another that counts against the global carbon budget.[127] The emergence of the city-state Singapore into the Top 10 of the 2014 EPI is testament to the ability of cities to play a significant role in global environmental governance. As such, cities offer opportunities when it comes to environmental sustainability. It is easier to develop the sewage systems that contribute to wastewater treatment, for instance, for densely settled areas.

The role of the EPI has evolved over time not only to be responsive to the global policy agenda, but also to actively shape it. The 2014 EPI and its findings are poised to play a critical role in the post-2015 development agenda (see Box: Mapping the SDGs and EPI). Its results

[127] Intergovernmental Panel on Climate Change. (2013) *Summary for Policymakers of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Available: http://www.ipcc.ch/report/ar5/wg1/. Last accessed: January 10, 2014.

are released at time when they can inform the United Nations' Sustainable Development Goals (SDGs), the success of which will depend on better data, clear targets, and strong monitoring. As 2015 approaches, and as the international community pursues the SDGs, our indicators are benchmarks by which the world can measure progress toward sustainable development. The 2014 EPI specifically supports the SDGs by providing a first-time metric to calculate national performance on wastewater treatment, a key component of a proposed SDG for water. The international community now has a starting point by which to understand and assess wastewater treatment, a major driver of water quality for both ecosystems and public health.

Data from novel sources and cutting-edge technologies are helping to improve the accuracy and importance of indicators. With the advent of big data and new technologies, a much wider array of tools is now available for filling key measurement gaps. The EPI makes use of these innovations, emergent technologies, and institutional forms. Forestry measures, for example, can now make use of satellite data to generate metrics that are far more comparable and comprehensive than what emerged from previous modeling efforts and national reports. New data using over 650,000 satellite images reveal the true global extent of forest loss and gain over the last decade.

However, data from these "non-official" sources are imperfect. The world still needs better measurement and indicator systems. To meet the growing demand for environmental performance indicators, the global community will need to build on existing strengths and invest in

MAPPING THE SDGs AND EPI

How does the 2014 EPI relate with ongoing discussions in the United Nations Open Working Group for Sustainable Development Goals (SDGs)?

Discussions within the Open Working Group for SDGs and On-going Consultations are still evolving, with the deadline for presenting final results to the UN General Assembly coming in Fall 2014. The General Assembly will then vote on the proposals that will officially become a part of the post-2015 development agenda.

There are many groups involved in the thematic consultations, which are providing materials and ideas for the SDGs. The Sustainable Development Solutions Network, led by Jeffrey Sachs, Director of the Earth Institute at Columbia University, for instance, has proposed a list of key issues, along with The World We Want consortium of inter-governmental and non-government organizations. Furthermore, country delegations have contributed to the process of convening stakeholders to provide inputs into the design of the SDGs.

Although the range of proposals is necessarily broad, Table 2 distills some of the major themes of the SDGs and maps them to the relevant EPI indicators to give a sense of how the world's aspirational goals relate to current EPI metrics.

innovative approaches. The EPI team remains committed to working with partners and pushing the envelope to develop useful measures that veer countries toward progress. Part of this commitment entails continuing to work with scientific experts and policymakers to design the "next generation" of environmental indicators. The 2014 EPI features two indicators – Air Pollution and Wastewater Treatment – that are the result of pilot efforts in partnership with global experts to actively shape the global policy agenda for environmental decisionmaking and future measurement efforts. Moving forward, better measures of agricultural sustainability, climate adaptation and resilience, toxic chemicals, and solid waste management are all high priorities. Such innovation will require close cooperation between governments, corporations, scientists, and civil society.

Finally, the EPI documents the tangible benefits that arise when policymakers pursue strong environmental performance and the damage that manifests when they do not. Nowhere is this clearer than in the disparity between results in the Environmental Health and Ecosystem Vitality objectives. Global focus and attention to Child Mortality, Access to Clean Drinking Water, and Improved Sanitation has resulted in measurable progress in nearly every country over the last decade. These successes have in large part been driven by international efforts, such as the Millennium Development Goals (MDGs), to establish global targets and finite timelines for achievement. When the World Health Organization and UNICEF announced in 2012 that the MDG related to the provision of safe drinking water was the first to be reached, the groups stressed that this was largely due to the clarity of the target and the international community's constant efforts to strengthen data collection and monitoring.[128] During the same period, however, a greater percentage of the world's population is being exposed to poor air quality than in the past and fish stocks are in stark decline. In terms of climate change, while countries have had variable success in reducing the carbon intensity of growth, overall emissions are still growing and stand to keep growing in the future.

We hope the 2014 EPI results are a useful conversation starter for countries to begin understanding how they perform on a range of high-priority environmental issues – both among peers and across time. As we always disclaim, the EPI is and remains a work in progress.

[128] UNICEF and World Health Organization. (2012) *Progress on drinking water and sanitation: 2012 update.* Available: http://www.unicef.org/media/files/JMPreport2012.pdf. Last accessed: January 13, 2014.

Table 2. Key issues being discussed in the context of the Sustainable Development Goals, with proposed EPI indicators that may overlap. Source: UNSD (2013).[1]

Thematic Areas	Sample Proposed Goals	Sample Proposed Targets	EPI Indicators that Overlap
Oceans and Seas	A stand-alone goal such as Healthy, Productive, and Resilient Oceans.	• Ensure that all fish stocks are being harvested sustainably. • Ensuring significant reductions in marine pollution.	• Marine Protected Areas • Coastal Shelf Fishing Pressure • Fish Stocks • Wastewater Treatment • Pesticide Regulation
Sustainable Transport	Access to goods and services while minimizing negative external effects.	• Bring urban air pollution within WHO limits for an additional 1.5 billion urban residents by 2030. • Double the efficiency of the global fleet, in 2030 for all new vehicles, and by 2050 for the complete global fleet.	• Household Air Quality • Air Pollution indicators • Climate and Energy
Forests	• A specific SDG aiming to protect and sustainably manage forests; • A cross-cutting "integrated landscapes SDG" focusing on land, forests, biodiversity, water and other renewable natural resources.	• Follow the Convention on Biological Diversity (CBD) Aichi targets, such as: to halve deforestation and the loss of other natural habitats by 2020.	• Change in Forest Cover • Marine Protected Areas • Terrestrial Protected Areas
Biodiversity	Protect nature • Reduce pressures on biodiversity; • Address the underlying causes of biodiversity loss.	• Protecting at least 17% of land and 10% of oceans through protected areas.	• Biodiversity and Habitat indicators
Climate Change	Curb human induced climate change and ensure sustainable energy;	• Reduce non-energy related emissions of greenhouse gases through improved practices in agriculture, forestry, waste management, and industry.	• Climate and Energy indicators
Sustainable Consumption and Production, including Chemicals and Waste	Improve quality of life by promoting efficient, responsible and clean production systems and sustainable lifestyles; • Specific goal on chemicals and waste management.	• By 2010, stakeholders at all levels will have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impact of natural resources use well within safe ecological limits.	• Pesticide Regulation
Sustainable Cities and Human Settlements	Empower cities that are environmentally sustainable, socially inclusive, economically productive and resilient.	• By 2030, renewable energy and recycled waste and improved energy efficiency in buildings. • Universal access to drinking water and reduced untreated waste and wastewater. • Low-carbon energy, transportation, and communication. • Ensure safe air quality and water quality for all.	• Wastewater Treatment • Air Pollution indicators • Access to Sanitation • Access to Drinking Water

Thematic Areas	Sample Proposed Goals	Sample Proposed Targets	EPI Indicators that Overlap
Energy	Secure sustainable energy for all.	• Ensuring universal access to modern energy services. • Doubling the rate of improvement in energy efficiency. • Doubling the share of renewable energy in the global energy mix.	• Access to Electricity • Climate and Energy indicators
Health and Sustainable Development	• Maximizing healthy lives. • Accelerating progress on the MDG health agenda. • Taking action on the social and environmental determinants to health.	• Reducing the burden of disease, ensuring universal health coverage and access. • Develop sustainable food systems that enable access to a balanced diet; measure progress by deaths and diseases attributed to air pollution.	• Child Mortality • Household Air Quality • Air Pollution indicators
Water and Sanitation	• Ensure a water secure world for all. • Securing sustainable water for all.	• Universal access to safe water, improved sanitation and hygiene by 2040. • Increase wastewater management and pollution prevention. • Water, sanitation and hygiene should be equitable and sustainable. • Reduce the urban population with untreated wastewater and untreated industrial wastewater flows.	• Access to Sanitation • Access to Drinking Water • Wastewater Treatment
Sustainable Agriculture	• Nurture healthy, sustainable, and productive ecosystems and support integrated evidence-based planning and management of land and natural resources. • Sustainable land use for all and by all.	• Agroforestry, sustainable agriculture and livestock practices, water management, and soil conservation.	• Future indicators desired for EPI development.
Desertification, Land Degradation and Drought		• Zero net land degradation by 2030, or achieving net restoration of degraded lands by 2030. • Drought policies and drought preparedness measures put in place in all drought-prone regions by 2020.	• Future indicators desired for EPI development.

[1] UN Division for Sustainable Development, Department of Economic and Social Affairs. (2013) United Nations Sustainable Development Knowledge Platform, Technical Support Team Issues Briefs. Available: http://sustainabledevelopment.un.org/index.php?menu=1528. Last accessed: January 13, 2014.

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