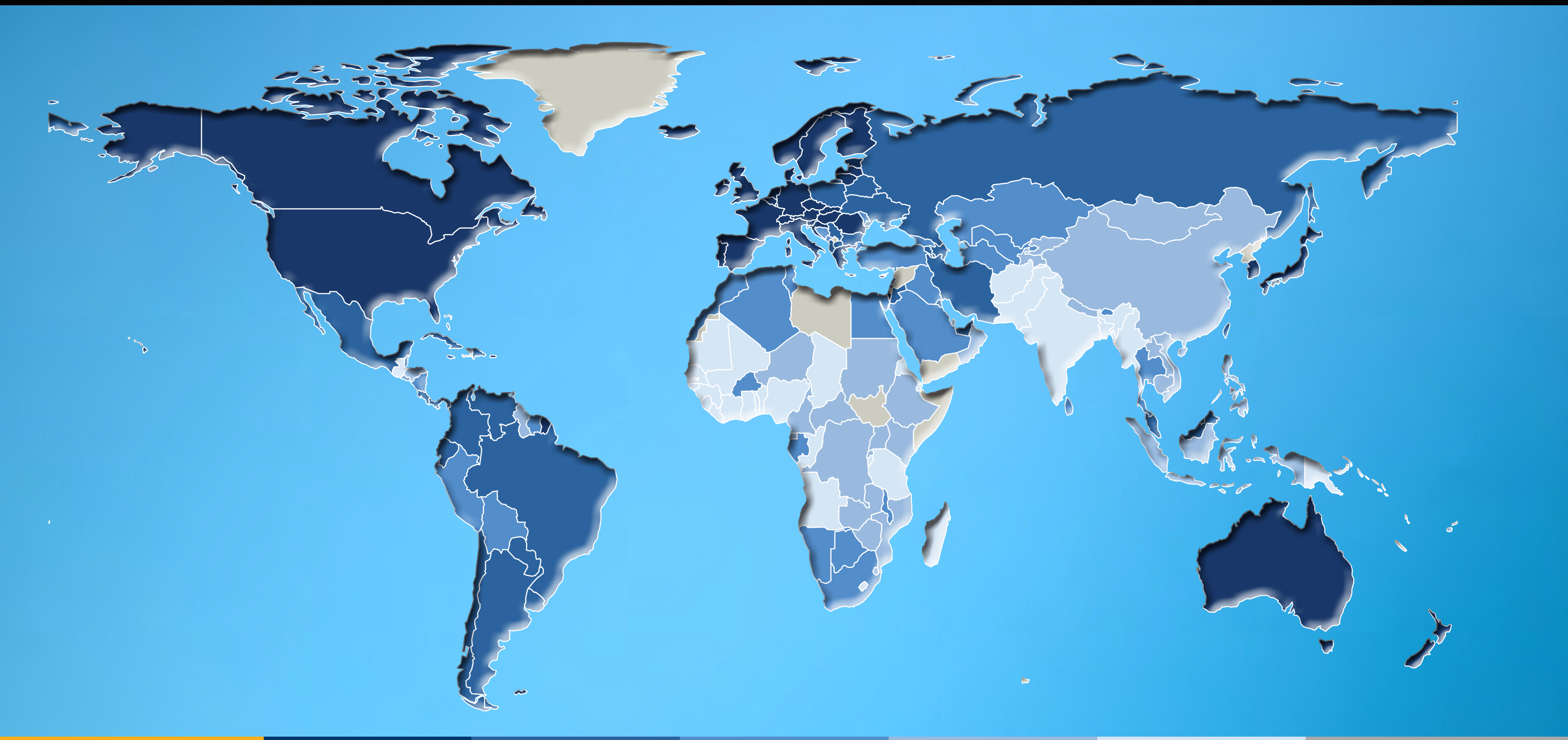
Environmental Performance Index 2020

Global metrics for the environment: Ranking country performance on sustainability issues



EPI RANKINGS	1–36	37–72	73–108	109–144	145–180	NA

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Complete methods, data, and results—including breakout scores and rankings for individual countries—are available online at epi.yale.edu.

THE ENVIRONMENTAL PERFORMANCE INDEX

The 2020 Environmental Performance Index (EPI) provides a data-driven summary of the state of sustainability around the world. Using 32 performance indicators across 11 issue categories, the EPI ranks 180 countries on environmental health and ecosystem vitality. These indicators provide a gauge at a national scale of how close countries are to established environmental policy targets. The EPI offers a scorecard that highlights leaders and laggards in environmental performance and provides practical guidance for countries that aspire to move toward a sustainable future.

EPI indicators provide a way to spot problems, set targets, track trends, understand outcomes, and identify best policy practices. Good data and fact-based analysis can also help government officials refine their policy agendas, facilitate communications with key stakeholders, and maximize the return on environmental investments. The EPI offers a powerful policy tool in support of efforts to meet the targets of the UN Sustainable Development Goals and to move society toward a sustainable future.

Overall EPI rankings indicate which countries are best addressing the environmental challenges that every nation faces. Going beyond the aggregate scores and drilling down into the data to analyze performance by issue category, policy objective, peer group, and country offers even greater value for policymakers. This granular view and comparative perspective can assist in understanding the determinants of environmental progress and in refining policy choices.

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ABBREVIATIONS

ABNJ	Areas Beyond National Jurisdiction
ALOS PALSAR	Advanced Land Operating Satellite Phased Array type L-band Synthetic Aperture Radar
ATP	Agriculture Transformation Pathways
BHI	Biodiversity Habitat Index
BLL	Blood lead level
CBD	Convention on Biological Diversity
CEDS	Community Emissions Data System
CH_4	Methane
CICA	University of Costa Rica's Environmental Pollution Research Centre
CIESIN	Center for International Earth Science Information Network
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CO_2	Carbon dioxide
COP	Conference of the Parties (UNFCCC)
COVID-19	Coronavirus disease of 2019
CRA	Comprehensive Risk Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DALY	Disability-adjusted life-year
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency (U.S.)
EPI	Environmental Performance Index
ESA	European Space Agency
EU	European Union
F-gases	Fluorinated gases
FAO	Food and Agriculture Organization (UN)
FAOSTAT	FAO's Corporate Statistical Database
FARC	Revolutionary Armed Forces of Colombia
GBD	Global Burden of Disease
GDP	Gross domestic product
GEO BON	Group on Earth Observations Biodiversity Observation Network
GFW	Global Forest Watch (WRI)
GHG	Greenhouse gas
GMW	Global Mangrove Watch
HAP	Household air pollution
IEA	International Energy Agency
IHME	Institute for Health Metrics and Evaluation
IMF	International Monetary Fund
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported, and unregulated (fishing)
JMP	Joint Monitoring Program for Water Supply and Sanitation
LASSO	Least absolute shrinkage and selection operator
MDG	Millennium Development Goal
MFA	Material flow accounting
MODIS	Moderate-resolution imaging spectroradiometer

ABBREVIATIONS

MPA	Marine Protected Area
MRIO	Multi-regional input-output
MTI	Marine Trophic Index
N	Nitrogen
N_2O	Nitrous oxide
NASA	National Aeronautics and Space Administration (U.S.)
NDC	Nationally Determined Contributions
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration (U.S.)
NUE	Nitrogen use efficiency
OECD	Organization for Economic Co-operation and Development
PADDD	Protected area downgrading, downsizing, and degazettement
PARI	Protected Area Representativeness Index
PATs	precision agriculture technologies
PIK	Potsdam Institute for Climate Impact Research
PM	Particulate matter
$PM_{2.5}$	Particulate matter having a diameter ≤2.5 microns
PPP	Purchasing power parity
PREDICTS	Projecting Responses of Ecological Diversity In Changing Terrestrial Systems
PRIMAP	Potsdam Realtime Integrated Model for probabilistic Assessment of emission Paths
SAU	*Sea Around Us*
SHI	Species Habitat Index
SIDS	Small Island Developing States
SDG	Sustainable Development Goal
SNMI	Sustainable Nitrogen Management Index
SO_2	Sulfur dioxide
SO_X	Sulfur oxides
SOFIA	State of World Fisheries and Aquaculture
SPI	Species Protection Index
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
USA	United States of America
WB	World Bank
WCMC	World Conservation Monitoring Centre
WDPA	World Database on Protected Areas
WGI	Worldwide Governance Indicators
WHO	World Health Organization
WMO	World Meteorological Organization
WRI	World Resources Institute
WWAP	World Water Assessment Program (UN)
WWF	World Wildlife Fund

Executive Summary

The 2020 Environmental Performance Index (EPI) provides a data-driven summary of the state of sustainability around the world. Using 32 performance indicators across 11 issue categories, the EPI ranks 180 countries on environmental health and ecosystem vitality. These indicators provide a gauge at a national scale of how close countries are to established environmental policy targets. The EPI offers a scorecard that highlights leaders and laggards in environmental performance and provides practical guidance for countries that aspire to move toward a sustainable future. The metrics on which the 2020 rankings are based come from a variety of sources and represent the most recent published data, often from 2017 or 2018. Thus the analysis does not reflect recent developments, including the dramatic drop in air pollution in 2020 in the wake of the COVID-19 pandemic or the huge increase in greenhouse gas emissions from the extensive Amazonian fires in 2019.

These indicators provide a way to spot problems, set targets, track trends, understand outcomes, and identify best policy practices. Good data and fact-based analysis can also help government officials refine their policy agendas, facilitate communications with key stakeholders, and maximize the return on environmental investments. The EPI offers a powerful policy tool in support of efforts to meet the targets of the UN Sustainable Development Goals and to move society toward a sustainable future.

Overall EPI rankings indicate which countries are best addressing the array of environmental challenges that every nation faces. Going beyond the aggregate scores and drilling down into the data to analyze performance by specific issue category, policy objective, peer group, and country can offer even greater value for policymakers. This granular view and comparative perspective can assist in understanding the determinants of environmental progress and in refining policy choices.

EXPLAINING PERFORMANCE

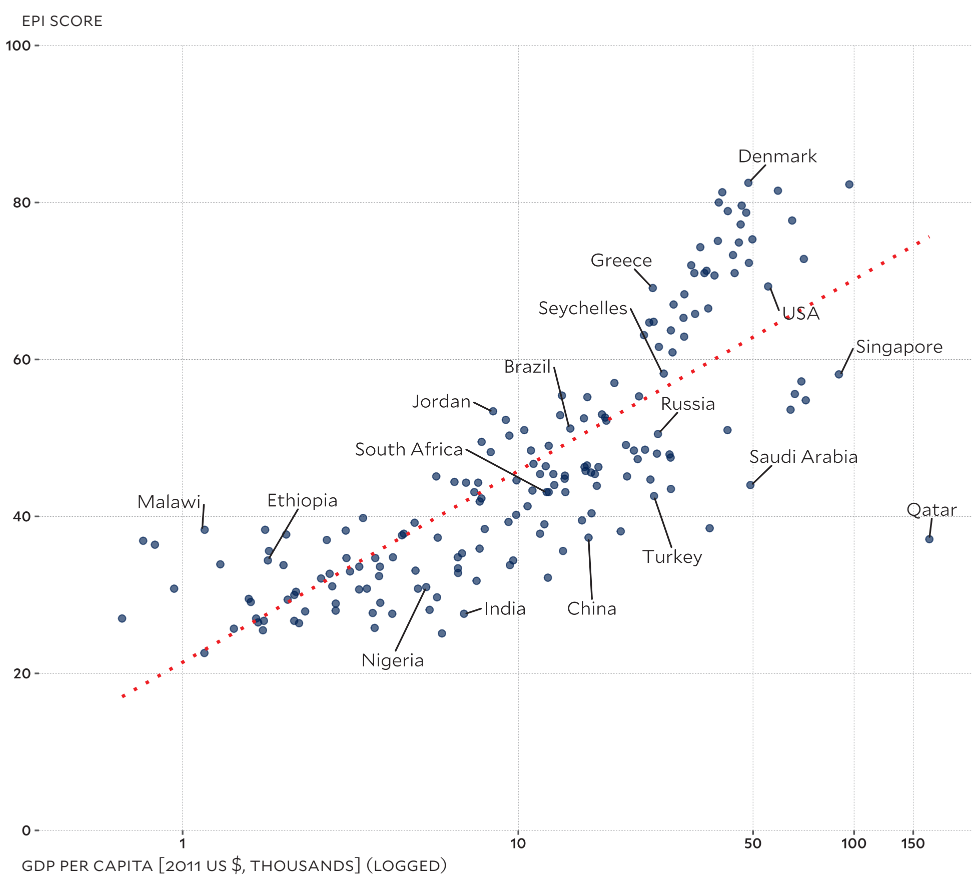
A number of striking conclusions emerge from the 2020 EPI rankings and indicators. First, good policy results are associated with wealth (GDP *per capita*), meaning that economic prosperity makes it possible for nations to invest in policies and programs that lead to desirable outcomes. This trend is especially true for issue categories under the umbrella of environmental health, as building the necessary infrastructure to provide clean drinking water and sanitation, reduce ambient air pollution, control hazardous waste, and respond to public health crises yields large returns for human well-being.

Second, the pursuit of economic prosperity – manifested in industrialization and urbanization – often means more pollution and other strains on ecosystem vitality, especially in the developing world, where air and water emissions remain significant. But at the same time, the data suggest countries need not sacrifice sustainability for economic security or *vice versa*. In every issue category, we find countries that rise above their economic peers. Policymakers and other stakeholders in these leading countries demonstrate that focused attention can mobilize communities to protect natural resources and human well-being despite the strains associated with economic growth. In this regard, indicators of good governance – including commitment to the rule of law, a vibrant press, and even-handed enforcement of regulations – have strong relationships with top-tier EPI scores, highlighting the importance of managing economic and environmental issues with a commitment to analytic rigor and carefully constructed policies.

Third, while top EPI performers pay attention to all areas of sustainability, their lagging peers tend to have uneven performance. Denmark, which ranks #1, has strong results across most issues and with leading-edge commitments and outcomes with regard to climate change mitigation. In general, high scorers exhibit long-standing policies and programs to protect public health, preserve natural resources, and decrease greenhouse gas emissions. The data further suggest that countries making concerted efforts to decarbonize their electricity sectors have made the greatest gains in combating climate change with associated benefits for ecosystems and human health. We note, however, that every country – including those at the top of the EPI rankings – still has issues to improve upon. No country can claim to be on a fully sustainable trajectory.

Fourth, laggards must redouble national sustainability efforts along all fronts. A number of important countries in the Global South, including India and Nigeria, come out near the bottom of the rankings. Their low EPI scores indicate the need for greater attention to the spectrum of sustainability requirements, with a high-priority focus on critical issues such as air and water quality, biodiversity, and climate change. Some of the other laggards, including Nepal and Afghanistan, face broader challenges such as civil unrest, and their low scores can almost all be attributed to weak governance.

FIGURE ES-1. The relationship between 2020 EPI Score and GDP *per capita* shows a strong positive correlation, although many countries out- or underperform their economic peers.



REFINING METRICS

Innovations in the 2020 EPI data and methodology reflect the latest advances in environmental science and indicator analysis. Notably, the 2020 rankings include for the first time a waste management metric and a pilot indicator on CO_2 emissions from land cover change. Other new indicators deepen the analysis of air quality, biodiversity & habitat, fisheries, ecosystem services, and climate change. As with every iteration of the EPI, full documentation of the methodology and all of the data are available online at epi.yale.edu. The EPI team invites feedback and suggestions for strengthening future versions of the Index.

While the EPI provides a framework for greater analytic rigor in environmental policymaking, it also reveals a number of severe data gaps that limit the analytic scope of the EPI rankings. As the EPI project has highlighted for two decades, better data collection, reporting, and verification across a range of environmental issues are urgently needed. The existing gaps are especially pronounced in the areas of sustainable agriculture, water resources, and threats to biodiversity. New investments in stronger global data systems are essential to better manage sustainable development challenges and to ensure that the global community does not breach fundamental planetary boundaries.

The inability to capture transboundary environmental impacts persists as a limitation of the current EPI framework. While the current methodology reveals important insights into how countries perform within their own borders, it does not account for “exported” impacts associated with imported products. With groundbreaking models and new datasets emerging, the EPI team has been working to produce new metrics and indices that account for the spillovers of harm associated with traded goods in an interconnected world.

GLOBAL PANDEMIC

The 2020 EPI emerges in the midst of the COVID-19 crisis that has challenged public health systems across the world and disrupted economic activity in every country. The global pandemic has made clear the profound interdependence of all nations and people on Earth as well as the importance of investing in resilience. Unintended consequences of the economic shutdown mandated in many nations include a sharp drop in pollution levels and the return of wildlife. The EPI team hopes that his unexpected glimpse of what a sustainable planet might look like from an ecological perspective – albeit at a terrible price in terms of public health and economic damage – will inspire the policy transformation required for a sustainable future that is both economically vigorous and environmentally sound.

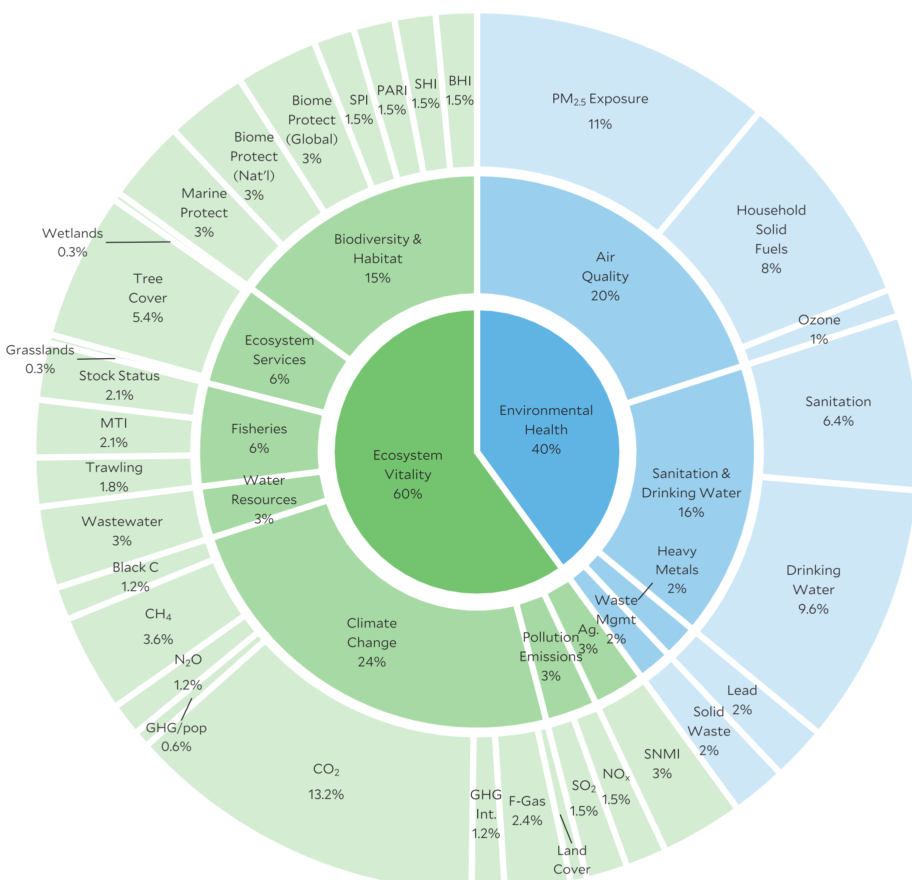


FIGURE ES-2. The 2020 EPI Framework. The framework organizes 32 indicators into 11 issue categories and two policy objectives, with weights shown at each level as a percentage of the total score.

TABLE ES-1. 2020 EPI rank, score, and regional rank (REG) for 180 countries.

RANK	COUNTRY	SCORE	REG
1	Denmark	82.5	1
2	Luxembourg	82.3	2
3	Switzerland	81.5	3
4	United Kingdom	81.3	4
5	France	80.0	5
6	Austria	79.6	6
7	Finland	78.9	7
8	Sweden	78.7	8
9	Norway	77.7	9
10	Germany	77.2	10
11	Netherlands	75.3	11
12	Japan	75.1	1
13	Australia	74.9	12
14	Spain	74.3	13
15	Belgium	73.3	14
16	Ireland	72.8	15
17	Iceland	72.3	16
18	Slovenia	72.0	1
19	New Zealand	71.3	17
20	Canada	71.0	18
	Czech Republic	71.0	2
	Italy	71.0	18
23	Malta	70.7	20
24	United States of America	69.3	21
25	Greece	69.1	3
26	Slovakia	68.3	4
27	Portugal	67.0	22
28	South Korea	66.5	2
29	Israel	65.8	1
30	Estonia	65.3	5
31	Cyprus	64.8	6
32	Romania	64.7	7
33	Hungary	63.7	8
34	Croatia	63.1	9
35	Lithuania	62.9	10
36	Latvia	61.6	11
37	Poland	60.9	12
38	Seychelles	58.2	1
39	Singapore	58.1	3
40	Taiwan	57.2	4
41	Bulgaria	57.0	13
42	United Arab Emirates	55.6	2
43	North Macedonia	55.4	14
44	Chile	55.3	1
45	Serbia	55.2	15
46	Brunei Darussalam	54.8	5
47	Kuwait	53.6	3
48	Jordan	53.4	4
49	Belarus	53.0	1
50	Colombia	52.9	2
51	Mexico	52.6	3
52	Costa Rica	52.5	4
53	Armenia	52.3	2
54	Argentina	52.2	5
55	Brazil	51.2	6
56	Bahrain	51.0	5
	Ecuador	51.0	7
58	Russia	50.5	3
59	Venezuela	50.3	8
60	Ukraine	49.5	4
61	Uruguay	49.1	9
62	Albania	49.0	16
63	Antigua and Barbuda	48.5	10
64	Cuba	48.4	11
	St. Vincent and Grenadines	48.4	11
66	Jamaica	48.2	13
67	Iran	48.0	6
68	Malaysia	47.9	6
69	Trinidad and Tobago	47.5	14
70	Panama	47.3	15
71	Tunisia	46.7	7
72	Azerbaijan	46.5	5
73	Paraguay	46.4	16
74	Dominican Republic	46.3	17
	Montenegro	46.3	17
76	Gabon	45.8	2
77	Barbados	45.6	18
78	Bosnia and Herzegovina	45.4	18
	Lebanon	45.4	8
	Thailand	45.4	7
81	Suriname	45.2	19
82	Mauritius	45.1	3
	Tonga	45.1	8
84	Algeria	44.8	9
85	Kazakhstan	44.7	6
86	Dominica	44.6	20
87	Moldova	44.4	7
88	Bolivia	44.3	21
	Uzbekistan	44.3	8
90	Peru	44.0	22
	Saudi Arabia	44.0	10
92	Turkmenistan	43.9	9
93	Bahamas	43.5	23
94	Egypt	43.3	11
95	El Salvador	43.1	24
	Grenada	43.1	24
	Saint Lucia	43.1	24
	South Africa	43.1	4
99	Turkey	42.6	19
100	Morocco	42.3	12
101	Belize	41.9	27
102	Georgia	41.3	10
103	Botswana	40.4	5
104	Namibia	40.2	6
105	Kyrgyzstan	39.8	11
106	Iraq	39.5	13
107	Bhutan	39.3	1
108	Nicaragua	39.2	28
109	Sri Lanka	39.0	2
110	Oman	38.5	14
111	Philippines	38.4	9
112	Burkina Faso	38.3	7
	Malawi	38.3	7
114	Tajikistan	38.2	12
115	Equatorial Guinea	38.1	9
116	Honduras	37.8	29
	Indonesia	37.8	10
118	Kiribati	37.7	11
119	São Tomé and Príncipe	37.6	10
120	China	37.3	12
120	Samoa	37.3	12
122	Qatar	37.1	15
123	Zimbabwe	37.0	11
124	Central African Republic	36.9	12
125	Dem. Rep. Congo	36.4	13
126	Guyana	35.9	30
127	Maldives	35.6	3
	Uganda	35.6	14
129	Timor-Leste	35.3	14
130	Laos	34.8	15
	Sudan	34.8	16
132	Kenya	34.7	15
	Zambia	34.7	15
134	Ethiopia	34.4	17
	Fiji	34.4	16
136	Mozambique	33.9	18
137	Eswatini	33.8	19
	Rwanda	33.8	19
139	Cambodia	33.6	17
	Cameroon	33.6	21
141	Viet Nam	33.4	18
142	Pakistan	33.1	4
143	Micronesia	33.0	19
144	Cabo Verde	32.8	22
145	Nepal	32.7	5
146	Papua New Guinea	32.4	20
147	Mongolia	32.2	21
148	Comoros	32.1	23
149	Guatemala	31.8	31
150	Tanzania	31.1	24
151	Nigeria	31.0	25
152	Marshall Islands	30.8	22
	Niger	30.8	26
	Republic of Congo	30.8	26
155	Senegal	30.7	28
156	Eritrea	30.4	29
157	Benin	30.0	30
158	Angola	29.7	31
159	Togo	29.5	32
160	Mali	29.4	33
161	Guinea-Bissau	29.1	34
162	Bangladesh	29.0	6
163	Vanuatu	28.9	23
164	Djibouti	28.1	35
165	Lesotho	28.0	36
166	Gambia	27.9	37
167	Mauritania	27.7	38
168	Ghana	27.6	39
	India	27.6	7
170	Burundi	27.0	40
	Haiti	27.0	32
172	Chad	26.7	41
	Solomon Islands	26.7	24
174	Madagascar	26.5	42
175	Guinea	26.4	43
176	Côte d'Ivoire	25.8	44
177	Sierra Leone	25.7	45
178	Afghanistan	25.5	8
179	Myanmar	25.1	25
180	Liberia	22.6	46

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

CREATING A COMPOSITE INDEX

As a composite index, the Environmental Performance Index distills data on many indicators of sustainability into a single number. Advances in scientific investigation, sensing methods, and data reporting mean the world's access to data on the state of the environment has never been richer. With every iteration of the EPI, we seek the best available data to produce useful and credible scores that address urgent questions.

For the 2020 EPI, we've assembled 32 indicators of environmental performance for 180 countries. The data come from trusted third-party sources like international governing bodies, nongovernmental organizations, and academic research centers. Credible datasets rely on established collection methods that have been peer-reviewed by the scientific community or endorsed by international authorities.

To give our metrics meaning to a broad audience, we take the data we receive from our providers and construct indicators on a 0–100 scale, from worst to best performance. For each country, we then weigh and aggregate the scores for indicators into issue categories, then into policy objectives, and then, finally, into an EPI score. Scores for all countries can be viewed or downloaded at our website, epi.yale.edu.

Chapter 1. Introduction

1. ENVIRONMENTAL METRICS AND A SUSTAINABLE FUTURE

Metrics have groundbreaking potential to propel us toward a sustainable future – but only if the work embraces data-driven policymaking, built on a foundation of careful measurement of environmental trends and progress. The world formally recognized the role of data with the adoption of the Sustainable Development Goals (SDGs) and the Paris Climate Change Agreement in 2015. The SDGs in particular contain quantified, time-bound targets that require every country to measure outcomes – and which allow citizens and civil society to hold leaders accountable to those targets. Good data and fact-based analysis together help government officials refine policy agendas, communicate with key stakeholders, identify best practices, and maximize the return on environmental investments. In the absence of data and other information, decision-makers and other stakeholders lack the context for identifying and prioritizing problems, crafting policies, tracking the effectiveness of those policies, and adapting and learning from their own experience and the experience of others.

For over 20 years, the Environmental Performance Index (EPI) has been the world's premier scorecard for tracking country-level progress toward international sustainable development targets. In a single score, the EPI captures an array of metrics on natural resource management and protection of human health from environmental risks. The 2020 EPI ranks 180 countries on 32 indicators across 11 issue categories. Policymakers, corporations, civil society, researchers, nongovernmental organizations, and the media rely on the biennial release of the EPI for insights on policies and trends in sustainability.

Complexity behind environmental challenges can be daunting and overwhelming. Data require rigorous analysis, organization, and communication in order to help decisionmakers navigate thorny issues. The discourse surrounding sustainable development can become mired in vague agendas, uncertainties about the nature of problems, and poorly defined solutions. The EPI serves as a powerful communications tool that resolves these difficulties, providing stakeholders with simpler translations of cutting-edge environmental science. We invite a wide audience – both inside and outside of government – to explore our environmental performance scores as they work toward improving the world around them. Our rankings are particularly useful for inspiring healthy competition between countries vying to be leaders of their peer groups. Within countries, trends in performance over time allow stakeholders to identify areas of progress, stagnation, or backsliding. We have designed the EPI with the intention of providing clarity on important sustainability issues and empowering a broad set of actors with tools for recasting their approach to environmental policy and setting bold new agendas.

2. THE 2020 ENVIRONMENTAL PERFORMANCE INDEX

As a composite index, the EPI distills data on many indicators of sustainability into a single number. Advances in scientific investigation, sensing methods, and data reporting make the world's access to data on the state of the environment richer than ever. For the 2020 EPI, we've assembled 32 indicators of environmental performance, as shown in Figure 1-1. The data come from trusted third-party sources like international governing bodies, nongovernmental organizations, and academic research centers. Credible datasets rely on established collection methods that have been peer-reviewed by the scientific community or endorsed by international authorities.

To give our metrics meaning to a broad audience, we take the data we receive and construct indicators on a 0–100 scale, from worst to best performance. A perfect 100 score corresponds to achievement of an internationally recognized sustainability target – where applicable – with placement on this scale showing how far a country is from environmental success. For each country, we then weight and aggregate the scores for indicators into 11 issue categories:

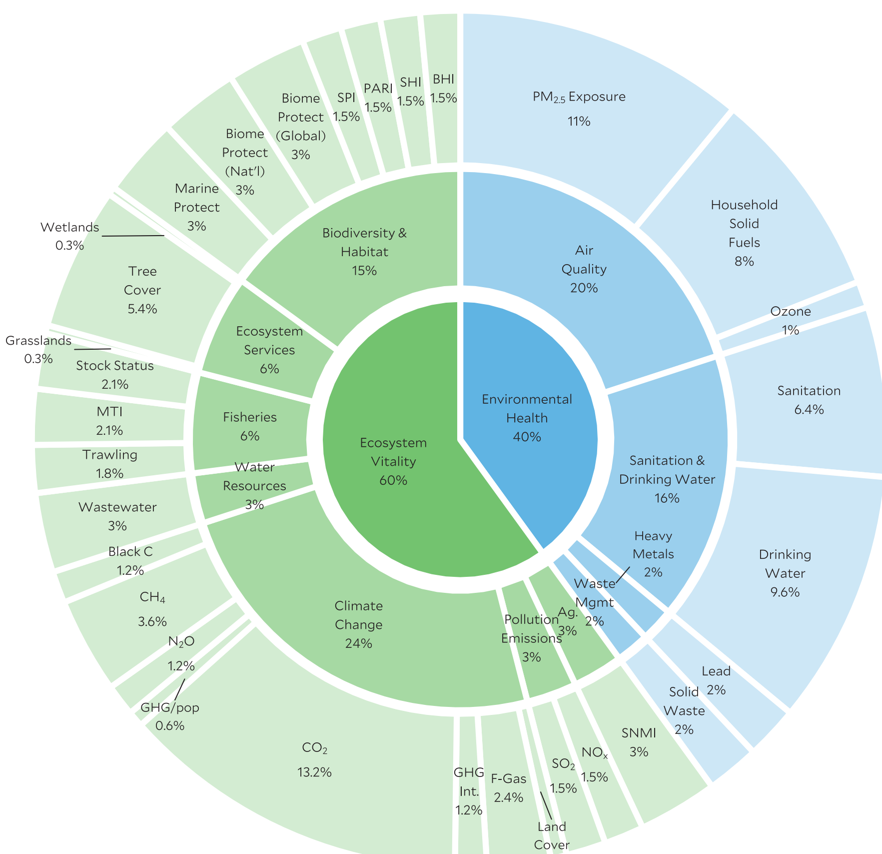
- Air Quality,
- Sanitation & Drinking Water,
- Heavy Metals,
- Waste Management,
- Biodiversity & Habitat,
- Ecosystem Services,
- Fisheries,
- Climate Change,
- Pollution Emissions,
- Water Resources, and
- Agriculture.

These issue category scores are then combined into two policy objectives – Environmental Health and Ecosystem Vitality – and then finally consolidated into the overall EPI. To track changes over time, we apply the same methods to historic data from a baseline year, generally ten years prior to the most recent year of data available, to calculate a baseline score and change over time. We also prepare a global scorecard showing the state of the world on each indicator for which data are available. All of these results from the 2020 EPI – scores, rankings, trends, peer comparison, and global metrics – translate complex metrics into useful tools for decisionmaking.

3. FILLING THE GAP ON WASTE MANAGEMENT

For the first time, the 2020 EPI incorporates data on waste management with a novel metric on controlled solid waste assembled from the latest efforts by leading scholars to measure this long-neglected issue. Since its inception, the EPI has highlighted gaps in our global understanding of environmental problems, and a lack of data on waste management has been among the most dire blindspots. Solid waste poses several threats when not disposed of in sustainable ways, generating air and water pollution, contaminating soils, and exposing humans to pathogens and hazardous materials. Importantly, poorly managed waste is also a significant source of greenhouse gases, as decomposing organic matter emits methane, a potent driver of climate change. Assembled by EPI researchers, our new indicator captures the percentage of solid waste in a country that is controlled *and measured* in a sustainable way, providing an important metric of not only appropriate disposal but also the state of countries' data systems for gathering and tracking information. As an indicator based on cutting-edge research, we offer this innovation as a prompt for further refinement of our approach – and also of the state of global data collection efforts. We provide further information about waste management in Chapter 7.

FIGURE 1-1. The 2020 EPI framework organizes 32 indicators into 11 issue categories and two policy objectives, with weights shown at each level as a percentage of the total score.



4. INNOVATIONS IN MEASURING PERFORMANCE

We include additional innovations in the 2020 EPI to reflect the latest advances in environmental science and refinements in how we think about indicator construction. The most significant changes we made are to our issue category on Climate Change. We add fluorinated gases to the suite of greenhouse gases tracked in the EPI, in recognition of their substantial contribution to climate forcing, despite the fact that not every country emits these "F-gases." We also change the method of calculating our metrics on greenhouse gas emissions, opting for average annual growth rates over the past decade. In the past, we have excluded greenhouse gas emissions from land use change and forestry in our analysis because of large uncertainties in available estimates. As a first step toward incorporating this important source, we also introduce a new metric on trends in CO_2 emissions from land cover change, estimated by our data partners at the Mullion Group using powerful new techniques for synthesizing geospatial data at various levels of disaggregation. Further information can be found in Chapter 11.

In every report, we refresh our data, scour the literature, and work with our data partners for the latest indicators to add to our report. In addition to the new indicators in Climate Change, we also update our measurements of particulate matter ($PM_{2.5}$) and Marine Trophic Index. We add pilot indicators on grassland and wetland losses to our existing measure of tree cover loss, folding them into our new issue category on Ecosystem Services. In Biodiversity & Habitat, we've refined techniques for measuring protected areas and added the newly available Biodiversity Habitat Index as an indicator in the 2020 EPI. These and other changes are further described in the report and online Technical Appendix. We strive to expand and improve the EPI in every iteration, welcoming suggestions and feedback on how we can continue to incorporate new data and breakthroughs at the forefront of scientific discovery.

5. PERSISTENT LIMITATIONS

The EPI provides a framework for greater analytic rigor in policymaking, but it also reveals a number of severe data gaps that limit the analytic scope of the rankings. As the EPI project has highlighted for two decades, better data collection, reporting, and verification across a range of environmental issues are urgently needed. The existing gaps are especially pronounced in the areas of agriculture, water resources, and threats to biodiversity. We would also ideally like to include additional indicators in our new Waste Management issue category, expanding our measurement to include hazardous wastes and other sources of solid waste, such as industrial facilities.

Even among the issue categories where we find robust metrics, persistent lags in data reporting limit our ability to incorporate recent changes in environmental outcomes. Thus the 2020 EPI does not reflect recent, headline-grabbing events, including the COVID-19 pandemic, the Amazonian forest fires, or the Australian bushfires. Even under normal circumstances, policymakers rely on timely information about the state of the world – and the consequences of policy decisions already enacted – in order to shape their agendas and refine approaches to environmental policy. While data reporting is frequently too delayed to be incorporated in many of these policy decisions, closing lags in data collection is feasible. New investments in stronger global data systems are essential to better manage sustainability challenges and to ensure that the global community does not breach fundamental planetary boundaries.

6. SPILLOVER ENVIRONMENTAL IMPACTS

Currently, the EPI does not account for spillover environmental impacts from countries' activities. In the context of sustainability, these spillovers include transboundary pollution flows, environmental impacts embedded in traded goods and services, and exploitation of international common pool resources. Unfortunately, environmental spillovers are poorly captured in current metrics of environmental performance (Sachs et al., 2017; Schmidt-Traub et al., 2019). We recognize that many indicators in the 2020 EPI only provide insights into environmental outcomes within a country's own borders. Air quality in many countries, for example, depends not only on domestic sources of pollutants but also on the activities in neighboring countries within the same airshed. Our estimates of emissions of greenhouse gases and other pollutants rely on production-based accounting that does not attribute environmental impacts to the country of final consumption. This unfairly rewards any country that "exports" dirty industry and then imports the produced goods. Fish stocks are global commons, especially on the high seas, and the data we use cannot yet attribute unsustainable exploitation to the countries most responsible for overfishing – whether in their own waters or in foreign territories. Results from the 2020 EPI should be interpreted in light of these spillovers and our limitations in measuring them, especially when countries consider strategies for mitigating the environmental pressures of industrial development.

As recognition of the role of spillovers in sustainable progress grows, the world will need new metrics for uncovering their influence on country performance. Recent advances from the field of industrial ecology – such as environmentally extended multi-regional input-output (MRIO) models, material flow analysis (MFA), and life cycle assessment – provide new data and tools that track the environmental impacts of trade, attribute harms to importing countries, and highlight ways that progress might be made to decouple resource use from economic growth (Hellweg & Zah, 2016; Krausmann et al., 2017; Schandl et al., 2018; Tukker et al., 2018; Wiedmann et al., 2015; Wiedmann & Lenzen, 2018). With collaborators across different disciplines and around the world, the EPI team is working to produce new metrics that account for the spillovers of harm in an interconnected world. We hope to include these transformative metrics in future versions of the EPI and other projects from the EPI team.

7. GLOBAL PANDEMIC

Uncertainty and change heralded the start of 2020 with the emergence of the global COVID-19 pandemic. The disease has left no aspect of life untouched, including the environment. While the effects of the pandemic are too recent to be captured by the data used in the 2020 EPI, the world now sees clearly the links between human activities and the environment, the interdependence of all nations and people on Earth, and the importance of investing in resilience. Economic shutdowns, travel restrictions, and other impediments to daily life have resulted in many unintended improvements in air and water quality, greenhouse gas emissions, biodiversity, and agricultural systems, among other environmental impacts. These effects come at a terrible price in terms of public health and economic damage. But the world also now faces an extraordinary opportunity for policy to transform older, dirtier sectors and behaviors and chart a course toward a future that is both economically vigorous and environmentally sound.

Cities around the world have caught a glimpse of a cleaner, more sustainable planet. As economic output has dropped and transportation halted, citizens found dazzling new skylines in China, Italy, New York, Los Angeles, India, and elsewhere around the world (Ellis-Petersen et al., 2020; Gardiner, 2020a; Mooney et al., 2020). Without motorboats, the canals of Venice flowed clearly (Braga et al., 2020). Wildlife have also ventured into human landscapes as sheltering residents ceded their streets (McCoy, 2020). Compounding the tragedy of disease and death, these benefits have always been attainable without such horrible costs, but short-sighted decisions and uninformed policies have long deprived people of healthful, sustainable outcomes. Relief from pollution and other harms to ecosystems need not be temporary – indeed, making these improvements permanent is imperative.

Rebuilding amid the pandemic, the world ignores the environment at its own peril. Evidence is now emerging that air quality – already an outsized threat to human health – is a major explanatory factor in COVID-19 outcomes. Researchers have found significant correlations between local air pollution concentrations and COVID-19 morbidity and mortality (Conticini et al., 2020; Ogen, 2020; Wu et al., 2020). Early research also indicates that fine particulate matter, a common and widespread pollutant, may act as a vector for viral particles, transporting them long distances (Coccia, 2020; Frontera et al., 2020; Martelletti & Martelletti, 2020; Setti et al., 2020), a phenomenon also found in other viruses (Cui et al., 2003; Qin et al., 2020; Yu et al., 2004). The case for vigorously combating air pollution is already extremely strong. If further studies support the linkages between air quality and pandemic outcomes, policymakers cannot fail to consider pollution regulations as a tool in the fight against the pandemic.

As charming as wildlife can be in city streets, the pandemic has also highlighted the importance of biodiversity and the interface between humans and animals. “Wet markets” where exotic animals, either farmed or poached, enter food systems are but one example of the many ways pathogens can jump from animals to humans. Wild landscapes face continual pressure from human activity, and habitat degradation and climate change will continue to drive animals into more frequent contact with people (Cohn, 2020). Three-quarters of emerging diseases worldwide come from animals, made worse by deforestation, hunting, and the global trade in wildlife (Johnson et al., 2020). Population growth, land use conversion to settlements, globalization, and extraction of natural resources also threaten to accelerate the rate of disease transmission to humans (Carroll et al., 2018). As the COVID-19 pandemic threatens economic and food security for vulnerable populations, poaching and illegal harvesting may increase, further raising global threats (Maron, 2020; Watts, 2020). Mitigating the public health threats from wildlife requires greater understanding of diseases and how they spread among animal populations (Robbins, 2020). Beyond human health, policymakers must protect biodiversity by preserving habitats and habitat quality, cracking down on poaching and the illegal wildlife trade, and alleviating other pressures like pollution and climate change. COVID-19 is only one example of the consequences of these long-time policy failures.

The intersection of the environment and the pandemic also transcends local impacts like threats to air quality and biodiversity. Economic disruption led to a sharp drop in GHG emissions (see Focus 11), reminding us that climate change, like the pandemic, is a global burden. Overcoming both COVID-19 and climate breakdown will require international coöperation, mutual assistance, and coördination among diverse actors and policies. The variation of outcomes we find in the 2020 EPI illustrates that even as some countries excel, a sustainable future depends on whether laggards can make progress. Resilient frameworks for tracking threats, whether to the environment or to public health, require analytical rigor and a foundation of robust data systems.

8. REPORT ORGANIZATION

While the 2020 Environmental Performance Index offers a rich array of environmental performance scores and rankings, this report provides narrative context for the numbers. Chapter 2 summarizes the results, highlighting key findings of the EPI, global performance, country performance, and trends among peer groups. In Chapter 3, we present further analysis of factors explaining performance in the 2020 EPI, offering insights for decisionmakers and other stakeholders about characteristics that are associated with countries which over- or underperform expectations across the EPI and its subcategories. Chapters 4–14 give background information on each of the issue categories in greater detail, explanations of the indicators, and discussions of the results. Chapter 15 describes our methodology, with illustrations of our choices and assumptions, and some details about the changes made in this version of the Index compared to previous iterations. Further details about the 2020 EPI are available on our website, epi.yale.edu, including data downloads, country profiles, and the Technical Appendix.

Chapter 2. Results

As a composite indicator of international environmental performance, the EPI allows for a variety of analyses of progress toward sustainability. Individual countries can, at the top level, inspect their overall 0–100 scores of the EPI, or drill down to understand their performance on our two policy objectives, 11 issue categories, or the 32 indicators that compose the Index. When data are available, we also provide scores based on historic performance, using our current methods to calculate scores from a decade prior to current records. These ten-year changes can give an indication of how a country has progressed – or regressed – over time.

Scores may also be compared across countries, and to this end, we provide EPI rankings to identify leaders and laggards, both overall and within each issue category. In addition to a global ranking, we allow countries to inspect how they perform within relevant peer groups, based on their regional neighbors or other characteristics. Further, we capture the aggregate state of the world in a global scorecard, showing how close the world community is to achieving sustainability targets for indicators with available data. This chapter reviews the results at a high level, and subsequent chapters explore performance within each issue category in greater depth. All of our results for the 2020 EPI are available online for further inspection and analysis at epi.yale.edu.

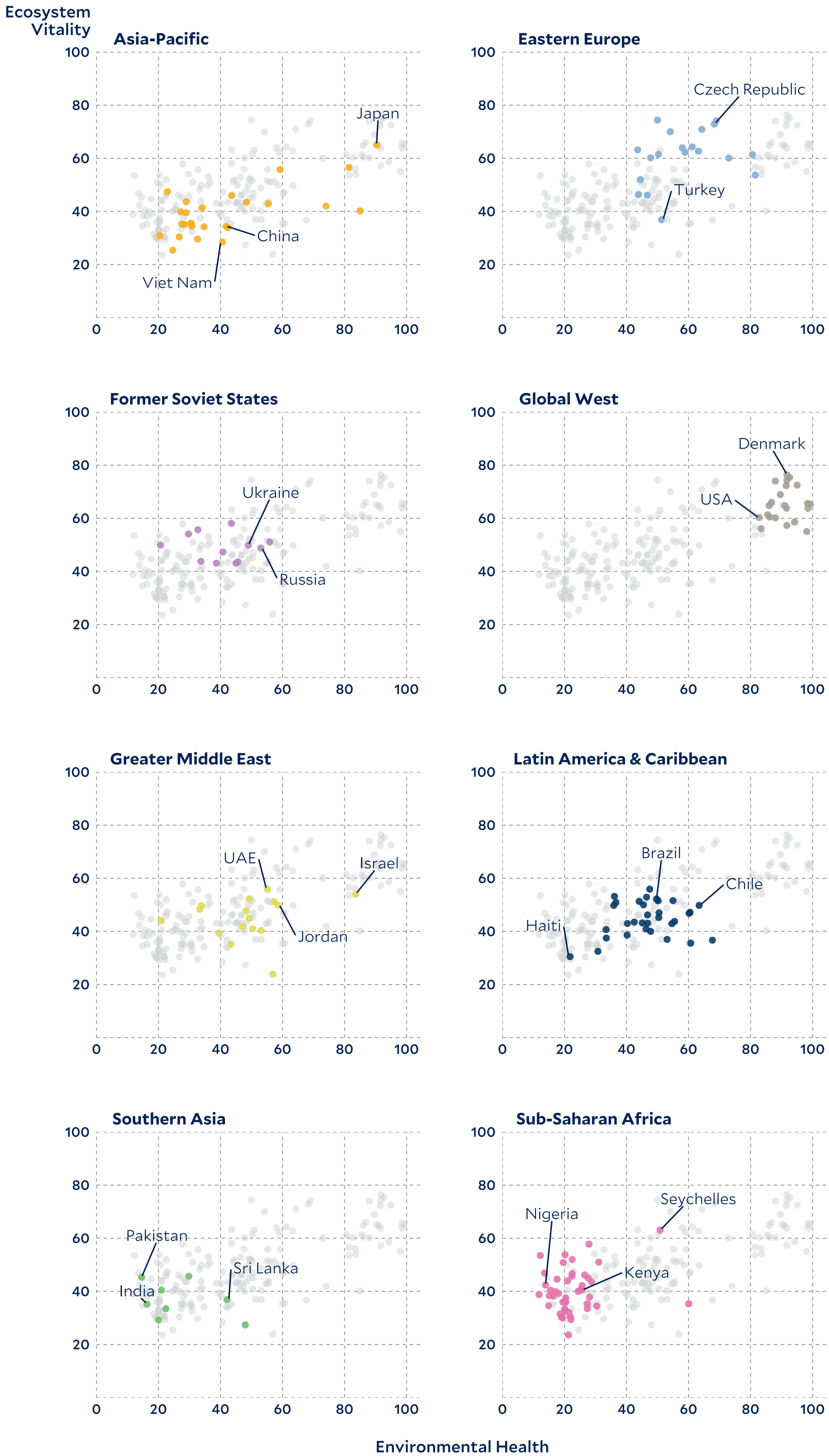
1. CHARACTERISTICS OF THE 2020 EPI

1.1 POLICY OBJECTIVES

At its broadest level, the EPI is composed of two policy objectives, Environmental Health and Ecosystem Vitality. As shown in Figure 2-1, Ecosystem Vitality has a narrower range, from Liberia at 23.6 to Denmark at 76.4, than the range of Environmental Health, from Lesotho at 11.8 to Finland at 99.3. This difference implies that it is much harder to achieve success in Ecosystem Vitality, as the solutions for environmental risks to human health are well known, if not widespread. We also see that these two components of the EPI are positively correlated ($r = 0.69$), suggesting that common factors may be driving – or hindering – success, which we explore further in Chapter 3. In Figure 2-2, we break down this relationship by geographical region. Two distinct clusters emerge at either ends of the distribution: the Global West scoring the highest in both dimensions, and Sub-Saharan Africa generally fairing poorly.

FIGURE 2-1. The relationship between sub-scores on the two policy objectives, Environmental Health and Ecosystem Vitality, in the 2020 EPI.

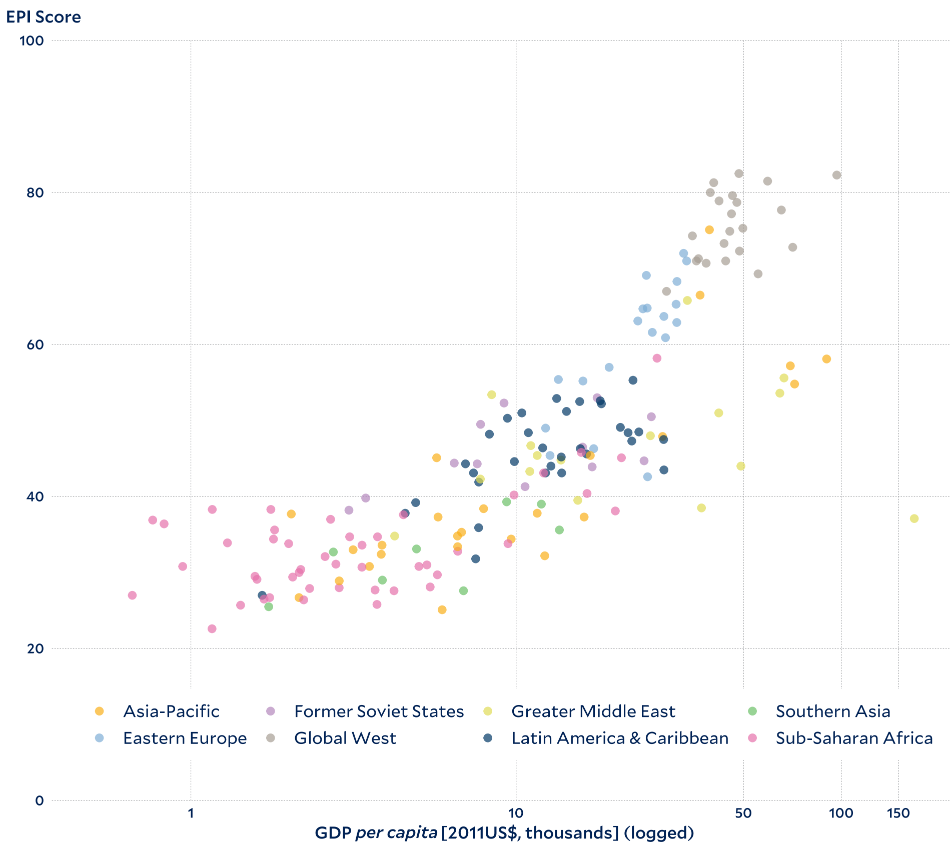
FIGURE 2-2. The relationship between sub-scores on the two policy objectives, Environmental Health and Ecosystem Vitality, in the 2020 EPI, by region.



1.2 COUNTRY WEALTH

As in previous reports and studies, the 2020 EPI shows a positive correlation (r = 0.80) between environmental performance and country wealth, as illustrated in Figure 2-3 and broken down by region in Figure 2-4.

FIGURE 2-3. The relationship between EPI score and country wealth, as measured by GDP per capita.



2.

FIGURE 2-4. The relationship between EPI score and country wealth, as measured by GDP per capita, by region.

One of the consistent lessons of the EPI is that achieving sustainability requires sufficient economic prosperity to fund public health and environmental infrastructure. As Figure 2-5 shows, this relationship is especially strong for issues within the Environmental Health policy objective, which require significant investments in sanitation infrastructure, waste management facilities, and air emission control technologies. Even within regions, the correlation between GDP and Environmental Health outcomes tends to be high, as shown in Figure 2-6.

FIGURE 2-5. The relationship between Environmental Health score and country wealth, as measured by GDP per capita.

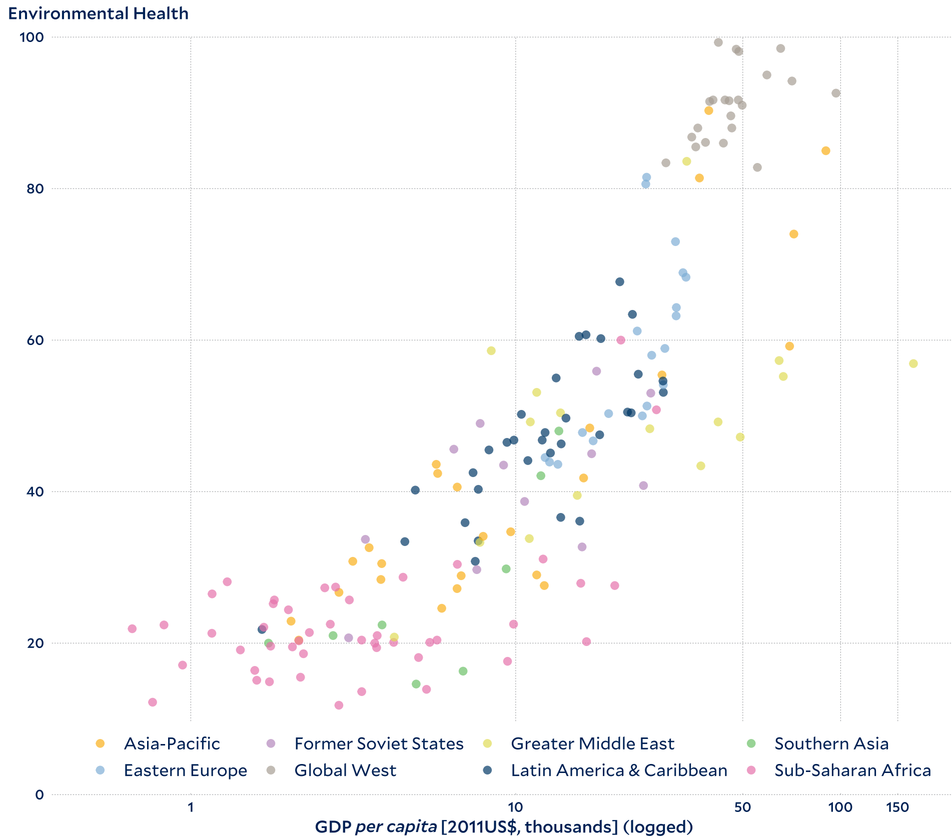


FIGURE 2-6. The relationship between Environmental Health score and country wealth, as measured by GDP per capita, by region.

The wealth-environment relationship is more complicated in regard to Ecosystem Vitality. The inherent tension of sustainable development is that income growth too often comes at the cost of the environment, especially from the exploitation of natural resources and heightened generation of pollutants through material and energy consumption. Thus, the correlation between country wealth and Ecosystem Vitality, as shown in Figure 2-7, is weaker.

However, as each of the regional breakdowns in Figures 2-2, 2-4, and 2-6 shows, some countries are able to achieve scores exceeding those of their peer nations at every level of economic development. This fact and the broader EPI analysis of success factors demonstrate that positive environmental performance requires not only economic prosperity but also good governance, including a strong rule of law, vibrant public engagement, an independent media, and well-crafted regulations. We explore these success factors in more detail in Chapter 3.

FIGURE 2-7. The relationship between Ecosystem Vitality score and country wealth, as measured by GDP per capita.

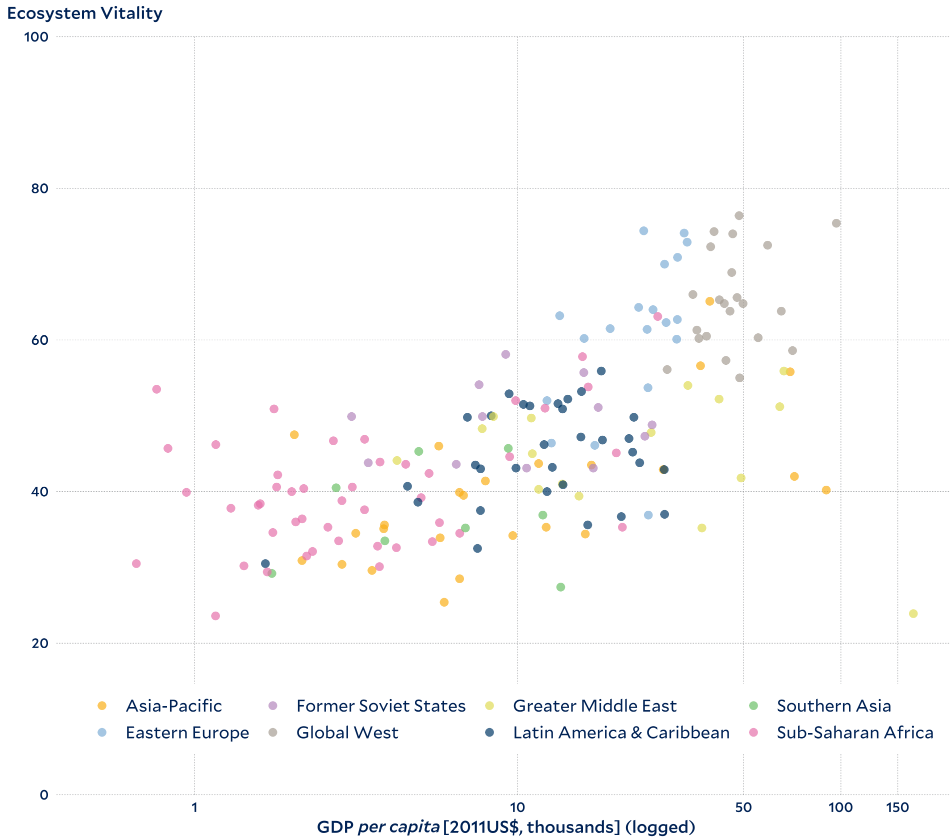


FIGURE 2-8. The relationship between Ecosystem Vitality score and country wealth, as measured by GDP per capita, by region.

2. GLOBAL SCORECARD

Aggregating across all countries and territories for which we have data, we also present a global scorecard that displays how the world is performing for the 2020 indicators, as well as baseline scores from roughly a decade ago. Figure 2-9 shows that the world is still far from achieving international sustainability targets, though there is evidence of some improvements over time. Increases in scores are more consistent in the Environmental Health policy objective, though current global scores are quite low. Despite the high performance of some countries in this dimension of the EPI, a large proportion of the Earth's population lives in countries where environmental risks continue to significantly harm human health. In contrast, the aggregate performance in Ecosystem Vitality, though mixed, is higher than in Environmental Health. Greater insights emerge from drilling further down into the performance within each issue category, covered briefly below and in more depth within each corresponding chapter of this report.

2.1 AIR QUALITY

Air Quality is the largest environmental threat to human health, accounting for over one-half of all life-years lost to deaths and disabilities worldwide, based on our analysis of estimates by the Institute for Health Metrics and Evaluation in the Global Burden of Disease study. Despite some progress over the past decade in *ozone exposure* and *household use of solid fuels*, reductions in *particulate matter* ($PM_{2.5}$) *exposure* have been small, representing a stubborn challenge for policymakers in the developing world. India and Pakistan place last in this issue category, joined in the bottom tier by Bangladesh and Nigeria – all countries with enormous populations. As these and other countries continue to urbanize, industrialize, and mobilize, controlling air quality should be a top priority for policymakers who wish to provide a foundation for future prosperity and human well-being.

2.2 SANITATION & DRINKING WATER

Driven by the Millennium Development Goals, the past ten years have seen an expansion in access to clean sanitation and drinking water facilities, with a corresponding drop in deaths and disease due to water-borne pathogens. As nations industrialize, governments tend to prioritize investments in sanitation infrastructure and strengthening of drinking water quality regulations, allowing for a moderate improvement in average global performance. However, expansion of clean water and sanitation services fails to keep pace with population growth in many countries. Life-years lost to death and disabilities from *unsafe sanitation* and *unsafe drinking water* remain particularly high in Sub-Saharan Africa and Southern Asia. Considerable action must be taken to extend safe drinking water and sanitation to the millions of people who continue to lack access to these services.

2.3 HEAVY METALS

Though heavy metal pollution remains a global problem, lead pollution continues to slowly decline, which has shown that policy changes can make a marked difference. Regulations banning or limiting lead in petrol, paint, and plumbing have successfully reduced life-years lost to death or disability from *lead exposure* in many countries. Leaded gasoline, once the primary cause of global lead pollution, has been phased out in all but two countries, Iraq and Algeria (UNEP, 2019a). However, lack of enforcement and the heightened prevalence of lead battery production and recycling contribute to high levels of *lead exposure* in low- and middle-income countries. Strong regulation and widespread adoption of safe industrial practices will be required to minimize the health impacts of this dangerous pollutant, as well as heavy metals in general.

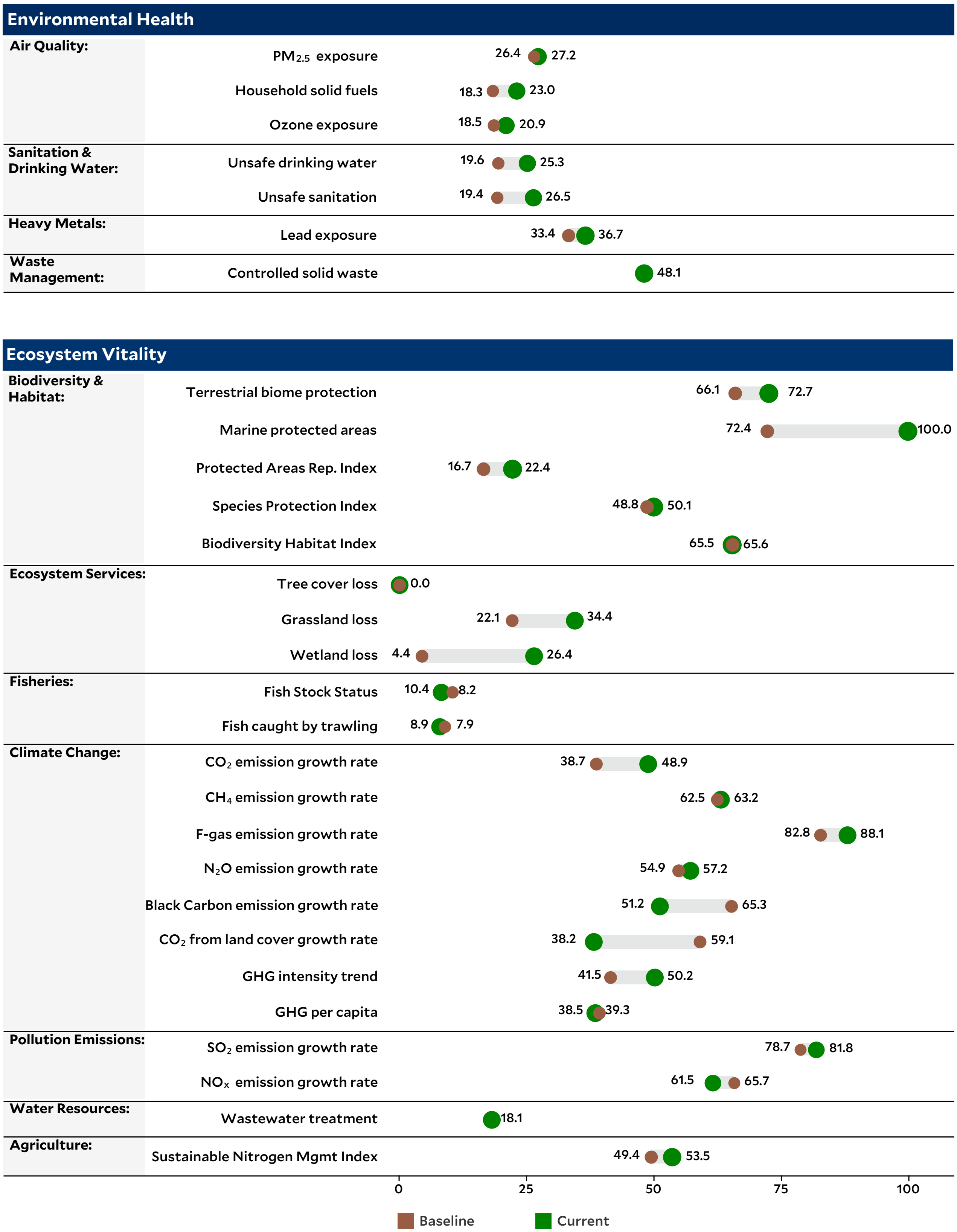
2.4 WASTE MANAGEMENT

Our new issue category on Waste Management shows that waste generation and disposal pose a significant threat to human health and the environment, generating toxic air and water pollution, enabling the spread of pathogens, harming marine life, and contributing to climate change. Globally, less than half of household and commercial solid waste is collected and treated in a manner that protects against environmental risks. Industrialized countries, particularly in Europe, exhibit the highest performance on *controlled solid waste,* while some low- and middle-income countries, including Colombia and Mauritius, have also adopted strong waste management systems suited to their development needs. We highlight the ongoing challenges involved in collecting comprehensive waste management data and call for countries to strengthen monitoring of this critical environmental issue.

2.5 BIODIVERSITY & HABITAT

The world has made significant strides in biodiversity protection, far exceeding the international goal of 10% for marine

FIGURE 2-9. Global scorecard showing distance to international sustainability targets for the Earth, aggregated across all countries. Current scores are based on most recent data, and baseline scores use data from roughly ten years prior.



protected area designation for 2020. Botswana and Zambia receive the top rankings on Biodiversity & Habitat due to high performance in *terrestrial biome protection* and low incidence of habitat degradation. Countries in Eastern and Western Europe show considerable progress in biodiversity protection through initiatives like the Natura 2000 protected area network. Lower average global scores on measures of ecological representativeness of protected areas, however, indicate that more work must be done to ensure the continued existence of high-quality habitat, free from human pressures, to protect the full diversity of life on Earth.

2.6 ECOSYSTEM SERVICES

Widespread *tree cover loss* drives low global performance in Ecosystem Services. Fires and commodity-driven deforestation continue to threaten forest habitat in much of the world, especially in countries in Latin America & the Caribbean. *Grassland loss* and *wetland loss* also remain high, although protection of these ecosystems has improved as more countries recognize their value for biodiversity habitat and climate change mitigation and adaptation. Despite advances in remote sensing technologies, the absence of harmonized monitoring efforts limits the ability to assess the status of global forests, grasslands, and wetland ecosystems in a comprehensive manner.

2.7 FISHERIES

The status of global Fisheries continues to deteriorate. Nearly one-third of global fish harvest comes from overexploited or collapsed fish stocks, and harmful practices like trawling account for 30–40% of global catch. While no country excels in Fisheries, Bahrain, Argentina, Australia, and Russia emerge as the worst performers. Countries must prioritize expanding monitoring efforts and modernizing data collection systems in order to facilitate the preservation of global fish stocks and the communities that rely on them.

2.8 CLIMATE CHANGE

Global action on Climate Change remains deeply insufficient to meet the goals of the 2015 Paris Climate Change Agreement. The world is slowly decoupling emissions from economic activity, with greenhouse gas emission intensity declining by 30% over the past two decades, but aggregate global emissions of carbon dioxide and other, more powerful greenhouse gases continue to increase at rates not in harmony with those goals. Though the *adjusted emission growth rate* is slowing for some greenhouse gases, accelerations in the growth rates of black carbon emissions and carbon dioxide emissions from land cover change signal the presence of critical policy gaps. Climate change leaders like Denmark, the United Kingdom, and Seychelles offer models of the strong, targeted policy needed for successful decarbonization.

2.9 POLLUTION EMISSIONS

Analysis of Pollution Emissions data from the Community Emissions Data System reveals uneven global performance. Sulfur dioxide (SO2) emissions are in decline in much of the world, resulting partly from strong air pollution regulations in industrialized nations. Global emissions of nitrogen oxides (NO_X) are increasing, however, as vehicle use and fossil fuel consumption expand in populous developing countries. Indonesia, India, and China account for a large proportion of this increase in NO_X. Controlling pollution emissions is crucial to protect human health, maintain soil and water quality, and preserve ecosystem function.

2.10 AGRICULTURE

Agriculture performance is tracked by examining the sustainability of global nitrogen management using indicators produced by the Appalachian Lab at the University of Maryland Center for Environmental Science. Small improvements in nitrogen management over a ten-year period result mainly from increased yields rather than improved efficiency. Mismanagement of nitrogen across the agricultural sector continues to threaten the health and sustainability of agricultural systems and the natural environment. We emphasize the critical need for enhanced monitoring and data collection in this sector and call for the development of new indicators that better reflect the full impacts of agricultural systems on soils, land and water resources, global nutrient cycles, and climate change.

2.11 WATER RESOURCES

Global performance in Water Resources remains low, with many developing countries lacking access to basic wastewater treatment. European countries and some water-stressed nations like Israel, Bahrain, and Singapore show high rates of *wastewater treatment* and water recycling, while Sub-Saharan Africa and Southern Asia receive average regional scores of zero. Large amounts of missing data in global inventories preclude comprehensive characterization of Water Resources, underscoring the need for countries to ramp up data collection and monitoring to satisfy the targets of SDG 6 (Clean Water and Sanitation).

3. GLOBAL RANKING

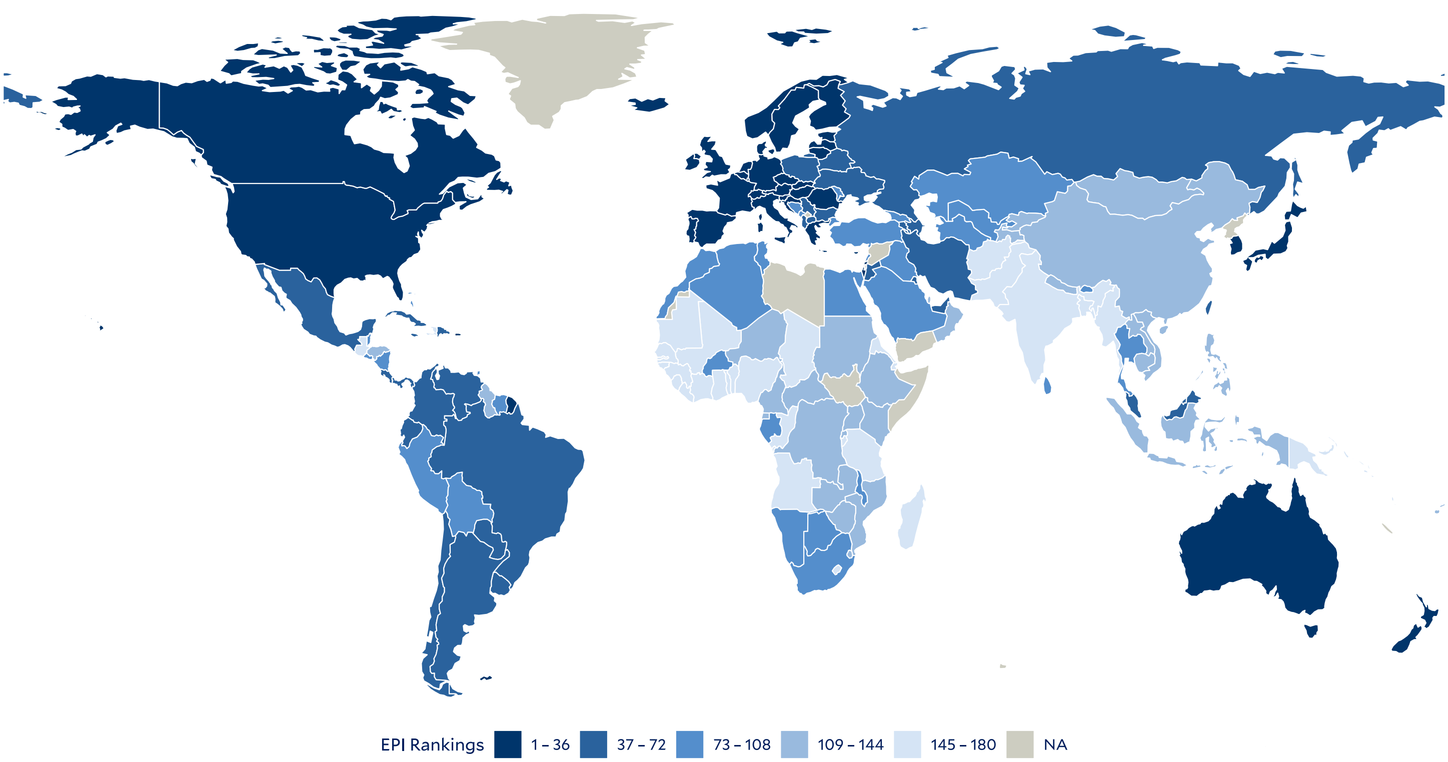
3.1 LEADERS

Across many versions of the EPI, wealthy democracies typically rise to the top of our rankings, and the 2020 EPI fits this pattern. Countries that lead in the EPI pay attention to all areas of sustainability, backing strong regulations with the investments required to generate sustainable outcomes. In general, high scorers exhibit long-standing policies and programs to protect public health, preserve natural resources, and decrease greenhouse gas emissions. The data further suggest that countries making concerted efforts to decarbonize their electricity sectors have made the greatest gains in combating climate change, seeing associated benefits for ecosystems and human health. No country, however, scores perfectly across all issue categories – and every country has multiple indicators with significant gaps between performance and sustainability targets. Transitioning to a sustainable world requires maintaining momentum among the leaders and disseminating best practices from those who have overcome obstacles common to all countries.

Denmark leads the world in the 2020 EPI with a score of 82.5, driven by strong performance across most issue categories. As seen in several leading nations, protections for public health place Denmark in the first tier on Environmental Health with a score of 91.7, though tackling *ozone exposure* is a lingering problem. On the EPI's new metric on Waste Management, Denmark also excels, with virtually all municipal solid waste controlled through recycling, composting, or incineration. Most importantly, Denmark stands out among all nations in its leading-edge commitments to climate change mitigation. Vigorous policies for decarbonizing its electricity sector, among other initiatives, have driven most greenhouse gas emissions down – even while maintaining a vibrant economy.

Luxembourg (82.3), Switzerland (81.5), the United Kingdom (81.3), and France (80.0) round out the top five countries in the 2020 EPI. All leaders score well on Environmental Health, but performance in Ecosystem Vitality differs among them. In Biodiversity & Habitat and Climate Change, especially, we place greater emphasis on leaders who are successfully addressing these crucial challenges to sustainability. France and the United Kingdom excel in the establishment of protected areas, and also score perfectly in the Species Protection Index.

MAP 2-1. Rankings in the 2020 Environmental Performance Index for 180 countries.



2.

TABLE 2-1. Global rankings, EPI scores, and regional rankings (REG).

RANK	COUNTRY	SCORE	REG
1	Denmark	82.5	1
2	Luxembourg	82.3	2
3	Switzerland	81.5	3
4	United Kingdom	81.3	4
5	France	80.0	5
6	Austria	79.6	6
7	Finland	78.9	7
8	Sweden	78.7	8
9	Norway	77.7	9
10	Germany	77.2	10
11	Netherlands	75.3	11
12	Japan	75.1	1
13	Australia	74.9	12
14	Spain	74.3	13
15	Belgium	73.3	14
16	Ireland	72.8	15
17	Iceland	72.3	16
18	Slovenia	72.0	1
19	New Zealand	71.3	17
20	Canada	71.0	18
	Czech Republic	71.0	2
	Italy	71.0	18
23	Malta	70.7	20
24	United States of America	69.3	21
25	Greece	69.1	3
26	Slovakia	68.3	4
27	Portugal	67.0	22
28	South Korea	66.5	2
29	Israel	65.8	1
30	Estonia	65.3	5
31	Cyprus	64.8	6
32	Romania	64.7	7
33	Hungary	63.7	8
34	Croatia	63.1	9
35	Lithuania	62.9	10
36	Latvia	61.6	11
37	Poland	60.9	12
38	Seychelles	58.2	1
39	Singapore	58.1	3
40	Taiwan	57.2	4
41	Bulgaria	57.0	13
42	United Arab Emirates	55.6	2
43	North Macedonia	55.4	14
44	Chile	55.3	1
45	Serbia	55.2	15
46	Brunei Darussalam	54.8	5
47	Kuwait	53.6	3
48	Jordan	53.4	4
49	Belarus	53.0	1
50	Colombia	52.9	2
51	Mexico	52.6	3
52	Costa Rica	52.5	4
53	Armenia	52.3	2
54	Argentina	52.2	5
55	Brazil	51.2	6
56	Bahrain	51.0	5
	Ecuador	51.0	7
58	Russia	50.5	3
59	Venezuela	50.3	8
60	Ukraine	49.5	4
61	Uruguay	49.1	9
62	Albania	49.0	16
63	Antigua and Barbuda	48.5	10
64	Cuba	48.4	11
	St. Vincent and Grenadines	48.4	11
66	Jamaica	48.2	13
67	Iran	48.0	6
68	Malaysia	47.9	6
69	Trinidad and Tobago	47.5	14
70	Panama	47.3	15
71	Tunisia	46.7	7
72	Azerbaijan	46.5	5
73	Paraguay	46.4	16
74	Dominican Republic	46.3	17
	Montenegro	46.3	17
76	Gabon	45.8	2
77	Barbados	45.6	18
78	Bosnia and Herzegovina	45.4	18
	Lebanon	45.4	8
	Thailand	45.4	7
81	Suriname	45.2	19
82	Mauritius	45.1	3
	Tonga	45.1	8
84	Algeria	44.8	9
85	Kazakhstan	44.7	6
86	Dominica	44.6	20
87	Moldova	44.4	7
88	Bolivia	44.3	21
	Uzbekistan	44.3	8
90	Peru	44.0	22
	Saudi Arabia	44.0	10
92	Turkmenistan	43.9	9
93	Bahamas	43.5	23
94	Egypt	43.3	11
95	El Salvador	43.1	24
	Grenada	43.1	24
	Saint Lucia	43.1	24
	South Africa	43.1	4
99	Turkey	42.6	19
100	Morocco	42.3	12
101	Belize	41.9	27
102	Georgia	41.3	10
103	Botswana	40.4	5
104	Namibia	40.2	6
105	Kyrgyzstan	39.8	11
106	Iraq	39.5	13
107	Bhutan	39.3	1
108	Nicaragua	39.2	28
109	Sri Lanka	39.0	2
110	Oman	38.5	14
111	Philippines	38.4	9
112	Burkina Faso	38.3	7
	Malawi	38.3	7
114	Tajikistan	38.2	12
115	Equatorial Guinea	38.1	9
116	Honduras	37.8	29
	Indonesia	37.8	10
118	Kiribati	37.7	11
119	São Tomé and Príncipe	37.6	10
120	China	37.3	12
120	Samoa	37.3	12
122	Qatar	37.1	15
123	Zimbabwe	37.0	11
124	Central African Republic	36.9	12
125	Dem. Rep. Congo	36.4	13
126	Guyana	35.9	30
127	Maldives	35.6	3
	Uganda	35.6	14
129	Timor-Leste	35.3	14
130	Laos	34.8	15
	Sudan	34.8	16
132	Kenya	34.7	15
	Zambia	34.7	15
134	Ethiopia	34.4	17
	Fiji	34.4	16
136	Mozambique	33.9	18
137	Eswatini	33.8	19
	Rwanda	33.8	19
139	Cambodia	33.6	17
	Cameroon	33.6	21
141	Viet Nam	33.4	18
142	Pakistan	33.1	4
143	Micronesia	33.0	19
144	Cabo Verde	32.8	22
145	Nepal	32.7	5
146	Papua New Guinea	32.4	20
147	Mongolia	32.2	21
148	Comoros	32.1	23
149	Guatemala	31.8	31
150	Tanzania	31.1	24
151	Nigeria	31.0	25
152	Marshall Islands	30.8	22
	Niger	30.8	26
	Republic of Congo	30.8	26
155	Senegal	30.7	28
156	Eritrea	30.4	29
157	Benin	30.0	30
158	Angola	29.7	31
159	Togo	29.5	32
160	Mali	29.4	33
161	Guinea-Bissau	29.1	34
162	Bangladesh	29.0	6
163	Vanuatu	28.9	23
164	Djibouti	28.1	35
165	Lesotho	28.0	36
166	Gambia	27.9	37
167	Mauritania	27.7	38
168	Ghana	27.6	39
	India	27.6	7
170	Burundi	27.0	40
	Haiti	27.0	32
172	Chad	26.7	41
	Solomon Islands	26.7	24
174	Madagascar	26.5	42
175	Guinea	26.4	43
176	Côte d'Ivoire	25.8	44
177	Sierra Leone	25.7	45
178	Afghanistan	25.5	8
179	Myanmar	25.1	25
180	Liberia	22.6	46

- Asia-Pacific
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- Southern Asia
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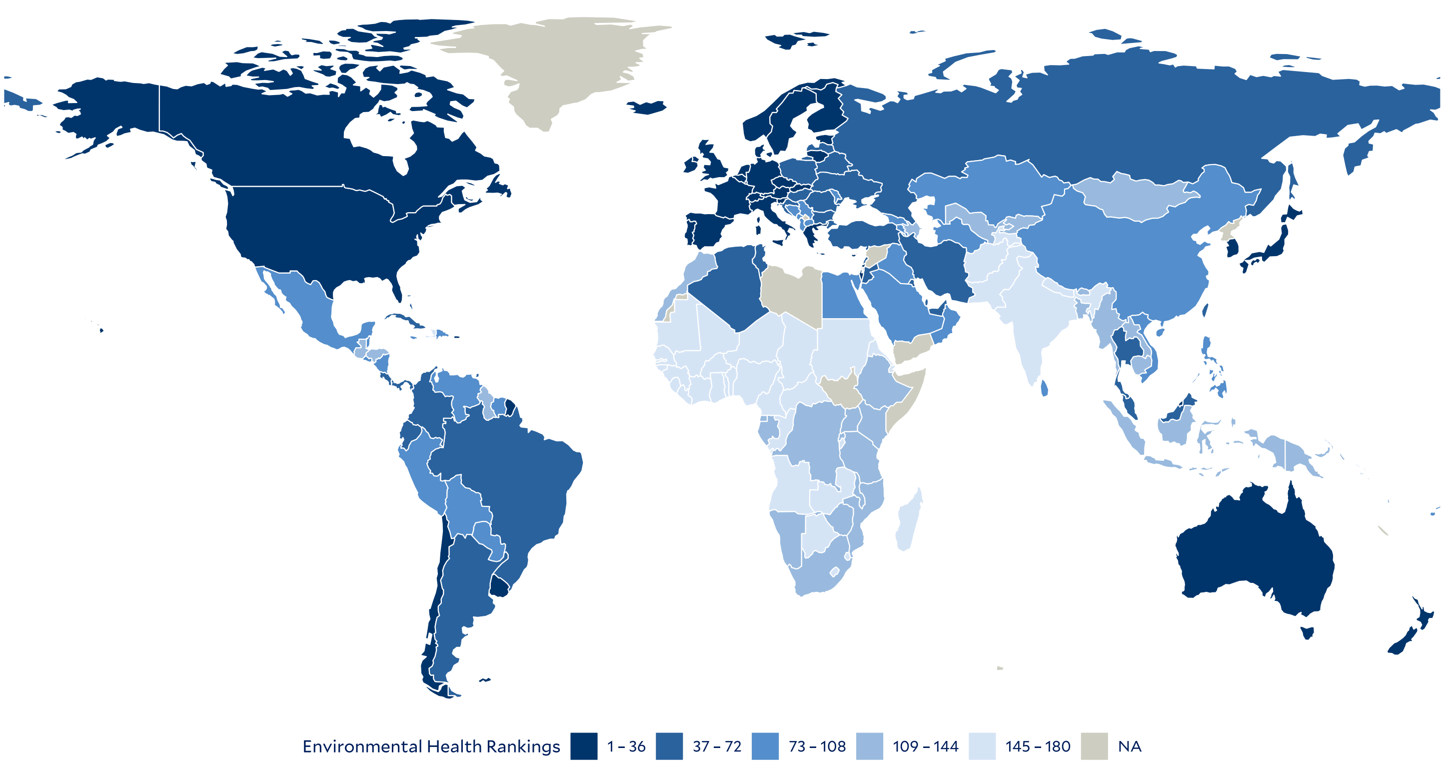
Within Environmental Health, Finland, Australia, and Sweden stand out for high scores in Air Quality. Six countries tie for the top rank in Sanitation & Drinking Water, including Finland, Iceland, the Netherlands, Norway, Switzerland, and the United Kingdom. Denmark, Finland, and Japan score highest in mitigating *lead exposure*, while the Netherlands and Colombia lead the world in Waste Management. In Ecosystem Vitality, Botswana and Zambia earn top scores in the Biodiversity & Habitat issue category, while Denmark ranks first in Ecosystem Services and Climate Change. Ukraine excels in sustainable nitrogen management, while Denmark, Finland, the Netherlands, Singapore, and Sweden share the top score in *wastewater treatment*.

The United States places 24th in the 2020 EPI. As with many wealthy democracies, the United States scores well on Air Quality (84.2) and Sanitation & Drinking Water (86.1), and also receives a top score on *marine protected areas*. However, relatively low scores on Water Resources (58.9) and Waste Management (48.3) place the United States' aggregate score near the back of the pack among industrialized nations, behind the United Kingdom (4th), France (5th), Germany (10th), Japan (12th), Australia (13th), and Canada (20th).

3.2 LAGGARDS

At the bottom of the 2020 EPI rankings are Côte d'Ivoire (25.8), Sierra Leone (25.7), Afghanistan (25.5), Myanmar (25.1), and Liberia (22.6). Low scores on the EPI indicate the need for national sustainability efforts on several fronts. Some of the lowest-ranking nations face broader challenges, such as civil unrest, but the low scores for others can be attributed to weak governance and poverty. Countries whose governments cannot effectively manage environmental problems at all, e.g., Yemen, Syria, and Libya, have been excluded from the 2020 EPI altogether. We draw special attention to the issue category Air Quality. As the dominant source of diseases and disability in our data, countries that score poorly in the 2020 EPI on Air Quality, such as Pakistan (Air Quality score of 9.9, the very bottom), India (13.4), Bangladesh (20.2), and China (27.1), face a public health crisis that demands urgent attention. Likewise, the world cannot achieve the ambitious targets of the 2015 Paris Climate Change Agreement without transforming performance in laggard countries, which are among the top emitters of greenhouse gases. Such a transition will require international efforts that include

MAP 2-2. Rankings in the Environmental Health policy objective.



2.

TABLE 2-2. Global rankings, Environmental Health scores, and regional rankings (REG).

RANK	COUNTRY	SCORE	REG
1	Denmark	76.4	1
2	Luxembourg	75.4	2
3	Romania	74.4	1
4	United Kingdom	74.3	3
5	Slovenia	74.1	2
6	Austria	74.0	4
7	Czech Republic	72.9	3
8	Switzerland	72.5	5
9	France	72.3	6
10	Slovakia	70.9	4
11	Hungary	70.0	5
12	Germany	68.9	7
13	Spain	66.0	8
14	Sweden	65.6	9
15	Finland	65.3	10
16	Japan	65.1	1
17	Belgium	64.8	11
	Netherlands	64.8	11
19	Croatia	64.3	6
20	Latvia	64.0	7
21	Australia	63.8	13
	Norway	63.8	13
23	North Macedonia	63.2	8
24	Seychelles	63.1	1
25	Lithuania	62.7	9
26	Poland	62.3	10
27	Bulgaria	61.5	11
28	Greece	61.4	12
29	Italy	61.3	15
30	Malta	60.5	16
31	United States of America	60.3	17
32	New Zealand	60.2	18
	Serbia	60.2	13
34	Estonia	60.1	14
35	Ireland	58.6	19
36	Armenia	58.1	1
37	Gabon	57.8	2
38	Canada	57.3	20
39	South Korea	56.6	2
40	Portugal	56.1	21
41	Mexico	55.9	1
	United Arab Emirates	55.9	1
43	Taiwan	55.8	3
44	Azerbaijan	55.7	2
45	Iceland	55.0	22
46	Uzbekistan	54.1	3
47	Israel	54.0	2
48	Botswana	53.8	3
49	Cyprus	53.7	15
50	Central African Republic	53.5	4
51	Dominican Republic	53.2	2
52	Venezuela	52.9	3
53	Bahrain	52.2	3
	Brazil	52.2	4
55	Albania	52.0	16
	Namibia	52.0	5
57	Colombia	51.6	5
58	Ecuador	51.5	6
59	St. Vincent and Grenadines	51.3	7
60	Kuwait	51.2	4
60	Kuwait	51.2	4
62	South Africa	51.0	6
63	Burkina Faso	50.9	7
	Suriname	50.9	8
65	Jamaica	50.0	9
66	Jordan	49.9	5
	Tajikistan	49.9	5
	Ukraine	49.9	5
69	Bolivia	49.8	10
	Chile	49.8	10
71	Egypt	49.7	6
72	Russia	48.8	7
73	Morocco	48.3	7
74	Iran	47.8	8
75	Kiribati	47.5	4
76	Kazakhstan	47.3	8
77	Costa Rica	47.2	12
78	Cuba	47.0	13
79	Cameroon	46.9	8
80	Argentina	46.8	14
81	Zimbabwe	46.7	9
82	Bosnia and Herzegovina	46.4	17
83	Malawi	46.2	10
	Paraguay	46.2	15
85	Montenegro	46.1	18
86	Tonga	46.0	5
87	Bhutan	45.7	1
	Dem. Rep. Congo	45.7	11
89	Pakistan	45.3	2
90	Panama	45.2	16
91	Equatorial Guinea	45.1	12
92	Tunisia	45.0	9
93	Eswatini	44.6	13
94	Sudan	44.1	10
95	Zambia	43.9	14
96	Antigua and Barbuda	43.8	17
	Kyrgyzstan	43.8	9
98	Indonesia	43.7	6
99	Moldova	43.6	10
	São Tomé and Príncipe	43.6	15
101	El Salvador	43.5	18
	Thailand	43.5	7
103	Peru	43.2	19
104	Dominica	43.1	20
	Georgia	43.1	11
	Turkmenistan	43.1	11
107	Belize	43.0	21
108	Malaysia	42.9	8
	Trinidad and Tobago	42.9	22
110	Nigeria	42.4	16
111	Uganda	42.2	17
112	Brunei Darussalam	42.0	9
113	Saudi Arabia	41.8	11
114	Philippines	41.4	10
115	Algeria	41.0	12
116	Grenada	40.9	23
117	Honduras	40.7	24
118	Ethiopia	40.6	18
	Kenya	40.6	18
120	Nepal	40.5	3
121	Eritrea	40.4	20
122	Lebanon	40.3	13
123	Singapore	40.2	11
124	Rwanda	40.0	21
	Saint Lucia	40.0	25
126	Laos	39.9	12
	Niger	39.9	22
128	Timor-Leste	39.5	13
129	Iraq	39.4	14
130	Republic of Congo	39.2	23
131	Lesotho	38.8	24
132	Nicaragua	38.6	26
133	Guinea-Bissau	38.4	25
134	Togo	38.2	26
135	Mozambique	37.8	27
136	Senegal	37.6	28
137	Guyana	37.5	27
138	Bahamas	37.0	28
139	Sri Lanka	36.9	4
	Turkey	36.9	19
141	Uruguay	36.7	29
142	Benin	36.4	29
143	Mali	36.0	30
144	Angola	35.9	31
145	Barbados	35.6	30
	Cambodia	35.6	14
147	Comoros	35.3	32
	Mauritius	35.3	32
	Mongolia	35.3	15
150	India	35.2	5
	Oman	35.2	15
152	Papua New Guinea	35.1	16
153	Chad	34.6	34
154	Cabo Verde	34.5	35
	Micronesia	34.5	17
156	China	34.4	18
157	Fiji	34.2	19
158	Samoa	33.9	20
159	Bangladesh	33.5	6
	Tanzania	33.5	36
161	Djibouti	33.4	37
162	Mauritania	32.8	38
163	Ghana	32.6	39
164	Guatemala	32.5	31
165	Gambia	32.1	40
166	Guinea	31.5	41
167	Solomon Islands	30.9	21
168	Burundi	30.5	42
	Haiti	30.5	32
170	Vanuatu	30.4	22
171	Sierra Leone	30.2	43
172	Côte d'Ivoire	30.1	44
173	Marshall Islands	29.6	23
174	Madagascar	29.4	45
175	Afghanistan	29.2	7
176	Viet Nam	28.5	24
177	Maldives	27.4	8
178	Myanmar	25.4	25
179	Qatar	23.9	16
180	Liberia	23.6	46

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capital investments, technological assistance, and the diffusion of policies for managing energy systems.

3.3 MOVERS

In addition to countries with high performance overall, the 2020 EPI identifies countries that have made significant improvements. Bahrain ranks as the most-improved country over the past decade, rising 16.3 points to a score of 51 on the 2020 EPI. This improvement is largely the result of efforts to reduce emissions of greenhouse gases and other air pollutants, resulting in energy use and carbon emissions plateauing in Bahrain in about 2014 (Climate Watch, 2020; IEA, 2020a). Bahrain has also committed to improving energy efficiency by 6% and increasing the share of renewable energy sources to 5% by 2025. It is furthermore making considerable investments in solar and waste-to-energy generation (Kingdom of Bahrain Sustainable Energy Unit, 2017; U.S. EIA, 2016). Seychelles also demonstrates exceptional progress on emission reductions, driven by an ambitious decarbonization plan that forms the center of the nation's "Blue Economy" development strategy (IMF, 2017; Roberts & Ali, 2016). Seychelles' decarbonization efforts have helped to raise its Climate Change issue category score by 42.6 points from ten years ago. Morocco, Croatia, Kuwait, and the United Arab Emirates also improved their EPI scores through expanded protection of biodiversity and habitat.

Meanwhile, Niger, Singapore, and Guyana slipped significantly in environmental performance, largely due to poor performance on Climate Change. Niger has one of the highest rates of population growth in the world, increasing at a rate of 3.8% per year (World Bank, 2020d). Between 2008 and 2017, the country's population grew from 15.2 million to nearly 22 million, putting greater stress on environmental resources (World Bank, 2020d). Niger's GHG emissions stem mostly from the agricultural sector, but a burgeoning oil production industry has added to this increase (USAID, 2019). In Guyana, rising CO_2 and methane emissions appear to be associated with a rapid expansion of offshore oil and gas exploration and development since 2015 (Center for International Environmental Law, 2019; Laville, 2018; Rystad Energy, 2020).

Countries at the top of the EPI rankings tend to exhibit little change over time. High scorers have less room for improvement, and the durability of good governance and investments in infrastructure make deterioration rare.

MAP 2-3. Rankings in the Ecosystem Vitality policy objective.

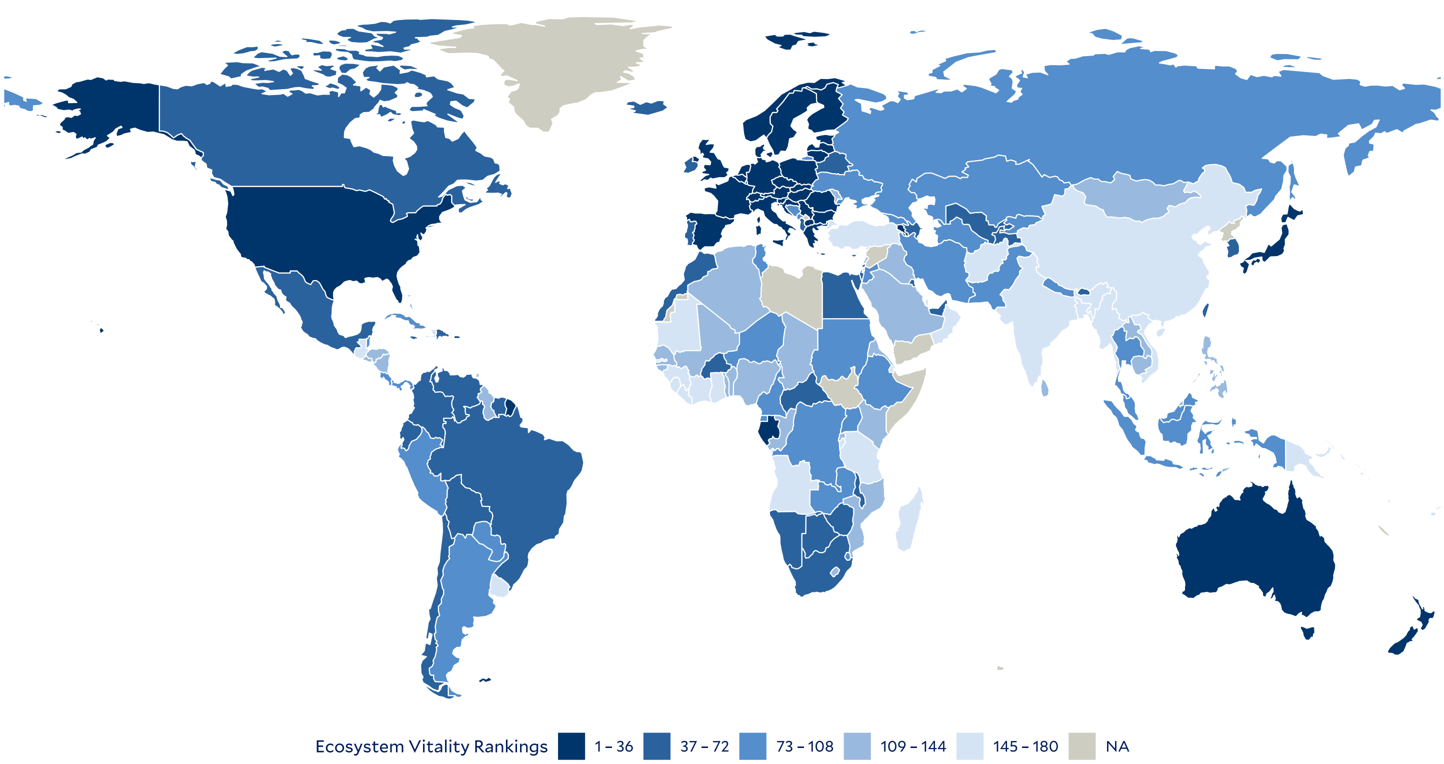

TABLE 2-3. Global rankings, Ecosystem Vitality scores, and regional rankings (REG).

RANK	COUNTRY	SCORE	REG
1	Finland	99.3	1
2	Norway	98.5	2
3	Sweden	98.4	3
4	Iceland	98.1	4
5	Switzerland	95.0	5
6	Ireland	94.2	6
7	Luxembourg	92.6	7
8	Canada	91.7	8
	Denmark	91.7	8
	United Kingdom	91.7	8
11	Australia	91.6	11
12	France	91.5	12
13	Netherlands	91.0	13
14	Japan	90.3	1
15	Germany	89.6	14
16	Austria	88.0	15
	New Zealand	88.0	15
18	Spain	86.8	17
19	Malta	86.1	18
20	Belgium	86.0	19
21	Italy	85.5	20
22	Singapore	85.0	2
23	Israel	83.6	1
24	Portugal	83.4	21
25	United States of America	82.8	22
26	Cyprus	81.5	1
27	South Korea	81.4	3
28	Greece	80.6	2
29	Brunei Darussalam	74.0	4
30	Estonia	73.0	3
31	Slovenia	68.9	4
32	Czech Republic	68.3	5
33	Uruguay	67.7	1
34	Slovakia	64.3	6
35	Chile	63.4	2
36	Lithuania	63.2	7
37	Croatia	61.2	8
38	Barbados	60.7	3
39	Costa Rica	60.5	4
40	Argentina	60.2	5
41	Mauritius	60.0	1
42	Taiwan	59.2	5
43	Poland	58.9	9
44	Jordan	58.6	2
45	Latvia	58.0	10
46	Kuwait	57.3	3
47	Qatar	56.9	4
48	Belarus	55.9	1
49	Antigua and Barbuda	55.5	6
50	Malaysia	55.4	6
51	United Arab Emirates	55.2	5
52	Colombia	55.0	7
53	Trinidad and Tobago	54.6	8
54	Hungary	54.1	11
55	Bahamas	53.1	9
	Lebanon	53.1	6
57	Russia	53.0	2
58	Turkey	51.3	12
59	Seychelles	50.8	2
60	Cuba	50.5	10
61	Algeria	50.4	7
	Panama	50.4	11
63	Bulgaria	50.3	13
64	Ecuador	50.2	12
65	Romania	50.0	14
66	Brazil	49.7	13
67	Bahrain	49.2	8
	Tunisia	49.2	8
69	Ukraine	49.0	3
70	Thailand	48.4	7
71	Iran	48.3	10
72	Maldives	48.0	1
73	Saint Lucia	47.8	14
	Serbia	47.8	15
75	Mexico	47.5	15
76	Saudi Arabia	47.2	11
77	Dominica	46.8	16
	Paraguay	46.8	16
79	Montenegro	46.7	16
80	Venezuela	46.5	18
81	Grenada	46.3	19
82	Moldova	45.6	4
83	Jamaica	45.5	20
84	Peru	45.1	21
85	Turkmenistan	45.0	5
86	Albania	44.5	17
87	St. Vincent and Grenadines	44.1	22
88	Bosnia and Herzegovina	43.9	18
89	North Macedonia	43.6	19
	Tonga	43.6	8
91	Armenia	43.5	6
92	Oman	43.4	12
93	El Salvador	42.5	23
94	Samoa	42.4	9
95	Sri Lanka	42.1	2
96	China	41.8	10
97	Kazakhstan	40.8	7
98	Viet Nam	40.6	11
99	Belize	40.3	24
100	Nicaragua	40.2	25
101	Iraq	39.5	13
102	Georgia	38.7	8
103	Suriname	36.6	26
104	Dominican Republic	36.1	27
105	Bolivia	35.9	28
106	Fiji	34.7	12
107	Philippines	34.1	13
108	Egypt	33.8	14
109	Kyrgyzstan	33.7	9
110	Guyana	33.5	29
111	Honduras	33.4	30
112	Morocco	33.3	15
113	Azerbaijan	32.7	10
114	Marshall Islands	32.6	14
115	South Africa	31.1	3
116	Guatemala	30.8	31
	Micronesia	30.8	15
118	Cambodia	30.5	16
119	Cabo Verde	30.4	4
120	Bhutan	29.8	3
121	Uzbekistan	29.7	11
122	Indonesia	29.0	17
123	Timor-Leste	28.9	18
124	São Tomé and Príncipe	28.7	5
125	Papua New Guinea	28.4	19
126	Mozambique	28.1	6
127	Gabon	27.9	7
128	Equatorial Guinea	27.6	8
	Mongolia	27.6	20
130	Tanzania	27.4	9
131	Comoros	27.3	10
132	Laos	27.2	21
133	Vanuatu	26.7	22
134	Malawi	26.5	11
135	Kenya	25.7	12
	Uganda	25.7	12
137	Ethiopia	25.2	14
138	Myanmar	24.6	23
139	Rwanda	24.4	15
140	Kiribati	22.9	24
141	Namibia	22.5	16
	Zimbabwe	22.5	16
143	Bangladesh	22.4	4
	Dem. Rep. Congo	22.4	18
145	Madagascar	22.1	19
146	Burundi	21.9	20
147	Haiti	21.8	32
148	Gambia	21.4	21
149	Liberia	21.3	22
150	Nepal	21.0	5
	Zambia	21.0	23
152	Sudan	20.8	16
153	Tajikistan	20.7	12
154	Angola	20.4	24
	Senegal	20.4	24
	Solomon Islands	20.4	25
157	Benin	20.3	26
158	Botswana	20.2	27
159	Djibouti	20.1	28
	Ghana	20.1	28
161	Afghanistan	20.0	6
	Mauritania	20.0	30
163	Burkina Faso	19.6	31
164	Mali	19.5	32
165	Côte d'Ivoire	19.4	33
166	Sierra Leone	19.1	34
167	Guinea	18.6	35
168	Republic of Congo	18.1	36
169	Eswatini	17.6	37
170	Niger	17.1	38
171	Togo	16.4	39
172	India	16.3	7
173	Eritrea	15.5	40
174	Guinea-Bissau	15.1	41
175	Chad	14.9	42
176	Pakistan	14.6	8
177	Nigeria	13.9	43
178	Cameroon	13.6	44
179	Central African Republic	12.2	45
180	Lesotho	11.8	46

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4. REGIONAL RANKINGS

Countries often find it useful to compare their results to their geographic neighbors rather than the entire world. For the 2020 EPI, we construct ranking tables for eight regions, shown in Map 2-4.

4.1 GLOBAL WEST

Western European countries lead the 2020 EPI list of top performers, occupying 16 of the top 20 positions. Many of these countries are members of the Organization for Economic Co-operation and Development (OECD), and all are ranked highly on the United Nations Human Development Index, a measure of quality of life within a country. Performance in these countries is especially high for issue categories within the Environmental Health policy objective. Although many countries in the Global West receive top scores in the 2020 EPI, every country has room for further improvement. For example, while the United Kingdom ranks 4th overall both in the region and across the world, it receives the lowest score for fisheries management of any Western European country, due to a history of setting fishing quotas far above scientifically recommended levels (G. Carpenter, 2020).

Portugal, in particular, lags behind its neighbors on many environmental issues, notably Climate Change (44th globally) and Ecosystem Services (174th globally). Portugal experienced a spike in emissions following the economic crisis of 2008–2009, and the ongoing government subsidization of coal, coupled with a decreased reliance on hydropower following successive years of drought, have frustrated efforts to decarbonize (Climate Change Performance Index, 2019). As Europe's largest exporter of eucalyptus pulp, Portugal experiences high levels of tree cover loss from its forestry sector, compounded by forest loss from a series of deadly wildfires in 2017 and 2018 (Frayer, 2017; GFW, 2020d; San-Miguel-Ayanz et al., 2019).

The United States also lags behind its peers in the Global West. While the United States (24th) scores among the top 30 nations worldwide, it ranks toward the bottom of its regional peer group due to poor performance in Waste Management and Water Resources. The United States' low score on Waste Management can be traced to the diffuse and highly localized nature of nonhazardous waste management, compounded by the absence of a unifying national waste policy and a lack

MAP 2-4. Regions of the world.

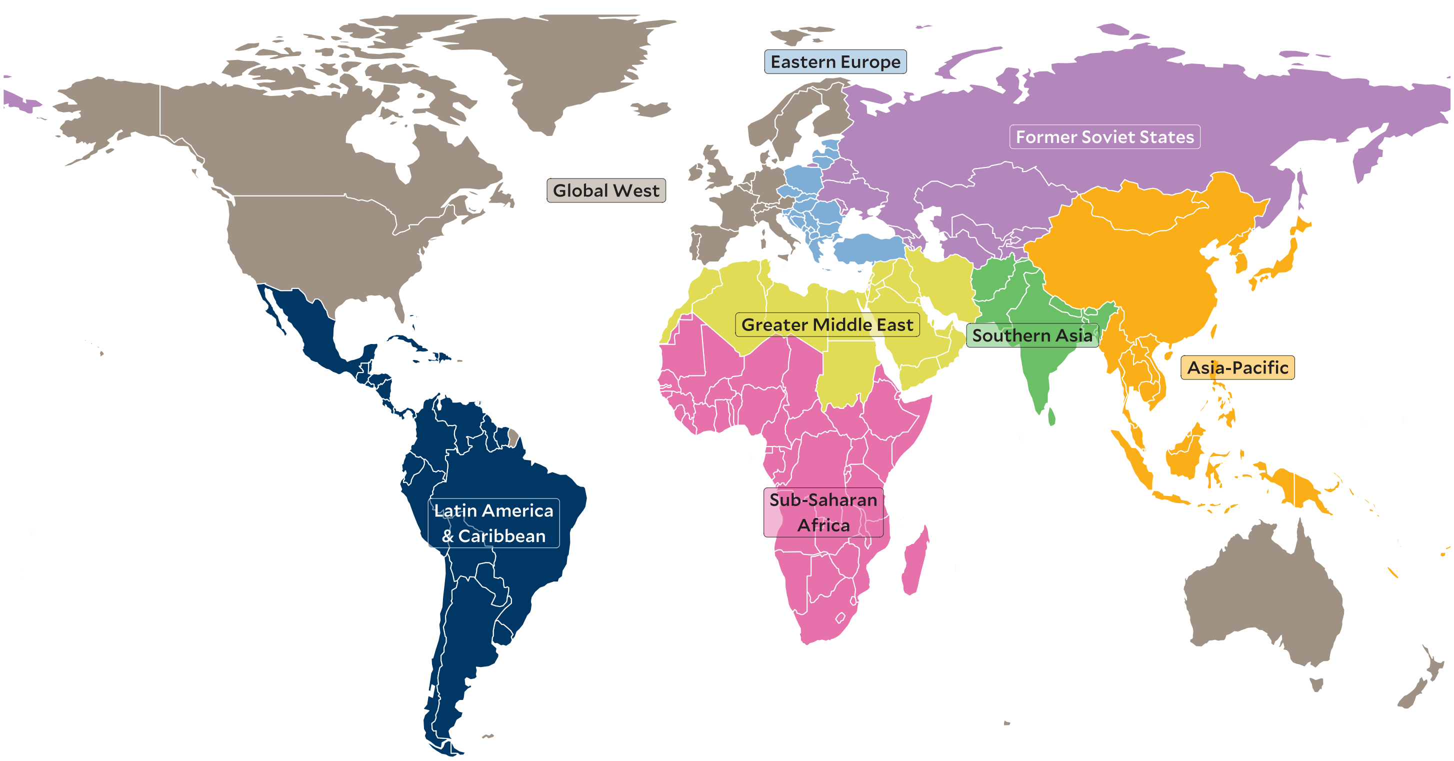


TABLE 2-4. Regional rankings, EPI scores, and global ranking.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Chile	55.3	44
2	Colombia	52.9	50
3	Mexico	52.6	51
4	Costa Rica	52.5	52
5	Argentina	52.2	54
6	Brazil	51.2	55
7	Ecuador	51.0	56
8	Venezuela	50.3	59
9	Uruguay	49.1	61
10	Antigua and Barbuda	48.5	63
11	Cuba	48.4	64
	St. Vincent and Grenadines	48.4	64
13	Jamaica	48.2	66
14	Trinidad and Tobago	47.5	69
15	Panama	47.3	70
16	Paraguay	46.4	73
17	Dominican Republic	46.3	74
18	Barbados	45.6	77
19	Suriname	45.2	81
20	Dominica	44.6	86
21	Bolivia	44.3	88
22	Peru	44.0	90
23	Bahamas	43.5	93
24	El Salvador	43.1	95
	Grenada	43.1	95
	Saint Lucia	43.1	95
27	Belize	41.9	101
28	Nicaragua	39.2	108
29	Honduras	37.8	116
30	Guyana	35.9	126
31	Guatemala	31.8	149
32	Haiti	27.0	170

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Slovenia	72.0	18
2	Czech Republic	71.0	20
3	Greece	69.1	25
4	Slovakia	68.3	26
5	Estonia	65.3	30
6	Cyprus	64.8	31
7	Romania	64.7	32
8	Hungary	63.7	33
9	Croatia	63.1	34
10	Lithuania	62.9	35
11	Latvia	61.6	36
12	Poland	60.9	37
13	Bulgaria	57.0	41
14	North Macedonia	55.4	43
15	Serbia	55.2	45
16	Albania	49.0	62
17	Montenegro	46.3	74
18	Bosnia and Herzegovina	45.4	78
19	Turkey	42.6	99

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Bhutan	39.3	107
2	Sri Lanka	39.0	109
3	Maldives	35.6	127
4	Pakistan	33.1	142
5	Nepal	32.7	145
6	Bangladesh	29.0	162
7	India	27.6	168
8	Afghanistan	25.5	178

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Denmark	82.5	1
2	Luxembourg	82.3	2
3	Switzerland	81.5	3
4	United Kingdom	81.3	4
5	France	80.0	5
6	Austria	79.6	6
7	Finland	78.9	7
8	Sweden	78.7	8
9	Norway	77.7	9
10	Germany	77.2	10
11	Netherlands	75.3	11
12	Australia	74.9	13
13	Spain	74.3	14
14	Belgium	73.3	15
15	Ireland	72.8	16
16	Iceland	72.3	17
17	New Zealand	71.3	19
18	Canada	71.0	20
	Italy	71.0	20
20	Malta	70.7	23
21	United States of America	69.3	24
22	Portugal	67.0	27

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Belarus	53.0	49
2	Armenia	52.3	53
3	Russia	50.5	58
4	Ukraine	49.5	60
5	Azerbaijan	46.5	72
6	Kazakhstan	44.7	85
7	Moldova	44.4	87
8	Uzbekistan	44.3	88
9	Turkmenistan	43.9	92
10	Georgia	41.3	102
11	Kyrgyzstan	39.8	105
12	Tajikistan	38.2	114

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Japan	75.1	12
2	South Korea	66.5	28
3	Singapore	58.1	39
4	Taiwan	57.2	40
5	Brunei Darussalam	54.8	46
6	Malaysia	47.9	68
7	Thailand	45.4	78
8	Tonga	45.1	82
9	Philippines	38.4	111
10	Indonesia	37.8	116
11	Kiribati	37.7	118
12	China	37.3	120
	Samoa	37.3	120
14	Timor-Leste	35.3	129
15	Laos	34.8	130
16	Fiji	34.4	134
17	Cambodia	33.6	139
18	Viet Nam	33.4	141
19	Micronesia	33.0	143
20	Papua New Guinea	32.4	146
21	Mongolia	32.2	147
22	Marshall Islands	30.8	152
23	Vanuatu	28.9	163
24	Solomon Islands	26.7	172
25	Myanmar	25.1	179

SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Seychelles	58.2	38
2	Gabon	45.8	76
3	Mauritius	45.1	82
4	South Africa	43.1	95
5	Botswana	40.4	103
6	Namibia	40.2	104
7	Burkina Faso	38.3	112
	Malawi	38.3	112
9	Equatorial Guinea	38.1	115
10	São Tomé and Príncipe	37.6	119
11	Zimbabwe	37.0	123
12	Central African Republic	36.9	124
13	Dem. Rep. Congo	36.4	125
14	Uganda	35.6	127
15	Kenya	34.7	132
	Zambia	34.7	132
17	Ethiopia	34.4	134
18	Mozambique	33.9	136
19	Eswatini	33.8	137
	Rwanda	33.8	137
21	Cameroon	33.6	139
22	Cabo Verde	32.8	144
23	Comoros	32.1	148
24	Tanzania	31.1	150
25	Nigeria	31.0	151
26	Niger	30.8	152
	Republic of Congo	30.8	152
28	Senegal	30.7	155
29	Eritrea	30.4	156
30	Benin	30.0	157
31	Angola	29.7	158
32	Togo	29.5	159
33	Mali	29.4	160
34	Guinea-Bissau	29.1	161
35	Djibouti	28.1	164
36	Lesotho	28.0	165
37	Gambia	27.9	166
38	Mauritania	27.7	167
39	Ghana	27.6	168
40	Burundi	27.0	170
41	Chad	26.7	172
42	Madagascar	26.5	174
43	Guinea	26.4	175
44	Côte d'Ivoire	25.8	176
45	Sierra Leone	25.7	177
46	Liberia	22.6	180

GREATER MIDDLE EAST

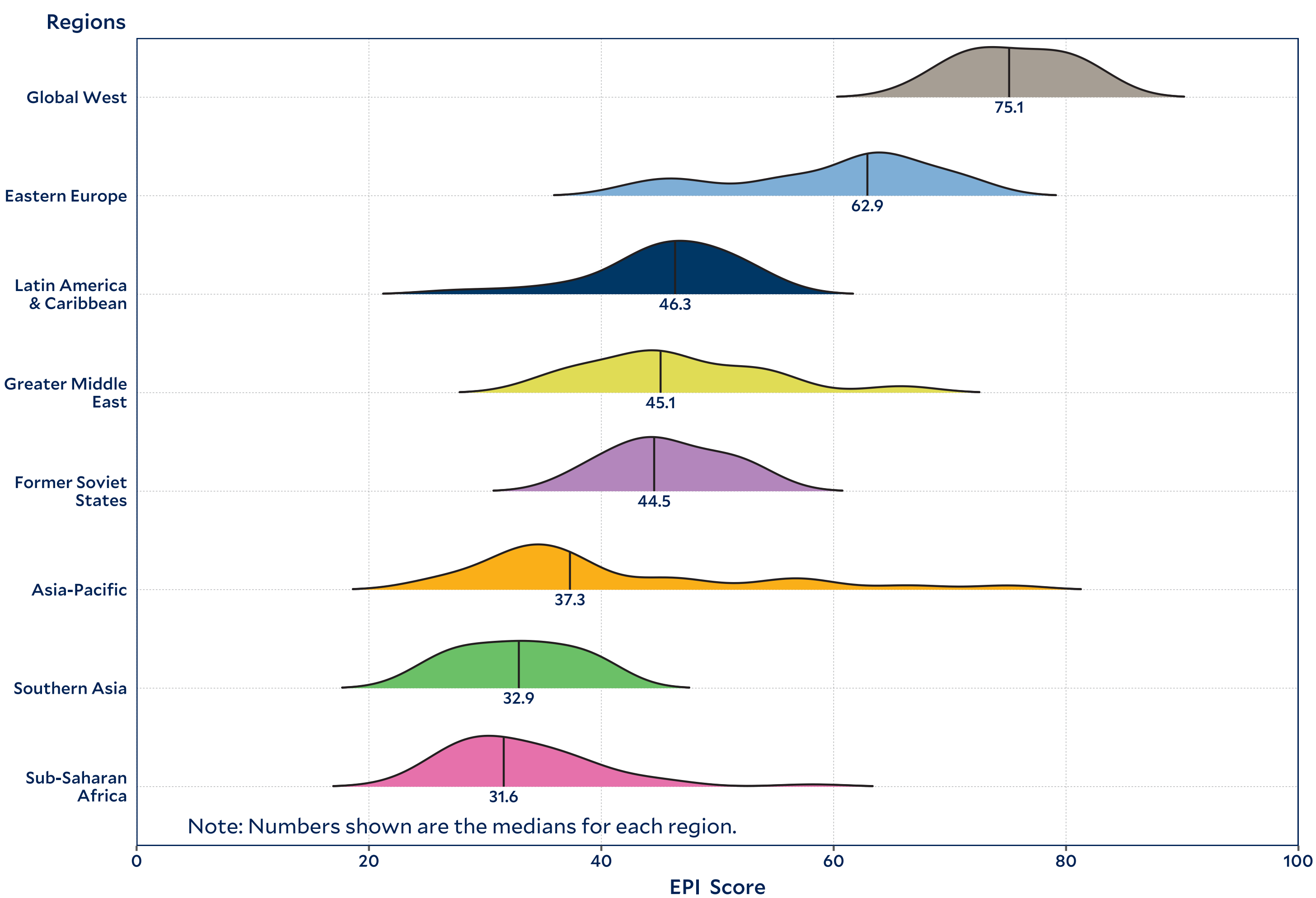
Reg Rank	Country	Score	Global Rank
1	Israel	65.8	29
2	United Arab Emirates	55.6	42
3	Kuwait	53.6	47
4	Jordan	53.4	48
5	Bahrain	51.0	56
6	Iran	48.0	67
7	Tunisia	46.7	71
8	Lebanon	45.4	78
9	Algeria	44.8	84
10	Saudi Arabia	44.0	90
11	Egypt	43.3	94
12	Morocco	42.3	100
13	Iraq	39.5	106
14	Oman	38.5	110
15	Qatar	37.1	122
16	Sudan	34.8	130

of comprehensive data collection at the federal level (Louis, 2004; Powell et al., 2016). Furthermore, national trends and statistics can often mask local service inequities and poor results at the community level.

Meeting the goals set out in the 2015 Paris Climate Change Agreement requires sustained cuts in emissions of all greenhouse gases, and the 2020 EPI makes it clear that no country is decarbonizing quickly enough. Over the last decade, many countries in the Global West have demonstrated more ambitious climate change policies than the rest of the world, but EPI Climate Change scores for Portugal, Germany, and Belgium have declined. Though Germany's *Energiewende* plan represents an admirable and ambitious commitment to lowering emissions, some analysts link Germany's nuclear phase-out to an increased reliance on coal power that may be hurting the country's progress (S. Carpenter, 2020). Countries in the Global West in general – but particularly Australia, Canada, and the United States – exhibit some of the worst performance in *GHG emissions per capita* due to high levels of consumption.

Despite some poor rankings in emissions, several countries excel in individual greenhouse gas reductions. Most notably, Denmark has lowered CO2 emissions due to the decarbonization of its electricity sector; the UK has reduced methane due to declines on coal extraction and improved landfill gas capture; and Norway has decreased fluorinated gases due to its escalating tax on emissions and strong regulatory framework (Flanagan et al., 2019; Norway Ministry of Climate and Environment, 2017; UK Department for Environment, Food, and Rural Affairs, 2020). To spread best practices around the world, policymakers must pay greater attention to how climate change leaders achieve success.

FIGURE 2-10. Regional performance on the 2020 EPI.



2.

TABLE 2-5. Regional rankings, Environmental Health scores, and global ranking.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Uruguay	67.7	33
2	Chile	63.4	35
3	Barbados	60.7	38
4	Costa Rica	60.5	39
5	Argentina	60.2	40
6	Antigua and Barbuda	55.5	49
7	Colombia	55.0	52
8	Trinidad and Tobago	54.6	53
9	Bahamas	53.1	55
10	Cuba	50.5	60
11	Panama	50.4	61
12	Ecuador	50.2	64
13	Brazil	49.7	66
14	Saint Lucia	47.8	73
15	Mexico	47.5	75
16	Dominica	46.8	77
	Paraguay	46.8	77
18	Venezuela	46.5	80
19	Grenada	46.3	81
20	Jamaica	45.5	83
21	Peru	45.1	84
22	St. Vincent and Grenadines	44.1	87
23	El Salvador	42.5	93
24	Belize	40.3	99
25	Nicaragua	40.2	100
26	Suriname	36.6	103
27	Dominican Republic	36.1	104
28	Bolivia	35.9	105
29	Guyana	33.5	110
30	Honduras	33.4	111
31	Guatemala	30.8	116
32	Haiti	21.8	147

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Cyprus	81.5	26
2	Greece	80.6	28
3	Estonia	73.0	30
4	Slovenia	68.9	31
5	Czech Republic	68.3	32
6	Slovakia	64.3	34
7	Lithuania	63.2	36
8	Croatia	61.2	37
9	Poland	58.9	43
10	Latvia	58.0	45
11	Hungary	54.1	54
12	Turkey	51.3	58
13	Bulgaria	50.3	63
14	Romania	50.0	65
15	Serbia	47.8	73
16	Montenegro	46.7	79
17	Albania	44.5	86
18	Bosnia and Herzegovina	43.9	88
19	North Macedonia	43.6	89

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Maldives	48.0	72
2	Sri Lanka	42.1	95
3	Bhutan	29.8	120
4	Bangladesh	22.4	143
5	Nepal	21.0	150
6	Afghanistan	20.0	161
7	India	16.3	172
8	Pakistan	14.6	176

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Finland	99.3	1
2	Norway	98.5	2
3	Sweden	98.4	3
4	Iceland	98.1	4
5	Switzerland	95.0	5
6	Ireland	94.2	6
7	Luxembourg	92.6	7
8	Canada	91.7	8
	Denmark	91.7	8
	United Kingdom	91.7	8
11	Australia	91.6	11
12	France	91.5	12
13	Netherlands	91.0	13
14	Germany	89.6	15
15	Austria	88.0	16
	New Zealand	88.0	16
17	Spain	86.8	18
18	Malta	86.1	19
19	Belgium	86.0	20
20	Italy	85.5	21
21	Portugal	83.4	24
22	United States of America	82.8	25

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Belarus	55.9	48
2	Russia	53.0	57
3	Ukraine	49.0	69
4	Moldova	45.6	82
5	Turkmenistan	45.0	85
6	Armenia	43.5	91
7	Kazakhstan	40.8	97
8	Georgia	38.7	102
9	Kyrgyzstan	33.7	109
10	Azerbaijan	32.7	113
11	Uzbekistan	29.7	121
12	Tajikistan	20.7	153

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Japan	90.3	14
2	Singapore	85.0	22
3	South Korea	81.4	27
4	Brunei Darussalam	74.0	29
5	Taiwan	59.2	42
6	Malaysia	55.4	50
7	Thailand	48.4	70
8	Tonga	43.6	89
9	Samoa	42.4	94
10	China	41.8	96
11	Viet Nam	40.6	98
12	Fiji	34.7	106
13	Philippines	34.1	107
14	Marshall Islands	32.6	114
15	Micronesia	30.8	116
16	Cambodia	30.5	118
17	Indonesia	29.0	122
18	Timor-Leste	28.9	123
19	Papua New Guinea	28.4	125
20	Mongolia	27.6	128
21	Laos	27.2	132
22	Vanuatu	26.7	133
23	Myanmar	24.6	138
24	Kiribati	22.9	140
25	Solomon Islands	20.4	154

SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Mauritius	60.0	41
2	Seychelles	50.8	59
3	South Africa	31.1	115
4	Cabo Verde	30.4	119
5	São Tomé and Príncipe	28.7	124
6	Mozambique	28.1	126
7	Gabon	27.9	127
8	Equatorial Guinea	27.6	128
9	Tanzania	27.4	130
10	Comoros	27.3	131
11	Malawi	26.5	134
12	Kenya	25.7	135
	Uganda	25.7	135
14	Ethiopia	25.2	137
15	Rwanda	24.4	139
16	Namibia	22.5	141
	Zimbabwe	22.5	141
18	Dem. Rep. Congo	22.4	143
19	Madagascar	22.1	145
20	Burundi	21.9	146
21	Gambia	21.4	148
22	Liberia	21.3	149
23	Zambia	21.0	150
24	Angola	20.4	154
	Senegal	20.4	154
26	Benin	20.3	157
27	Botswana	20.2	158
28	Djibouti	20.1	159
	Ghana	20.1	159
30	Mauritania	20.0	161
31	Burkina Faso	19.6	163
32	Mali	19.5	164
33	Côte d'Ivoire	19.4	165
34	Sierra Leone	19.1	166
35	Guinea	18.6	167
36	Republic of Congo	18.1	168
37	Eswatini	17.6	169
38	Niger	17.1	170
39	Togo	16.4	171
40	Eritrea	15.5	173
41	Guinea-Bissau	15.1	174
42	Chad	14.9	175
43	Nigeria	13.9	177
44	Cameroon	13.6	178
45	Central African Republic	12.2	179
46	Lesotho	11.8	180

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Israel	83.6	23
2	Jordan	58.6	44
3	Kuwait	57.3	46
4	Qatar	56.9	47
5	United Arab Emirates	55.2	51
6	Lebanon	53.1	55
7	Algeria	50.4	61
8	Bahrain	49.2	67
	Tunisia	49.2	67
10	Iran	48.3	71
11	Saudi Arabia	47.2	76
12	Oman	43.4	92
13	Iraq	39.5	101
14	Egypt	33.8	108
15	Morocco	33.3	112
16	Sudan	20.8	152

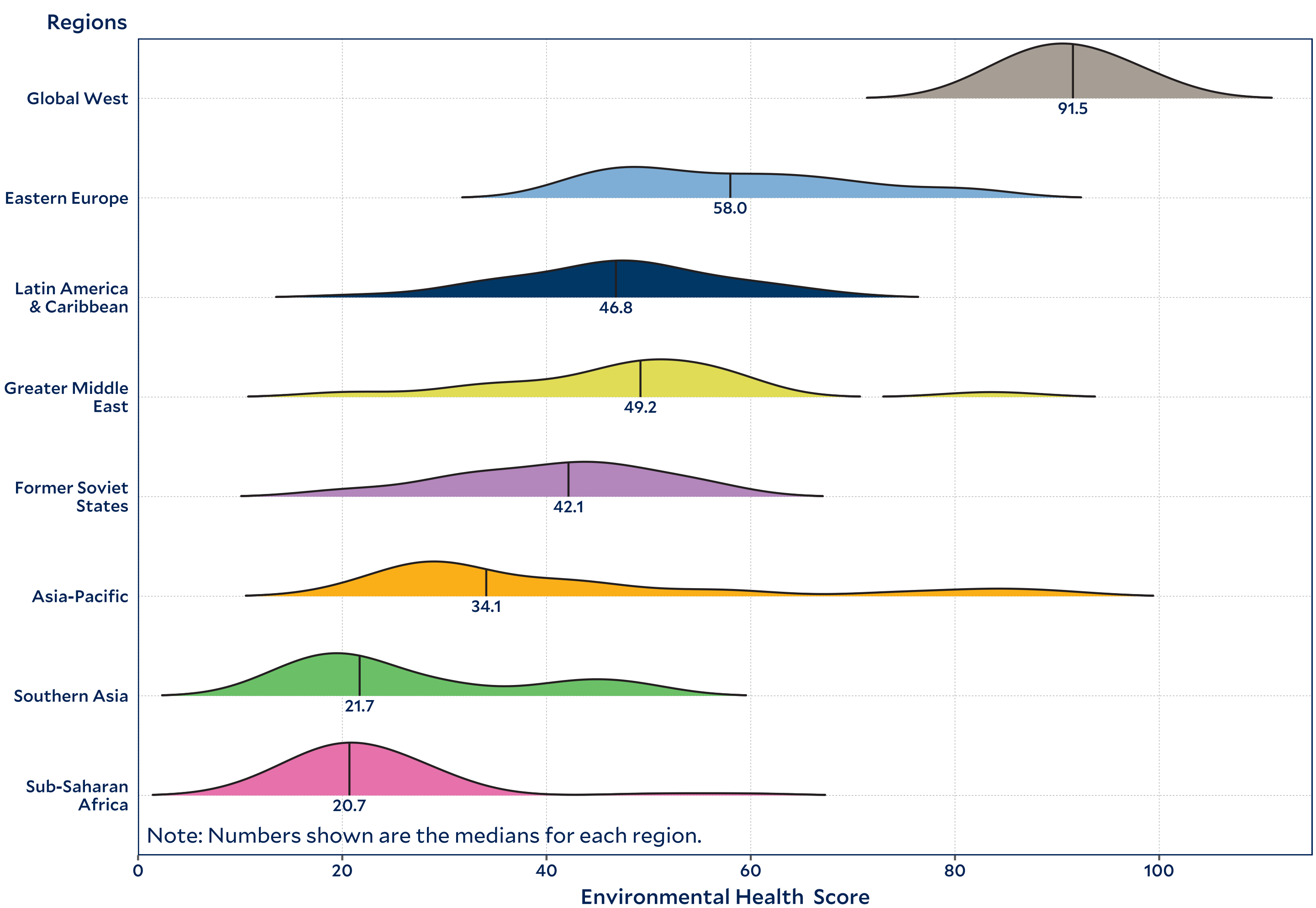
4.2 EASTERN EUROPE

Scores for Eastern European nations range widely, but generally trend toward relatively strong performance. Fifteen out of 19 Eastern European countries place within the global top 50. Regional average scores are particularly high for Agriculture and Biodiversity & Habitat. Many Eastern European countries show considerable progress on Climate Change in particular. In response to growing regulatory costs that disincentivize coal power plants and decreased costs for renewable energy sources, these countries are decommissioning old coal plants and upgrading other fossil-intensive facilities (Wynn & Coghe, 2017). Indeed, fuel switching strategies that eliminate coal-burning power plants remain a proven pathway to lower emissions.

Romania, for example, now sources 38% of its electricity from renewable energy and is home to the largest onshore wind farm in Europe. The Czech Republic's emissions have declined as the result of an economic transition away from heavy industry and a gradual shift from coal to nuclear power and renewables, which will only improve with a planned complete phase-out of coal-fired power generation as part of the nation's Just Transition policy framework (Czech Republic Ministry of the Environment, 2017; Heilmann et al., 2020).

While some issue areas are improving, countries are trending in the wrong direction on other issues. For instance, Latvia experienced one of the largest declines in its Fisheries scores, and Turkey ranks lowest among Eastern European countries, with poor performance in biodiversity protection, fisheries management, and climate change mitigation. Turkey's low scores suggest critical policy gaps in these areas.

FIGURE 2-11. Regional performance on the Environmental Health policy objective.



2.

TABLE 2-6. Regional rankings, Ecosystem Vitality scores, and global ranking.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Mexico	55.9	41
2	Dominican Republic	53.2	51
3	Venezuela	52.9	52
4	Brazil	52.2	53
5	Colombia	51.6	57
6	Ecuador	51.5	58
7	St. Vincent and Grenadines	51.3	59
8	Suriname	50.9	63
9	Jamaica	50.0	65
10	Bolivia	49.8	69
	Chile	49.8	69
12	Costa Rica	47.2	77
13	Cuba	47.0	78
14	Argentina	46.8	80
15	Paraguay	46.2	83
16	Panama	45.2	90
17	Antigua and Barbuda	43.8	96
18	El Salvador	43.5	101
19	Peru	43.2	103
20	Dominica	43.1	104
21	Belize	43.0	107
22	Trinidad and Tobago	42.9	108
23	Grenada	40.9	116
24	Honduras	40.7	117
25	Saint Lucia	40.0	124
26	Nicaragua	38.6	132
27	Guyana	37.5	137
28	Bahamas	37.0	138
29	Uruguay	36.7	141
30	Barbados	35.6	145
31	Guatemala	32.5	164
32	Haiti	30.5	168

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Romania	74.4	3
2	Slovenia	74.1	5
3	Czech Republic	72.9	7
4	Slovakia	70.9	10
5	Hungary	70.0	11
6	Croatia	64.3	19
7	Latvia	64.0	20
8	North Macedonia	63.2	23
9	Lithuania	62.7	25
10	Poland	62.3	26
11	Bulgaria	61.5	27
12	Greece	61.4	28
13	Serbia	60.2	32
14	Estonia	60.1	34
15	Cyprus	53.7	49
16	Albania	52.0	55
17	Bosnia and Herzegovina	46.4	82
18	Montenegro	46.1	85
19	Turkey	36.9	139

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Bhutan	45.7	87
2	Pakistan	45.3	89
3	Nepal	40.5	120
4	Sri Lanka	36.9	139
5	India	35.2	150
6	Bangladesh	33.5	159
7	Afghanistan	29.2	175
8	Maldives	27.4	177

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Denmark	76.4	1
2	Luxembourg	75.4	2
3	United Kingdom	74.3	4
4	Austria	74.0	6
5	Switzerland	72.5	8
6	France	72.3	9
7	Germany	68.9	12
8	Spain	66.0	13
9	Sweden	65.6	14
10	Finland	65.3	15
11	Belgium	64.8	17
	Netherlands	64.8	17
13	Australia	63.8	21
	Norway	63.8	21
15	Italy	61.3	29
16	Malta	60.5	30
17	United States of America	60.3	31
18	New Zealand	60.2	32
19	Ireland	58.6	35
20	Canada	57.3	38
21	Portugal	56.1	40
22	Iceland	55.0	45

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Armenia	58.1	36
2	Azerbaijan	55.7	44
3	Uzbekistan	54.1	46
4	Belarus	51.1	61
5	Tajikistan	49.9	66
	Ukraine	49.9	66
7	Russia	48.8	72
8	Kazakhstan	47.3	76
9	Kyrgyzstan	43.8	96
10	Moldova	43.6	99
11	Georgia	43.1	104
	Turkmenistan	43.1	104

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Japan	65.1	16
2	South Korea	56.6	39
3	Taiwan	55.8	43
4	Kiribati	47.5	75
5	Tonga	46.0	86
6	Indonesia	43.7	98
7	Thailand	43.5	101
8	Malaysia	42.9	108
9	Brunei Darussalam	42.0	112
10	Philippines	41.4	114
11	Singapore	40.2	123
12	Laos	39.9	126
13	Timor-Leste	39.5	128
14	Cambodia	35.6	145
15	Mongolia	35.3	147
16	Papua New Guinea	35.1	152
17	Micronesia	34.5	154
18	China	34.4	156
19	Fiji	34.2	157
20	Samoa	33.9	158
21	Solomon Islands	30.9	167
22	Vanuatu	30.4	170
23	Marshall Islands	29.6	173
24	Viet Nam	28.5	176
25	Myanmar	25.4	178

SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Seychelles	63.1	24
2	Gabon	57.8	37
3	Botswana	53.8	48
4	Central African Republic	53.5	50
5	Namibia	52.0	55
6	South Africa	51.0	62
7	Burkina Faso	50.9	63
8	Cameroon	46.9	79
9	Zimbabwe	46.7	81
10	Malawi	46.2	83
11	Dem. Rep. Congo	45.7	87
12	Equatorial Guinea	45.1	91
13	Eswatini	44.6	93
14	Zambia	43.9	95
15	São Tomé and Príncipe	43.6	99
16	Nigeria	42.4	110
17	Uganda	42.2	111
18	Ethiopia	40.6	118
	Kenya	40.6	118
20	Eritrea	40.4	121
21	Rwanda	40.0	124
22	Niger	39.9	126
23	Republic of Congo	39.2	130
24	Lesotho	38.8	131
25	Guinea-Bissau	38.4	133
26	Togo	38.2	134
27	Mozambique	37.8	135
28	Senegal	37.6	136
29	Benin	36.4	142
30	Mali	36.0	143
31	Angola	35.9	144
32	Comoros	35.3	147
	Mauritius	35.3	147
34	Chad	34.6	153
35	Cabo Verde	34.5	154
36	Tanzania	33.5	159
37	Djibouti	33.4	161
38	Mauritania	32.8	162
39	Ghana	32.6	163
40	Gambia	32.1	165
41	Guinea	31.5	166
42	Burundi	30.5	168
43	Sierra Leone	30.2	171
44	Côte d'Ivoire	30.1	172
45	Madagascar	29.4	174
46	Liberia	23.6	180

GREATER MIDDLE EAST

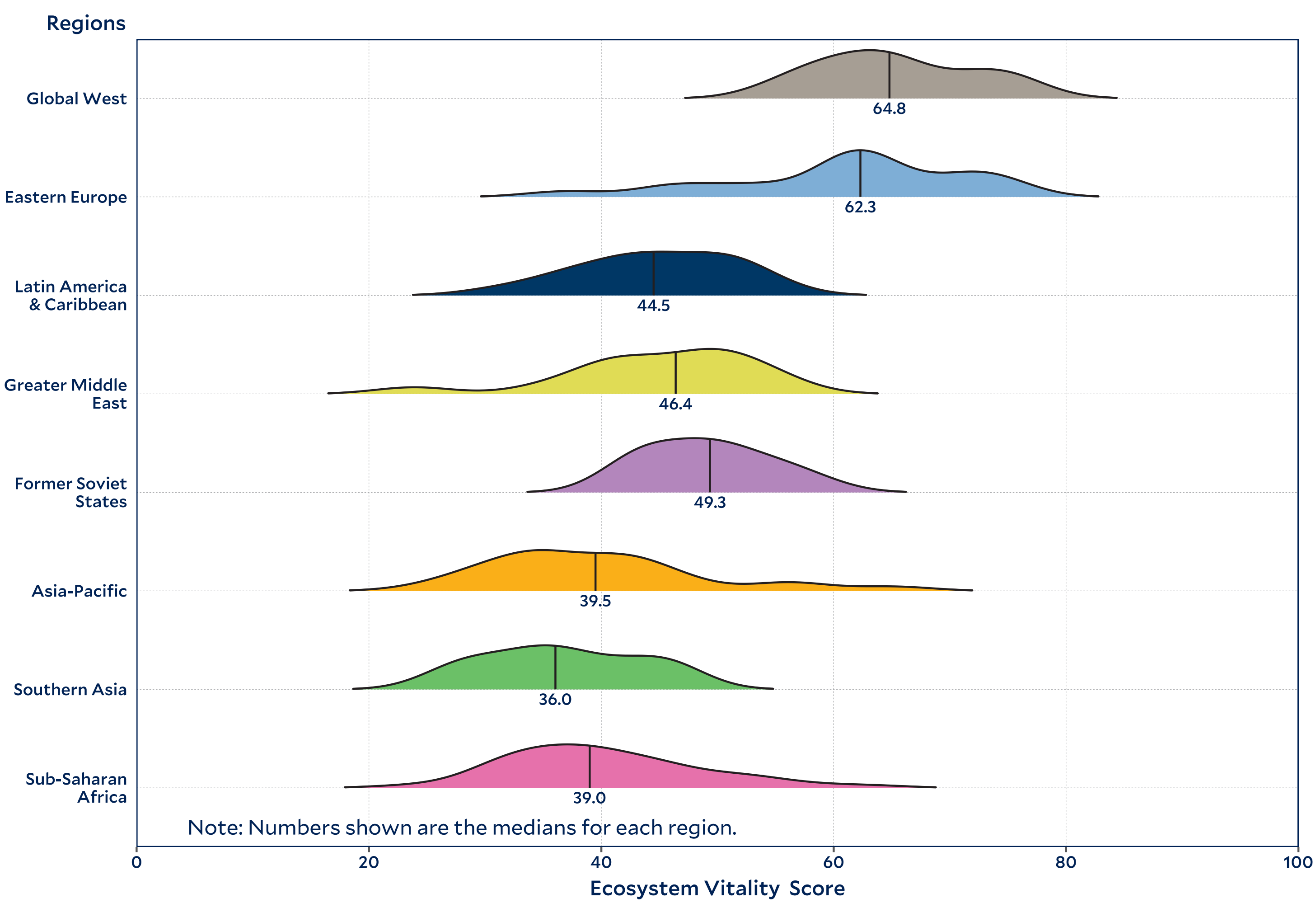
Reg Rank	Country	Score	Global Rank
1	United Arab Emirates	55.9	41
2	Israel	54.0	47
3	Bahrain	52.2	53
4	Kuwait	51.2	60
5	Jordan	49.9	66
6	Egypt	49.7	71
7	Morocco	48.3	73
8	Iran	47.8	74
9	Tunisia	45.0	92
10	Sudan	44.1	94
11	Saudi Arabia	41.8	113
12	Algeria	41.0	115
13	Lebanon	40.3	122
14	Iraq	39.4	129
15	Oman	35.2	150
16	Qatar	23.9	179

4.3 LATIN AMERICA & THE CARIBBEAN

Nations in Latin America & the Caribbean are broadly distributed over the middle half of the 2020 EPI rankings. Chile, with an overall EPI score of 55.3, and Colombia, with a score of 52.9, lead the region, driven by high scores in Water Resources, Heavy Metals, and Waste Management. Levels of development vary widely among Latin American countries, resulting in a broad range of governance effectiveness and, in turn, the level of provision for human health services and ecosystem protection. Performance tends to be uneven within countries, with leaders on one issue often lagging behind on others. For instance, Mexico receives the top score in the region for Ecosystem Vitality but ranks 15th on Environmental Health. Uruguay ranks 1st in the region on Environmental Health but scores among the worst on Ecosystem Vitality, mostly due to a lack of biodiversity and habitat protection. Inconsistent scores across issue categories suggest that countries have further room to improve on more crosscutting environmental governance efforts.

Environmental protection is of critical importance in Latin America & the Caribbean, a region that is home to over 40% of the Earth's biodiversity and more than 25% of its forests. The area also encompasses the Amazon rainforest, the world's richest zone of biodiversity (UNEP, 2016). Deforestation and agricultural expansion continue to threaten this region's unique ecosystems, contributing to low average regional scores on Biodiversity & Habitat and Ecosystem Services. Though very recent events such as the burning of the Amazon in Brazil, Bolivia, and Peru in late 2019 are not captured in the 2020 EPI scores, these events continue a troubling trend of increasing ecosystem destruction and deterioration. However, some countries have made significant progress. Bahamas, Chile, and Mexico substantially improve

FIGURE 2-12. Regional performance on the Ecosystem Vitality policy objective.



their scores on protection of biodiversity and habitat, largely through the expansion of their marine protected area networks.

The lowest rankings in Latin America & the Caribbean go to Guyana (30th in region, 126th globally), Guatemala (31st in region, 149th globally), and Haiti (32nd in region, 170th globally). Guyana shows particularly poor performance on Air Quality and Water Resources but receives top regional scores on Ecosystem Services. Guatemala and Haiti lag behind their neighbors on a broad spectrum of environmental issues. Countries in the bottom rankings often struggle with conflict or weak governance, and Haiti in particular has faced significant political, economic, and social challenges throughout its history (UNEP, 2013). National efforts to improve sustainability on multiple fronts, including air and water pollution, biodiversity protection, and the transition to a clean energy future, can help boost human health and social and economic outcomes as well as environmental performance.

4.4 GREATER MIDDLE EAST

Countries in the Greater Middle East exhibit a wide range of environmental performance, from Israel (ranked 29th globally) and the United Arab Emirates (42nd) to Qatar (122nd) and Sudan (130th). Top regional rankings for Israel and UAE reflect strong results on Environmental Health and high scores on indicators in Biodiversity & Habitat as well as Water Resources. Successful campaigns to reduce household use of solid fuels have boosted Environmental Health scores in many countries across the region (UNEP, 2017). Sudan lags on Environmental Health, with particularly low scores on Air Quality and Sanitation & Drinking Water. Performance in Ecosystem Vitality is more uneven, with Morocco, UAE, and Kuwait substantially improving biodiversity protection, while Qatar and Bahrain show substantial declines in Fisheries due to increasing but unmeasured fishing, land reclamation, and dredging (FAO, 2017).

Despite high concentrations of wealth in the region, action on Climate Change in the Greater Middle East has been halting. Qatar shows the lowest overall performance on Climate Change of any country, and shares the bottom score on *GHG emissions per capita* with Saudi Arabia, UAE, Kuwait, and Bahrain. Climate Change scores for Iraq, Algeria, and Lebanon all declined over the past decade. Large fossil fuel subsidies and economic dependence on oil and gas production contribute to wasteful energy use and high levels of GHG emissions in these countries. Instead, countries in the Greater Middle East could take advantage of the region's vast potential for renewable energy and accelerate efforts to diversify their energy portfolios (Dudley, 2018; Nematollahi et al., 2016).

4.5 FORMER SOVIET STATES

Among the Former Soviet States, which span across much of central Asia, Belarus ranks 1st (49th globally), driven by high performance in Waste Management, Air Quality, and Sanitation & Drinking Water. Russia, the largest country in the region, ranks 3rd in the region and 58th overall. The Former Soviet States receive the highest regional average score in Ecosystem Services, with Tajikistan, Turkmenistan, and Kyrgyzstan demonstrating high retention of forest cover and Moldova earning a top score on grasslands. Some countries show leadership in individual issue categories, such as Ukraine's 1st place ranking in Agriculture. However, the Former Soviet States collectively show poor performance in Biodiversity & Habitat and Waste Management and receive the lowest average regional score for Fisheries. Tajikistan ranks last in the region and 114th overall, with poor performance across all four Environmental Health issue categories, signaling a need for concerted policy action on public health and environmental protection.

4.6 ASIA-PACIFIC

The spread in rankings among Asia-Pacific countries is greater than for any other region, reflecting a wide range of economic development and political diversity. Japan ranks 1st among Asia-Pacific countries and 12th in the world, leading the region on Climate Change, Air Quality, and Sanitation & Drinking Water. South Korea, Singapore, and Taiwan also emerge as strong performers across a range of issues, including climate change governance. Notably, Singapore earns a nearly perfect score (99.6 out of 100) on the EPI's new indicator for Waste Management, but its Climate Change score dropped by 38.6 points over the past ten years due to high emissions from its petrochemical industry, construction, and transportation (Chai Chin, 2019) . These countries have experienced rapid periods of economic growth and improved productivity, which have since translated into higher levels of human development and environmental performance. However, there is still room for improvement on a number of issues. Currently, no country is decarbonizing quickly enough to meet the goals of the Paris Climate Change Agreement.

Global scores on fisheries management are extraordinarily low, and every country must make substantial improvements on this issue. While every nation has work to do to achieve sustainable fisheries, the Asia-Pacific region scores relatively high on this metric – with a regional average of 18.0 out of 100. Countries from this region earn 10 of the top 15 ranks, with Singapore, Fiji, and Kiribati in the top three positions. Small island developing nations and other countries in Southeast Asia are in a state of economic transition, as many continue to suffer from limited resources as well as weak environmental governance. Biodiversity loss therefore remains a pressing problem, especially in Pacific island nations, such as Micronesia and the Marshall Islands, where rapid urbanization and population growth crowd out valuable habitats (S. Taylor & Kumar, 2016; UNEP, 2014). Deforestation threatens vital ecosystem services in Malaysia, Laos, Cambodia, and Indonesia, reflecting a need for strong sustainable forest management measures.

Overall laggards in this region include Vanuatu (23rd in region, 163rd globally), the Solomon Islands (24th in region, 172nd globally), and Myanmar (25th in region, 179th globally). Myanmar's score is brought down by particularly poor performance on household use of solid fuels, marine ecosystem protection, and CO_2 mitigation, while Vanuatu lags behind its neighbors on air pollution. Policymakers and environmental managers in these countries must make sustainability central to national development strategies in order to promote the well-being of people and the planet.

4.7 SOUTHERN ASIA

Southern Asia has the second-lowest regional ranking on the 2020 EPI, with Bangladesh (163nd), India (168th), and Afghanistan (178th) among the lowest-scoring countries in both their region and the world. Poor performance in India is especially concerning, where a population of nearly 1.4 billion people face serious environmental health risks. The 2020 EPI shows essentially no improvement in India's overall environmental performance over the past decade, though there are gains and losses on individual issues. Nepal, India, and Pakistan receive the bottom three scores for Air Quality, with pollution from solid fuels, coal and crop residue burning, and poorly regulated motor vehicles endangering the lives of millions of people each year. Perhaps most critically, India places 106th in the world on climate change mitigation. Despite recent investments in renewable energy, India's emissions continue to increase, and its Climate Change score dropped by 2.9 points over the past decade. India's ability and willingness to accelerate its decarbonization agenda will be decisive in the fight to keep global temperatures from rising by more than 1.5°C.

Leading the region is Bhutan (107th), with relatively high scores in biodiversity and habitat protection – perhaps not a surprise for a nation that has constitutionally mandated that 60% of its territory must remain as undeveloped forest. Maldives scores in the top ten globally on Fisheries, and Afghanistan and Pakistan show good retention of Ecosystem Services. Strong attention to environmental health and ecosystem protection will be crucial for sustainable development in countries in Southern Asia.

4.8 SUB-SAHARAN AFRICA

Sub-Saharan African countries score lower than any other region, occupying 32 of the bottom 50 rankings. Rising populations and rapidly growing urban centers in Sub-Saharan Africa continue to overwhelm environmental infrastructure and put substantial pressure on limited natural resources. Millions of people live without access to basic water and sanitation services. These countries have major opportunities to make rapid improvements in environmental performance with investments in clean water, sanitation, waste management, and renewable energy. While such projects would go a long way in improving environmental and human well-being, they would require substantial capital investments. Despite the daunting economic challenges Sub-Saharan African countries face, some have still made significant progress on issue categories within the EPI. Seychelles ranks 1st in the region and 38th in the world, spurred by its success in reducing emissions of greenhouse gases and other air pollutants and its commitment to marine protection through a "Blue Economy" plan (Roberts & Ali, 2016). Mauritius leads the region on Waste Management, while Botswana and Zambia receive top scores on Biodiversity & Habitat.

5. PEER GROUPS

Beyond regions, we also provide additional peer groups based on shared geographical, commercial, historical, or cultural characteristics. The number of possible peer groups most likely exceeds the number of countries in the 2020 EPI, as each country may find multiple points of reference, including those for each issue category or policy objective. We encourage countries to customize their own peer groups from the data and results posted online at epi.yale.edu.

2.

TABLE 2-7. Rankings, EPI scores, and ten-year changes in EPI score, by peer group.

Association of Southeast Asia

RANK	COUNTRY	SCORE	10-YR Δ
1	Singapore	58.1	-8.4
2	Brunei Darussalam	54.8	+2.0
3	Malaysia	47.9	+4.4
4	Thailand	45.4	+4.1
	Group Average	*40.9*	
5	Philippines	38.4	-4.1
6	Indonesia	37.8	+4.1
7	Laos	34.8	-2.8
8	Cambodia	33.6	-0.2
9	Viet Nam	33.4	+5.4
10	Myanmar	25.1	-1.2

OPEC Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	United Arab Emirates	55.6	+11.3
2	Kuwait	53.6	+12.8
3	Venezuela	50.3	-0.5
4	Iran	48.0	+9.1
5	Gabon	45.8	+4.4
6	Algeria	44.8	+0.5
7	Saudi Arabia	44.0	+6.4
	Group Average	*42.6*	
8	Iraq	39.5	+0.2
9	Equatorial Guinea	38.1	+9.6
10	Nigeria	31.0	+3.6
11	Republic of Congo	30.8	-1.5
12	Angola	29.7	+5.3

La Francophonie

RANK	COUNTRY	SCORE	10-YR Δ
1	Luxembourg	82.3	+11.6
2	Switzerland	81.5	+8.6
3	France	80.0	+5.8
4	Belgium	73.3	+2.1
5	Canada	71.0	+3.7
6	Greece	69.1	+3.4
7	Romania	64.7	+8.1
8	Seychelles	58.2	+14.8
9	Bulgaria	57.0	+4.2
10	North Macedonia	55.4	+2.2
11	Armenia	52.3	+4.5
12	Albania	49.0	+10.2
13	Tunisia	46.7	+6.4
14	Gabon	45.8	+4.4
15	Lebanon	45.4	+1.1
16	Mauritius	45.1	+6.2
17	Dominica	44.6	+1.1
18	Moldova	44.4	-2.3
19	Egypt	43.3	+7.7
20	Saint Lucia	43.1	-1.4
21	Morocco	42.3	+13.3
	Group Average	*42.3*	
22	Burkina Faso	38.3	+6.9
23	Equatorial Guinea	38.1	+9.6
24	São Tomé and Príncipe	37.6	+5.3
25	Central African Republic	36.9	-3.9
26	Dem. Rep. Congo	36.4	-0.4
27	Laos	34.8	-2.8
28	Rwanda	33.8	-1.5
29	Cambodia	33.6	-0.2
	Cameroon	33.6	+1.5
31	Viet Nam	33.4	+5.4
32	Cabo Verde	32.8	+5.9
33	Comoros	32.1	-1.2
34	Niger	30.8	-8.1
	Republic of Congo	30.8	-1.5
36	Senegal	30.7	-2.7
37	Benin	30.0	+2.7
38	Togo	29.5	-2.1
39	Mali	29.4	-3.3
40	Guinea-Bissau	29.1	-0.9
41	Vanuatu	28.9	-11.9
42	Djibouti	28.1	+2.3
43	Mauritania	27.7	+0.3
44	Burundi	27.0	-11.1
	Haiti	27.0	+4.2
46	Chad	26.7	-0.9
47	Madagascar	26.5	-6.6
48	Guinea	26.4	-4.2
49	Côte d'Ivoire	25.8	-8.5

Arab League

RANK	COUNTRY	SCORE	10-YR Δ
1	United Arab Emirates	55.6	+11.3
2	Kuwait	53.6	+12.8
3	Jordan	53.4	+11.2
4	Bahrain	51.0	+17.3
5	Tunisia	46.7	+6.4
6	Lebanon	45.4	+1.1
7	Algeria	44.8	+0.5
8	Saudi Arabia	44.0	+6.4
9	Egypt	43.3	+7.7
10	Morocco	42.3	+13.3
	Group Average	*42.2*	
11	Iraq	39.5	+0.2
12	Oman	38.5	+11.0
13	Qatar	37.1	-4.8
14	Sudan	34.8	+8.4
15	Comoros	32.1	-1.2
16	Djibouti	28.1	+2.3
17	Mauritania	27.7	+0.3

European Union - 27

RANK	COUNTRY	SCORE	10-YR Δ
1	Denmark	82.5	+7.3
2	Luxembourg	82.3	+11.6
3	France	80.0	+5.8
4	Austria	79.6	+5.4
5	Finland	78.9	+6.0
6	Sweden	78.7	+5.3
7	Germany	77.2	+1.2
8	Netherlands	75.3	+1.5
9	Spain	74.3	+8.6
10	Belgium	73.3	+2.1
11	Ireland	72.8	+2.9
12	Slovenia	72.0	+4.6
13	Czech Republic	71.0	+4.0
	Italy	71.0	+1.1
15	Malta	70.7	+11.6
	Group Average	*70.7*	
16	Greece	69.1	+3.4
17	Slovakia	68.3	+3.9
18	Portugal	67.0	+4.0
19	Estonia	65.3	+4.3
20	Cyprus	64.8	+6.3
21	Romania	64.7	+8.1
22	Hungary	63.7	+3.3
23	Croatia	63.1	+13.4
24	Lithuania	62.9	+5.2
25	Latvia	61.6	+5.0
26	Poland	60.9	+1.1
27	Bulgaria	57.0	+4.2

Emerging Markets

RANK	COUNTRY	SCORE	10-YR Δ
1	Czech Republic	71.0	+4.0
2	Greece	69.1	+3.4
3	South Korea	66.5	+2.2
4	Hungary	63.7	+3.3
5	Poland	60.9	+1.1
6	Taiwan	57.2	+4.6
7	United Arab Emirates	55.6	+11.3
8	Chile	55.3	+3.7
9	Kuwait	53.6	+12.8
10	Colombia	52.9	+0.9
11	Mexico	52.6	+7.4
12	Argentina	52.2	+5.0
13	Brazil	51.2	+4.9
14	Russia	50.5	+3.9
	Group Average	*49.4*	
15	Malaysia	47.9	+4.4
16	Thailand	45.4	+4.1
17	Peru	44.0	-0.8
	Saudi Arabia	44.0	+6.4
19	Egypt	43.3	+7.7
20	South Africa	43.1	+8.5
21	Turkey	42.6	+2.1
22	Philippines	38.4	-4.1
23	Indonesia	37.8	+4.1
24	China	37.3	+8.4
25	Qatar	37.1	-4.8
26	Pakistan	33.1	+6.1
27	India	27.6	0.0

Least Developed Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Bhutan	39.3	-9.6
2	Burkina Faso	38.3	+6.9
	Malawi	38.3	-2.6
4	Kiribati	37.7	+6.2
5	São Tomé and Príncipe	37.6	+5.3
6	Central African Republic	36.9	-3.9
7	Dem. Rep. Congo	36.4	-0.4
8	Uganda	35.6	+1.8
9	Timor-Leste	35.3	-3.0
10	Laos	34.8	-2.8
	Sudan	34.8	+8.4
12	Zambia	34.7	-7.3
13	Ethiopia	34.4	+0.2
14	Mozambique	33.9	+5.3
15	Rwanda	33.8	-1.5
16	Cambodia	33.6	-0.2
17	Nepal	32.7	-8.1
18	Comoros	32.1	-1.2
	Group Average	*31.2*	
19	Tanzania	31.1	+1.7
20	Niger	30.8	-8.1
21	Senegal	30.7	-2.7
22	Eritrea	30.4	-3.7
23	Benin	30.0	+2.7
24	Angola	29.7	+5.3
25	Togo	29.5	-2.1
26	Mali	29.4	-3.3
27	Guinea-Bissau	29.1	-0.9
28	Bangladesh	29.0	-0.1
29	Vanuatu	28.9	-11.9
30	Djibouti	28.1	+2.3
31	Lesotho	28.0	-1.0
32	Gambia	27.9	+3.6
33	Mauritania	27.7	+0.3
34	Burundi	27.0	-11.1
	Haiti	27.0	+4.2
36	Chad	26.7	-0.9
	Solomon Islands	26.7	-2.0
38	Madagascar	26.5	-6.6
39	Guinea	26.4	-4.2
40	Sierra Leone	25.7	+0.7
41	Afghanistan	25.5	+5.0
42	Myanmar	25.1	-1.2
43	Liberia	22.6	-3.7

Landlocked Developing Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	North Macedonia	55.4	+2.2
2	Armenia	52.3	+4.5
3	Azerbaijan	46.5	+4.0
4	Paraguay	46.4	-4.9
5	Kazakhstan	44.7	+9.0
6	Moldova	44.4	-2.3
7	Bolivia	44.3	-0.3
	Uzbekistan	44.3	+3.1
9	Turkmenistan	43.9	+8.4
10	Botswana	40.4	-1.1
11	Kyrgyzstan	39.8	-1.9
12	Bhutan	39.3	-9.6
13	Burkina Faso	38.3	+6.9
	Malawi	38.3	-2.6
15	Tajikistan	38.2	-0.7
	Group Average	*37.7*	
16	Zimbabwe	37.0	-7.3
17	Central African Republic	36.9	-3.9
18	Uganda	35.6	+1.8
19	Laos	34.8	-2.8
20	Zambia	34.7	-7.3
21	Ethiopia	34.4	+0.2
22	Eswatini	33.8	-1.6
	Rwanda	33.8	-1.5
24	Nepal	32.7	-8.1
25	Mongolia	32.2	-7.6
26	Niger	30.8	-8.1
27	Mali	29.4	-3.3
28	Lesotho	28.0	-1.0
29	Burundi	27.0	-11.1
30	Chad	26.7	-0.9
31	Afghanistan	25.5	+5.0

TABLE 2-7. Rankings, EPI scores, and ten-year changes in EPI score, by peer group.

Organisation of Islamic Cooperation

RANK	COUNTRY	SCORE	10-YR Δ
1	United Arab Emirates	55.6	+11.3
2	Brunei Darussalam	54.8	+2.0
3	Kuwait	53.6	+12.8
4	Jordan	53.4	+11.2
5	Bahrain	51.0	+17.3
6	Albania	49.0	+10.2
7	Iran	48.0	+9.1
8	Malaysia	47.9	+4.4
9	Tunisia	46.7	+6.4
10	Azerbaijan	46.5	+4.0
11	Gabon	45.8	+4.4
12	Lebanon	45.4	+1.1
13	Suriname	45.2	-7.1
14	Algeria	44.8	+0.5
15	Kazakhstan	44.7	+9.0
16	Uzbekistan	44.3	+3.1
17	Saudi Arabia	44.0	+6.4
18	Turkmenistan	43.9	+8.4
19	Egypt	43.3	+7.7
20	Turkey	42.6	+2.1
21	Morocco	42.3	+13.3
22	Kyrgyzstan	39.8	-1.9
23	Iraq	39.5	+0.2
24	Oman	38.5	+11.0
25	Burkina Faso	38.3	+6.9
	Group Average	***38.3***	
26	Tajikistan	38.2	-0.7
27	Indonesia	37.8	+4.1
28	Qatar	37.1	-4.8
29	Guyana	35.9	-6.4
30	Maldives	35.6	+6.7
	Uganda	35.6	+1.8
32	Sudan	34.8	+8.4
33	Mozambique	33.9	+5.3
34	Cameroon	33.6	+1.5
35	Pakistan	33.1	+6.1
36	Comoros	32.1	-1.2
37	Nigeria	31.0	+3.6
38	Niger	30.8	-8.1
39	Senegal	30.7	-2.7
40	Benin	30.0	+2.7
41	Togo	29.5	-2.1
42	Mali	29.4	-3.3
43	Guinea-Bissau	29.1	-0.9
44	Bangladesh	29.0	-0.1
45	Djibouti	28.1	+2.3
46	Gambia	27.9	+3.6
47	Mauritania	27.7	+0.3
48	Chad	26.7	-0.9
49	Guinea	26.4	-4.2
50	Côte d'Ivoire	25.8	-8.5
51	Sierra Leone	25.7	+0.7
52	Afghanistan	25.5	+5.0

G-20

RANK	COUNTRY	SCORE	10-YR Δ
1	United Kingdom	81.3	+9.0
2	France	80.0	+5.8
3	Germany	77.2	+1.2
4	Japan	75.1	-0.5
5	Australia	74.9	+5.5
6	Canada	71.0	+3.7
	Italy	71.0	+1.1
8	United States of America	69.3	+2.9
9	South Korea	66.5	+2.2
	Group Average	***58.2***	
10	Mexico	52.6	+7.4
11	Argentina	52.2	+5.0
12	Brazil	51.2	+4.9
13	Russia	50.5	+3.9
14	Saudi Arabia	44.0	+6.4
15	South Africa	43.1	+8.5
16	Turkey	42.6	+2.1
17	Indonesia	37.8	+4.1
18	China	37.3	+8.4
19	India	27.6	0.0

Commonwealth of Nations

RANK	COUNTRY	SCORE	10-YR Δ
1	United Kingdom	81.3	+9.0
2	Australia	74.9	+5.5
3	New Zealand	71.3	+1.8
4	Canada	71.0	+3.7
5	Malta	70.7	+11.6
6	Cyprus	64.8	+6.3
7	Seychelles	58.2	+14.8
8	Singapore	58.1	-8.4
9	Brunei Darussalam	54.8	+2.0
10	Antigua and Barbuda	48.5	+3.3
11	Saint Vincent and the Grena..	48.4	+6.1
12	Jamaica	48.2	+2.0
13	Malaysia	47.9	+4.4
14	Trinidad and Tobago	47.5	+10.7
15	Barbados	45.6	+0.9
16	Mauritius	45.1	+6.2
	Tonga	45.1	+2.4
18	Dominica	44.6	+1.1
19	Bahamas	43.5	-2.4
20	Grenada	43.1	+5.4
	Saint Lucia	43.1	-1.4
	South Africa	43.1	+8.5
	Group Average	***42.5***	
23	Belize	41.9	-2.0
24	Botswana	40.4	-1.1
25	Namibia	40.2	+9.1
26	Sri Lanka	39.0	-0.6
27	Malawi	38.3	-2.6
28	Kiribati	37.7	+6.2
29	Samoa	37.3	-3.9
30	Guyana	35.9	-6.4
31	Maldives	35.6	+6.7
	Uganda	35.6	+1.8
33	Kenya	34.7	0.0
	Zambia	34.7	-7.3
35	Fiji	34.4	-2.6
36	Mozambique	33.9	+5.3
37	Eswatini	33.8	-1.6
	Rwanda	33.8	-1.5
39	Cameroon	33.6	+1.5
40	Pakistan	33.1	+6.1
41	Papua New Guinea	32.4	+7.7
42	Tanzania	31.1	+1.7
43	Nigeria	31.0	+3.6
44	Bangladesh	29.0	-0.1
45	Vanuatu	28.9	-11.9
46	Lesotho	28.0	-1.0
47	Gambia	27.9	+3.6
48	Ghana	27.6	-4.4
	India	27.6	0.0
50	Solomon Islands	26.7	-2.0
51	Sierra Leone	25.7	+0.7

Organization of Ibero-American States

RANK	COUNTRY	SCORE	10-YR Δ
1	Spain	74.3	+8.6
2	Portugal	67.0	+4.0
3	Chile	55.3	+3.7
4	Colombia	52.9	+0.9
5	Mexico	52.6	+7.4
6	Costa Rica	52.5	+1.0
7	Argentina	52.2	+5.0
8	Brazil	51.2	+4.9
9	Ecuador	51.0	+3.9
10	Venezuela	50.3	-0.5
11	Uruguay	49.1	+1.0
	Group Average	***48.9***	
12	Cuba	48.4	+0.8
13	Panama	47.3	+3.3
14	Paraguay	46.4	-4.9
15	Dominican Republic	46.3	+3.0
16	Bolivia	44.3	-0.3
17	Peru	44.0	-0.8
18	El Salvador	43.1	+5.6
19	Nicaragua	39.2	+0.1
20	Equatorial Guinea	38.1	+9.6
21	Honduras	37.8	+6.5
22	Guatemala	31.8	-0.3

Small Island Developing States

RANK	COUNTRY	SCORE	10-YR Δ
1	Seychelles	58.2	+14.8
2	Singapore	58.1	-8.4
3	Bahrain	51.0	+17.3
4	Antigua and Barbuda	48.5	+3.3
5	Cuba	48.4	+0.8
	Saint Vincent and the Grena..	48.4	+6.1
7	Jamaica	48.2	+2.0
8	Trinidad and Tobago	47.5	+10.7
9	Dominican Republic	46.3	+3.0
10	Barbados	45.6	+0.9
11	Suriname	45.2	-7.1
12	Mauritius	45.1	+6.2
	Tonga	45.1	+2.4
14	Dominica	44.6	+1.1
15	Bahamas	43.5	-2.4
16	Grenada	43.1	+5.4
	Saint Lucia	43.1	-1.4
18	Belize	41.9	-2.0
	Group Average	***40.5***	
19	Kiribati	37.7	+6.2
20	São Tomé and Príncipe	37.6	+5.3
21	Samoa	37.3	-3.9
22	Guyana	35.9	-6.4
23	Maldives	35.6	+6.7
24	Timor-Leste	35.3	-3.0
25	Fiji	34.4	-2.6
26	Micronesia	33.0	-4.8
27	Cabo Verde	32.8	+5.9
28	Papua New Guinea	32.4	+7.7
29	Comoros	32.1	-1.2
30	Marshall Islands	30.8	+1.1
31	Guinea-Bissau	29.1	-0.9
32	Vanuatu	28.9	-11.9
33	Haiti	27.0	+4.2
34	Solomon Islands	26.7	-2.0

OECD Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Denmark	82.5	+7.3
2	Luxembourg	82.3	+11.6
3	Switzerland	81.5	+8.6
4	United Kingdom	81.3	+9.0
5	France	80.0	+5.8
6	Austria	79.6	+5.4
7	Finland	78.9	+6.0
8	Sweden	78.7	+5.3
9	Norway	77.7	+7.6
10	Germany	77.2	+1.2
11	Netherlands	75.3	+1.5
12	Japan	75.1	-0.5
13	Australia	74.9	+5.5
14	Spain	74.3	+8.6
15	Belgium	73.3	+2.1
16	Ireland	72.8	+2.9
17	Iceland	72.3	+0.4
18	Slovenia	72.0	+4.6
19	New Zealand	71.3	+1.8
20	Canada	71.0	+3.7
	Czech Republic	71.0	+4.0
	Italy	71.0	+1.1
	Group Average	***70.7***	
23	United States of America	69.3	+2.9
24	Greece	69.1	+3.4
25	Slovakia	68.3	+3.9
26	Portugal	67.0	+4.0
27	South Korea	66.5	+2.2
28	Israel	65.8	+5.2
29	Estonia	65.3	+4.3
30	Hungary	63.7	+3.3
31	Lithuania	62.9	+5.2
32	Latvia	61.6	+5.0
33	Poland	60.9	+1.1
34	Chile	55.3	+3.7
35	Mexico	52.6	+7.4
36	Turkey	42.6	+2.1

TABLE 2-8. Rankings, Environmental Health scores, and ten-year changes in score, by peer group.

Association of Southeast Asia

RANK	COUNTRY	SCORE	10-YR Δ
1	Singapore	85.0	+2.8
2	Brunei Darussalam	74.0	+0.1
3	Malaysia	55.4	+3.8
4	Thailand	48.4	+4.9
	Group Average	*44.9*	
5	Viet Nam	40.6	+4.0
6	Philippines	34.1	+4.9
7	Cambodia	30.5	+4.4
8	Indonesia	29.0	+4.2
9	Laos	27.2	+5.6
10	Myanmar	24.6	+5.9

OPEC Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Kuwait	57.3	+4.5
2	United Arab Emirates	55.2	+3.6
3	Algeria	50.4	+5.1
4	Iran	48.3	+6.4
5	Saudi Arabia	47.2	+7.8
6	Venezuela	46.5	+2.3
7	Iraq	39.5	+11.2
	Group Average	*37.7*	
8	Gabon	27.9	+6.5
9	Equatorial Guinea	27.6	+4.0
10	Angola	20.4	+2.9
11	Republic of Congo	18.1	+3.4
12	Nigeria	13.9	+1.1

La Francophonie

RANK	COUNTRY	SCORE	10-YR Δ
1	Switzerland	95.0	+4.3
2	Luxembourg	92.6	+5.8
3	Canada	91.7	+3.3
4	France	91.5	+6.3
5	Belgium	86.0	+5.7
6	Greece	80.6	+4.5
7	Mauritius	60.0	+4.6
8	Lebanon	53.1	+6.6
9	Seychelles	50.8	+2.1
10	Bulgaria	50.3	+3.8
11	Romania	50.0	+5.5
12	Tunisia	49.2	+5.2
13	Saint Lucia	47.8	+1.0
14	Dominica	46.8	+0.7
15	Moldova	45.6	+8.2
16	Albania	44.5	+3.1
17	North Macedonia	43.6	+4.0
18	Armenia	43.5	+4.1
19	Viet Nam	40.6	+4.0
	Group Average	*37.4*	
20	Egypt	33.8	+6.8
21	Morocco	33.3	+5.6
22	Cambodia	30.5	+4.4
23	Cabo Verde	30.4	-1.7
24	São Tomé and Príncipe	28.7	+3.2
25	Gabon	27.9	+6.5
26	Equatorial Guinea	27.6	+4.0
27	Comoros	27.3	+0.9
28	Laos	27.2	+5.6
29	Vanuatu	26.7	+0.4
30	Rwanda	24.4	+1.6
31	Dem. Rep. Congo	22.4	+2.0
32	Madagascar	22.1	+1.0
33	Burundi	21.9	+1.2
34	Haiti	21.8	+1.7
35	Senegal	20.4	+0.3
36	Benin	20.3	+0.5
37	Djibouti	20.1	+2.9
38	Mauritania	20.0	+3.2
39	Burkina Faso	19.6	-0.4
40	Mali	19.5	+0.9
41	Côte d'Ivoire	19.4	+1.6
42	Guinea	18.6	+1.3
43	Republic of Congo	18.1	+3.4
44	Niger	17.1	-0.6
45	Togo	16.4	+1.3
46	Guinea-Bissau	15.1	+2.5
47	Chad	14.9	-1.0
48	Cameroon	13.6	+2.2
49	Central African Republic	12.2	-0.1

Arab League

RANK	COUNTRY	SCORE	10-YR Δ
1	Jordan	58.6	+7.0
2	Kuwait	57.3	+4.5
3	Qatar	56.9	+3.7
4	United Arab Emirates	55.2	+3.6
5	Lebanon	53.1	+6.6
6	Algeria	50.4	+5.1
7	Bahrain	49.2	+5.5
	Tunisia	49.2	+5.2
9	Saudi Arabia	47.2	+7.8
10	Oman	43.4	+7.0
	Group Average	*42.1*	
11	Iraq	39.5	+11.2
12	Egypt	33.8	+6.8
13	Morocco	33.3	+5.6
14	Comoros	27.3	+0.9
15	Sudan	20.8	+3.3
16	Djibouti	20.1	+2.9
17	Mauritania	20.0	+3.2

European Union - 27

RANK	COUNTRY	SCORE	10-YR Δ
1	Finland	99.3	+3.5
2	Sweden	98.4	+3.0
3	Ireland	94.2	+6.5
4	Luxembourg	92.6	+5.8
5	Denmark	91.7	+5.7
6	France	91.5	+6.3
7	Netherlands	91.0	+3.6
8	Germany	89.6	+3.9
9	Austria	88.0	+5.2
10	Spain	86.8	+4.7
11	Malta	86.1	+6.1
12	Belgium	86.0	+5.7
13	Italy	85.5	+4.6
14	Portugal	83.4	+7.1
15	Cyprus	81.5	+5.2
16	Greece	80.6	+4.5
	Group Average	*77.6*	
17	Estonia	73.0	+9.6
18	Slovenia	68.9	+3.6
19	Czech Republic	68.3	+3.8
20	Slovakia	64.3	+4.9
21	Lithuania	63.2	+8.0
22	Croatia	61.2	+4.6
23	Poland	58.9	+4.8
24	Latvia	58.0	+7.4
25	Hungary	54.1	+4.1
26	Bulgaria	50.3	+3.8
27	Romania	50.0	+5.5

Emerging Markets

RANK	COUNTRY	SCORE	10-YR Δ
1	South Korea	81.4	+2.3
2	Greece	80.6	+4.5
3	Czech Republic	68.3	+3.8
4	Chile	63.4	+3.7
5	Argentina	60.2	+3.4
6	Taiwan	59.2	+2.8
7	Poland	58.9	+4.8
8	Kuwait	57.3	+4.5
9	Qatar	56.9	+3.7
10	Malaysia	55.4	+3.8
11	United Arab Emirates	55.2	+3.6
12	Colombia	55.0	+5.9
13	Hungary	54.1	+4.1
14	Russia	53.0	+8.0
15	Turkey	51.3	+6.5
	Group Average	*50.0*	
16	Brazil	49.7	+7.0
17	Thailand	48.4	+4.9
18	Mexico	47.5	+2.8
19	Saudi Arabia	47.2	+7.8
20	Peru	45.1	+3.6
21	China	41.8	+5.5
22	Philippines	34.1	+4.9
23	Egypt	33.8	+6.8
24	South Africa	31.1	+7.1
25	Indonesia	29.0	+4.2
26	India	16.3	+3.9
27	Pakistan	14.6	+1.8

Least Developed Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Cambodia	30.5	+4.4
2	Bhutan	29.8	+2.2
3	Timor-Leste	28.9	-0.3
4	São Tomé and Príncipe	28.7	+3.2
5	Mozambique	28.1	+1.5
6	Tanzania	27.4	+1.8
7	Comoros	27.3	+0.9
8	Laos	27.2	+5.6
9	Vanuatu	26.7	+0.4
10	Malawi	26.5	+2.8
11	Uganda	25.7	+0.7
12	Ethiopia	25.2	+1.4
13	Myanmar	24.6	+5.9
14	Rwanda	24.4	+1.6
15	Kiribati	22.9	+1.0
16	Bangladesh	22.4	+2.7
	Dem. Rep. Congo	22.4	+2.0
18	Madagascar	22.1	+1.0
19	Burundi	21.9	+1.2
	Group Average	*21.9*	
20	Haiti	21.8	+1.7
21	Gambia	21.4	+0.1
22	Liberia	21.3	+1.0
23	Nepal	21.0	+2.3
	Zambia	21.0	+2.8
25	Sudan	20.8	+3.3
26	Angola	20.4	+2.9
	Senegal	20.4	+0.3
	Solomon Islands	20.4	-0.1
29	Benin	20.3	+0.5
30	Djibouti	20.1	+2.9
31	Afghanistan	20.0	+1.0
	Mauritania	20.0	+3.2
33	Burkina Faso	19.6	-0.4
34	Mali	19.5	+0.9
35	Sierra Leone	19.1	+0.9
36	Guinea	18.6	+1.3
37	Niger	17.1	-0.6
38	Togo	16.4	+1.3
39	Eritrea	15.5	+1.5
40	Guinea-Bissau	15.1	+2.5
41	Chad	14.9	-1.0
42	Central African Republic	12.2	-0.1
43	Lesotho	11.8	+2.2

Landlocked Developing Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Paraguay	46.8	+3.6
2	Moldova	45.6	+8.2
3	Turkmenistan	45.0	+6.3
4	North Macedonia	43.6	+4.0
5	Armenia	43.5	+4.1
6	Kazakhstan	40.8	+5.2
7	Bolivia	35.9	+3.8
8	Kyrgyzstan	33.7	+4.9
9	Azerbaijan	32.7	+3.3
10	Bhutan	29.8	+2.2
11	Uzbekistan	29.7	+3.0
12	Mongolia	27.6	+3.0
	Group Average	*27.2*	
13	Laos	27.2	+5.6
14	Malawi	26.5	+2.8
15	Uganda	25.7	+0.7
16	Ethiopia	25.2	+1.4
17	Rwanda	24.4	+1.6
18	Zimbabwe	22.5	+2.7
19	Burundi	21.9	+1.2
20	Nepal	21.0	+2.3
	Zambia	21.0	+2.8
22	Tajikistan	20.7	+2.6
23	Botswana	20.2	+4.2
24	Afghanistan	20.0	+1.0
25	Burkina Faso	19.6	-0.4
26	Mali	19.5	+0.9
27	Eswatini	17.6	+3.9
28	Niger	17.1	-0.6
29	Chad	14.9	-1.0
30	Central African Republic	12.2	-0.1
31	Lesotho	11.8	+2.2

TABLE 2-8. Rankings, Environmental Health scores, and ten-year changes in score, by peer group.

Organisation of Islamic Cooperation

RANK	COUNTRY	SCORE	10-YR Δ
1	Brunei Darussalam	74.0	+0.1
2	Jordan	58.6	+7.0
3	Kuwait	57.3	+4.5
4	Qatar	56.9	+3.7
5	Malaysia	55.4	+3.8
6	United Arab Emirates	55.2	+3.6
7	Lebanon	53.1	+6.6
8	Turkey	51.3	+6.5
9	Algeria	50.4	+5.1
10	Bahrain	49.2	+5.5
	Tunisia	49.2	+5.2
12	Iran	48.3	+6.4
13	Maldives	48.0	+4.9
14	Saudi Arabia	47.2	+7.8
15	Turkmenistan	45.0	+6.3
16	Albania	44.5	+3.1
17	Oman	43.4	+7.0
18	Kazakhstan	40.8	+5.2
19	Iraq	39.5	+11.2
20	Suriname	36.6	+2.7
21	Egypt	33.8	+6.8
22	Kyrgyzstan	33.7	+4.9
23	Guyana	33.5	+4.7
24	Morocco	33.3	+5.6
	Group Average	*33.2*	
25	Azerbaijan	32.7	+3.3
26	Uzbekistan	29.7	+3.0
27	Indonesia	29.0	+4.2
28	Mozambique	28.1	+1.5
29	Gabon	27.9	+6.5
30	Comoros	27.3	+0.9
31	Uganda	25.7	+0.7
32	Bangladesh	22.4	+2.7
33	Gambia	21.4	+0.1
34	Sudan	20.8	+3.3
35	Tajikistan	20.7	+2.6
36	Senegal	20.4	+0.3
37	Benin	20.3	+0.5
38	Djibouti	20.1	+2.9
39	Afghanistan	20.0	+1.0
	Mauritania	20.0	+3.2
41	Burkina Faso	19.6	-0.4
42	Mali	19.5	+0.9
43	Côte d'Ivoire	19.4	+1.6
44	Sierra Leone	19.1	+0.9
45	Guinea	18.6	+1.3
46	Niger	17.1	-0.6
47	Togo	16.4	+1.3
48	Guinea-Bissau	15.1	+2.5
49	Chad	14.9	-1.0
50	Pakistan	14.6	+1.8
51	Nigeria	13.9	+1.1
52	Cameroon	13.6	+2.2

G-20

RANK	COUNTRY	SCORE	10-YR Δ
1	Canada	91.7	+3.3
	United Kingdom	91.7	+3.4
3	Australia	91.6	+2.3
4	France	91.5	+6.3
5	Japan	90.3	+0.4
6	Germany	89.6	+3.9
7	Italy	85.5	+4.6
8	United States of America	82.8	+4.8
9	South Korea	81.4	+2.3
	Group Average	*64.4*	
10	Argentina	60.2	+3.4
11	Russia	53.0	+8.0
12	Turkey	51.3	+6.5
13	Brazil	49.7	+7.0
14	Mexico	47.5	+2.8
15	Saudi Arabia	47.2	+7.8
16	China	41.8	+5.5
17	South Africa	31.1	+7.1
18	Indonesia	29.0	+4.2
19	India	16.3	+3.9

Commonwealth of Nations

RANK	COUNTRY	SCORE	10-YR Δ
1	Canada	91.7	+3.3
	United Kingdom	91.7	+3.4
3	Australia	91.6	+2.3
4	New Zealand	88.0	+2.1
5	Malta	86.1	+6.1
6	Singapore	85.0	+2.8
7	Cyprus	81.5	+5.2
8	Brunei Darussalam	74.0	+0.1
9	Barbados	60.7	+0.9
10	Mauritius	60.0	+4.6
11	Antigua and Barbuda	55.5	+2.2
12	Malaysia	55.4	+3.8
13	Trinidad and Tobago	54.6	+2.2
14	Bahamas	53.1	+1.7
15	Seychelles	50.8	+2.1
16	Maldives	48.0	+4.9
17	Saint Lucia	47.8	+1.0
18	Dominica	46.8	+0.7
19	Grenada	46.3	+1.9
20	Jamaica	45.5	-0.1
21	Saint Vincent and the Grena..	44.1	+1.2
22	Tonga	43.6	+0.9
23	Samoa	42.4	+0.7
24	Sri Lanka	42.1	+4.2
	Group Average	*41.5*	
25	Belize	40.3	+1.1
26	Fiji	34.7	+1.7
27	Guyana	33.5	+4.7
28	South Africa	31.1	+7.1
29	Papua New Guinea	28.4	+1.7
30	Mozambique	28.1	+1.5
31	Tanzania	27.4	+1.8
32	Vanuatu	26.7	+0.4
33	Malawi	26.5	+2.8
34	Kenya	25.7	+4.0
	Uganda	25.7	+0.7
36	Rwanda	24.4	+1.6
37	Kiribati	22.9	+1.0
38	Namibia	22.5	+3.8
39	Bangladesh	22.4	+2.7
40	Gambia	21.4	+0.1
41	Zambia	21.0	+2.8
42	Solomon Islands	20.4	-0.1
43	Botswana	20.2	+4.2
44	Ghana	20.1	+1.3
45	Sierra Leone	19.1	+0.9
46	Eswatini	17.6	+3.9
47	India	16.3	+3.9
48	Pakistan	14.6	+1.8
49	Nigeria	13.9	+1.1
50	Cameroon	13.6	+2.2
51	Lesotho	11.8	+2.2

Organization of Ibero-American States

RANK	COUNTRY	SCORE	10-YR Δ
1	Spain	86.8	+4.7
2	Portugal	83.4	+7.1
3	Uruguay	67.7	+4.6
4	Chile	63.4	+3.7
5	Costa Rica	60.5	+3.3
6	Argentina	60.2	+3.4
7	Colombia	55.0	+5.9
8	Cuba	50.5	+2.8
	Group Average	*50.5*	
9	Panama	50.4	+5.8
10	Ecuador	50.2	+5.1
11	Brazil	49.7	+7.0
12	Mexico	47.5	+2.8
13	Paraguay	46.8	+3.6
14	Venezuela	46.5	+2.3
15	Peru	45.1	+3.6
16	El Salvador	42.5	+2.1
17	Nicaragua	40.2	+2.8
18	Dominican Republic	36.1	+0.7
19	Bolivia	35.9	+3.8
20	Honduras	33.4	+1.7
21	Guatemala	30.8	+3.6
22	Equatorial Guinea	27.6	+4.0

Small Island Developing States

RANK	COUNTRY	SCORE	10-YR Δ
1	Singapore	85.0	+2.8
2	Barbados	60.7	+0.9
3	Mauritius	60.0	+4.6
4	Antigua and Barbuda	55.5	+2.2
5	Trinidad and Tobago	54.6	+2.2
6	Bahamas	53.1	+1.7
7	Seychelles	50.8	+2.1
8	Cuba	50.5	+2.8
9	Bahrain	49.2	+5.5
10	Maldives	48.0	+4.9
11	Saint Lucia	47.8	+1.0
12	Dominica	46.8	+0.7
13	Grenada	46.3	+1.9
14	Jamaica	45.5	-0.1
15	Saint Vincent and the Grena..	44.1	+1.2
16	Tonga	43.6	+0.9
17	Samoa	42.4	+0.7
	Group Average	*40.6*	
18	Belize	40.3	+1.1
19	Suriname	36.6	+2.7
20	Dominican Republic	36.1	+0.7
21	Fiji	34.7	+1.7
22	Guyana	33.5	+4.7
23	Marshall Islands	32.6	+2.7
24	Micronesia	30.8	+1.2
25	Cabo Verde	30.4	-1.7
26	Timor-Leste	28.9	-0.3
27	São Tomé and Príncipe	28.7	+3.2
28	Papua New Guinea	28.4	+1.7
29	Comoros	27.3	+0.9
30	Vanuatu	26.7	+0.4
31	Kiribati	22.9	+1.0
32	Haiti	21.8	+1.7
33	Solomon Islands	20.4	-0.1
34	Guinea-Bissau	15.1	+2.5

OECD Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Finland	99.3	+3.5
2	Norway	98.5	+4.1
3	Sweden	98.4	+3.0
4	Iceland	98.1	+1.0
5	Switzerland	95.0	+4.3
6	Ireland	94.2	+6.5
7	Luxembourg	92.6	+5.8
8	Canada	91.7	+3.3
	Denmark	91.7	+5.7
	United Kingdom	91.7	+3.4
11	Australia	91.6	+2.3
12	France	91.5	+6.3
13	Netherlands	91.0	+3.6
14	Japan	90.3	+0.4
15	Germany	89.6	+3.9
16	Austria	88.0	+5.2
	New Zealand	88.0	+2.1
18	Spain	86.8	+4.7
19	Belgium	86.0	+5.7
20	Italy	85.5	+4.6
21	Israel	83.6	+4.5
22	Portugal	83.4	+7.1
23	United States of America	82.8	+4.8
24	South Korea	81.4	+2.3
	Group Average	*81.2*	
25	Greece	80.6	+4.5
26	Estonia	73.0	+9.6
27	Slovenia	68.9	+3.6
28	Czech Republic	68.3	+3.8
29	Slovakia	64.3	+4.9
30	Chile	63.4	+3.7
31	Lithuania	63.2	+8.0
32	Poland	58.9	+4.8
33	Latvia	58.0	+7.4
34	Hungary	54.1	+4.1
35	Turkey	51.3	+6.5
36	Mexico	47.5	+2.8

2.

TABLE 2-9. Rankings, Ecosystem Vitality scores, and ten-year changes in score, by peer group.

Association of Southeast Asia

RANK	COUNTRY	SCORE	10-YR Δ
1	Indonesia	43.7	+4.1
2	Thailand	43.5	+3.6
3	Malaysia	42.9	+4.8
4	Brunei Darussalam	42.0	+3.2
5	Philippines	41.4	-10.0
6	Singapore	40.2	-15.8
7	Laos	39.9	-8.3
	Group Average	*38.3*	
8	Cambodia	35.6	-3.3
9	Viet Nam	28.5	+6.3
10	Myanmar	25.4	-6.0

OPEC Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Gabon	57.8	+3.0
2	United Arab Emirates	55.9	+16.4
3	Venezuela	52.9	-2.2
4	Kuwait	51.2	+18.4
5	Iran	47.8	+10.9
	Group Average	*45.9*	
6	Equatorial Guinea	45.1	+13.3
7	Nigeria	42.4	+5.2
8	Saudi Arabia	41.8	+5.4
9	Algeria	41.0	-2.6
10	Iraq	39.4	-7.3
11	Republic of Congo	39.2	-4.8
12	Angola	35.9	+6.8

La Francophonie

RANK	COUNTRY	SCORE	10-YR Δ
1	Luxembourg	75.4	+15.5
2	Romania	74.4	+9.7
3	Switzerland	72.5	+11.5
4	France	72.3	+5.4
5	Belgium	64.8	-0.3
6	North Macedonia	63.2	+0.9
7	Seychelles	63.1	+23.3
8	Bulgaria	61.5	+4.5
9	Greece	61.4	+2.7
10	Armenia	58.1	+4.7
11	Gabon	57.8	+3.0
12	Canada	57.3	+4.1
13	Central African Republic	53.5	-6.2
14	Albania	52.0	+14.9
15	Burkina Faso	50.9	+11.9
16	Egypt	49.7	+8.3
17	Morocco	48.3	+18.4
18	Cameroon	46.9	+1.0
19	Dem. Rep. Congo	45.7	-2.1
	Group Average	*45.5*	
20	Equatorial Guinea	45.1	+13.3
21	Tunisia	45.0	+7.1
22	Moldova	43.6	-9.3
	São Tomé and Príncipe	43.6	+6.7
24	Dominica	43.1	+1.4
25	Lebanon	40.3	-2.5
26	Rwanda	40.0	-3.7
	Saint Lucia	40.0	-3.0
28	Laos	39.9	-8.3
	Niger	39.9	-13.2
30	Republic of Congo	39.2	-4.8
31	Guinea-Bissau	38.4	-3.2
32	Togo	38.2	-4.4
33	Senegal	37.6	-4.6
34	Benin	36.4	+4.2
35	Mali	36.0	-6.1
36	Cambodia	35.6	-3.3
37	Comoros	35.3	-2.7
	Mauritius	35.3	+7.5
39	Chad	34.6	-0.9
40	Cabo Verde	34.5	+11.1
41	Djibouti	33.4	+1.9
42	Mauritania	32.8	-1.6
43	Guinea	31.5	-8.1
44	Burundi	30.5	-19.2
	Haiti	30.5	+5.8
46	Vanuatu	30.4	-20.1
47	Côte d'Ivoire	30.1	-15.3
48	Madagascar	29.4	-11.7
49	Viet Nam	28.5	+6.3

Arab League

RANK	COUNTRY	SCORE	10-YR Δ
1	United Arab Emirates	55.9	+16.4
2	Bahrain	52.2	+25.2
3	Kuwait	51.2	+18.4
4	Jordan	49.9	+13.9
5	Egypt	49.7	+8.3
6	Morocco	48.3	+18.4
7	Tunisia	45.0	+7.1
8	Sudan	44.1	+11.8
	Group Average	*42.3*	
9	Saudi Arabia	41.8	+5.4
10	Algeria	41.0	-2.6
11	Lebanon	40.3	-2.5
12	Iraq	39.4	-7.3
13	Comoros	35.3	-2.7
14	Oman	35.2	+13.6
15	Djibouti	33.4	+1.9
16	Mauritania	32.8	-1.6
17	Qatar	23.9	-10.5

European Union - 27

RANK	COUNTRY	SCORE	10-YR Δ
1	Denmark	76.4	+8.4
2	Luxembourg	75.4	+15.5
3	Romania	74.4	+9.7
4	Slovenia	74.1	+5.3
5	Austria	74.0	+5.5
6	Czech Republic	72.9	+4.2
7	France	72.3	+5.4
8	Slovakia	70.9	+3.1
9	Hungary	70.0	+2.7
10	Germany	68.9	-0.6
	Group Average	*66.0*	
11	Spain	66.0	+11.2
12	Sweden	65.6	+6.9
13	Finland	65.3	+7.6
14	Belgium	64.8	-0.3
	Netherlands	64.8	0.0
16	Croatia	64.3	+19.2
17	Latvia	64.0	+3.3
18	Lithuania	62.7	+3.3
19	Poland	62.3	-1.3
20	Bulgaria	61.5	+4.5
21	Greece	61.4	+2.7
22	Italy	61.3	-1.3
23	Malta	60.5	+15.4
24	Estonia	60.1	+0.7
25	Ireland	58.6	+0.6
26	Portugal	56.1	+2.0
27	Cyprus	53.7	+7.0

Emerging Markets

RANK	COUNTRY	SCORE	10-YR Δ
1	Czech Republic	72.9	+4.2
2	Hungary	70.0	+2.7
3	Poland	62.3	-1.3
4	Greece	61.4	+2.7
5	South Korea	56.6	+2.1
6	Mexico	55.9	+10.3
	United Arab Emirates	55.9	+16.4
8	Taiwan	55.8	+5.7
9	Brazil	52.2	+3.5
10	Colombia	51.6	-2.2
11	Kuwait	51.2	+18.4
12	South Africa	51.0	+9.4
13	Chile	49.8	+3.6
14	Egypt	49.7	+8.3
	Group Average	*49.0*	
15	Russia	48.8	+1.1
16	Argentina	46.8	+5.9
17	Pakistan	45.3	+8.8
18	Indonesia	43.7	+4.1
19	Thailand	43.5	+3.6
20	Peru	43.2	-3.9
21	Malaysia	42.9	+4.8
22	Saudi Arabia	41.8	+5.4
23	Philippines	41.4	-10.0
24	Turkey	36.9	-0.7
25	India	35.2	-2.5
26	China	34.4	+10.5
27	Qatar	23.9	-10.5

Least Developed Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Central African Republic	53.5	-6.2
2	Burkina Faso	50.9	+11.9
3	Kiribati	47.5	+9.6
4	Malawi	46.2	-6.2
5	Bhutan	45.7	-17.3
	Dem. Rep. Congo	45.7	-2.1
7	Sudan	44.1	+11.8
8	Zambia	43.9	-13.9
9	São Tomé and Príncipe	43.6	+6.7
10	Uganda	42.2	+2.5
11	Ethiopia	40.6	-0.6
12	Nepal	40.5	-15.1
13	Eritrea	40.4	-7.1
14	Rwanda	40.0	-3.7
15	Laos	39.9	-8.3
	Niger	39.9	-13.2
17	Timor-Leste	39.5	-4.8
18	Lesotho	38.8	-3.1
19	Guinea-Bissau	38.4	-3.2
20	Togo	38.2	-4.4
21	Mozambique	37.8	+7.9
22	Senegal	37.6	-4.6
	Group Average	*37.3*	
23	Benin	36.4	+4.2
24	Mali	36.0	-6.1
25	Angola	35.9	+6.8
26	Cambodia	35.6	-3.3
27	Comoros	35.3	-2.7
28	Chad	34.6	-0.9
29	Bangladesh	33.5	-1.9
	Tanzania	33.5	+1.7
31	Djibouti	33.4	+1.9
32	Mauritania	32.8	-1.6
33	Gambia	32.1	+5.7
34	Guinea	31.5	-8.1
35	Solomon Islands	30.9	-3.3
36	Burundi	30.5	-19.2
	Haiti	30.5	+5.8
38	Vanuatu	30.4	-20.1
39	Sierra Leone	30.2	+0.7
40	Madagascar	29.4	-11.7
41	Afghanistan	29.2	+7.7
42	Myanmar	25.4	-6.0
43	Liberia	23.6	-6.7

Landlocked Developing Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	North Macedonia	63.2	+0.9
2	Armenia	58.1	+4.7
3	Azerbaijan	55.7	+4.5
4	Uzbekistan	54.1	+3.2
5	Botswana	53.8	-4.7
6	Central African Republic	53.5	-6.2
7	Burkina Faso	50.9	+11.9
8	Tajikistan	49.9	-2.9
9	Bolivia	49.8	-3.2
10	Kazakhstan	47.3	+11.5
11	Zimbabwe	46.7	-14.0
12	Malawi	46.2	-6.2
	Paraguay	46.2	-10.5
14	Bhutan	45.7	-17.3
	Group Average	*44.8*	
15	Eswatini	44.6	-5.4
16	Zambia	43.9	-13.9
17	Kyrgyzstan	43.8	-6.6
18	Moldova	43.6	-9.3
19	Turkmenistan	43.1	+9.8
20	Uganda	42.2	+2.5
21	Ethiopia	40.6	-0.6
22	Nepal	40.5	-15.1
23	Rwanda	40.0	-3.7
24	Laos	39.9	-8.3
	Niger	39.9	-13.2
26	Lesotho	38.8	-3.1
27	Mali	36.0	-6.1
28	Mongolia	35.3	-14.7
29	Chad	34.6	-0.9
30	Burundi	30.5	-19.2
31	Afghanistan	29.2	+7.7

TABLE 2-9. Rankings, Ecosystem Vitality scores, and ten-year changes in score, by peer group.

Organisation of Islamic Cooperation

RANK	COUNTRY	SCORE	10-YR Δ
1	Gabon	57.8	+3.0
2	United Arab Emirates	55.9	+16.4
3	Azerbaijan	55.7	+4.5
4	Uzbekistan	54.1	+3.2
5	Bahrain	52.2	+25.2
6	Albania	52.0	+14.9
7	Kuwait	51.2	+18.4
8	Burkina Faso	50.9	+11.9
	Suriname	50.9	-13.7
10	Jordan	49.9	+13.9
	Tajikistan	49.9	-2.9
12	Egypt	49.7	+8.3
13	Morocco	48.3	+18.4
14	Iran	47.8	+10.9
15	Kazakhstan	47.3	+11.5
16	Cameroon	46.9	+1.0
17	Pakistan	45.3	+8.8
18	Tunisia	45.0	+7.1
19	Sudan	44.1	+11.8
20	Kyrgyzstan	43.8	-6.6
21	Indonesia	43.7	+4.1
22	Turkmenistan	43.1	+9.8
23	Malaysia	42.9	+4.8
24	Nigeria	42.4	+5.2
25	Uganda	42.2	+2.5
26	Brunei Darussalam	42.0	+3.2
27	Saudi Arabia	41.8	+5.4
	Group Average	*41.6*	
28	Algeria	41.0	-2.6
29	Lebanon	40.3	-2.5
30	Niger	39.9	-13.2
31	Iraq	39.4	-7.3
32	Guinea-Bissau	38.4	-3.2
33	Togo	38.2	-4.4
34	Mozambique	37.8	+7.9
35	Senegal	37.6	-4.6
36	Guyana	37.5	-13.7
37	Turkey	36.9	-0.7
38	Benin	36.4	+4.2
39	Mali	36.0	-6.1
40	Comoros	35.3	-2.7
41	Oman	35.2	+13.6
42	Chad	34.6	-0.9
43	Bangladesh	33.5	-1.9
44	Djibouti	33.4	+1.9
45	Mauritania	32.8	-1.6
46	Gambia	32.1	+5.7
47	Guinea	31.5	-8.1
48	Sierra Leone	30.2	+0.7
49	Côte d'Ivoire	30.1	-15.3
50	Afghanistan	29.2	+7.7
51	Maldives	27.4	+8.1
52	Qatar	23.9	-10.5

G-20

RANK	COUNTRY	SCORE	10-YR Δ
1	United Kingdom	74.3	+12.7
2	France	72.3	+5.4
3	Germany	68.9	-0.6
4	Japan	65.1	-0.9
5	Australia	63.8	+7.6
6	Italy	61.3	-1.3
7	United States of America	60.3	+1.7
8	Canada	57.3	+4.1
9	South Korea	56.6	+2.1
10	Mexico	55.9	+10.3
	Group Average	*54.0*	
11	Brazil	52.2	+3.5
12	South Africa	51.0	+9.4
13	Russia	48.8	+1.1
14	Argentina	46.8	+5.9
15	Indonesia	43.7	+4.1
16	Saudi Arabia	41.8	+5.4
17	Turkey	36.9	-0.7
18	India	35.2	-2.5
19	China	34.4	+10.5

Commonwealth of Nations

RANK	COUNTRY	SCORE	10-YR Δ
1	United Kingdom	74.3	+12.7
2	Australia	63.8	+7.6
3	Seychelles	63.1	+23.3
4	Malta	60.5	+15.4
5	New Zealand	60.2	+1.7
6	Canada	57.3	+4.1
7	Botswana	53.8	-4.7
8	Cyprus	53.7	+7.0
9	Namibia	52.0	+12.6
10	Saint Vincent and the Grena..	51.3	+9.4
11	South Africa	51.0	+9.4
12	Jamaica	50.0	+3.4
13	Kiribati	47.5	+9.6
14	Cameroon	46.9	+1.0
15	Malawi	46.2	-6.2
16	Tonga	46.0	+3.3
17	Pakistan	45.3	+8.8
18	Eswatini	44.6	-5.4
19	Zambia	43.9	-13.9
20	Antigua and Barbuda	43.8	+4.0
	Group Average	*43.2*	
21	Dominica	43.1	+1.4
22	Belize	43.0	-4.1
23	Malaysia	42.9	+4.8
	Trinidad and Tobago	42.9	+16.6
25	Nigeria	42.4	+5.2
26	Uganda	42.2	+2.5
27	Brunei Darussalam	42.0	+3.2
28	Grenada	40.9	+7.7
29	Kenya	40.6	-2.8
30	Singapore	40.2	-15.8
31	Rwanda	40.0	-3.7
	Saint Lucia	40.0	-3.0
33	Lesotho	38.8	-3.1
34	Mozambique	37.8	+7.9
35	Guyana	37.5	-13.7
36	Bahamas	37.0	-5.3
37	Sri Lanka	36.9	-3.9
38	Barbados	35.6	+1.0
39	Mauritius	35.3	+7.5
40	India	35.2	-2.5
41	Papua New Guinea	35.1	+11.7
42	Fiji	34.2	-5.4
43	Samoa	33.9	-7.0
44	Bangladesh	33.5	-1.9
	Tanzania	33.5	+1.7
46	Ghana	32.6	-8.2
47	Gambia	32.1	+5.7
48	Solomon Islands	30.9	-3.3
49	Vanuatu	30.4	-20.1
50	Sierra Leone	30.2	+0.7
51	Maldives	27.4	+8.1

Organization of Ibero-American States

RANK	COUNTRY	SCORE	10-YR Δ
1	Spain	66.0	+11.2
2	Portugal	56.1	+2.0
3	Mexico	55.9	+10.3
4	Dominican Republic	53.2	+4.6
5	Venezuela	52.9	-2.2
6	Brazil	52.2	+3.5
7	Colombia	51.6	-2.2
8	Ecuador	51.5	+3.1
9	Bolivia	49.8	-3.2
	Chile	49.8	+3.6
	Group Average	*47.8*	
11	Costa Rica	47.2	-0.5
12	Cuba	47.0	-0.6
13	Argentina	46.8	+5.9
14	Paraguay	46.2	-10.5
15	Panama	45.2	+1.5
16	Equatorial Guinea	45.1	+13.3
17	El Salvador	43.5	+8.0
18	Peru	43.2	-3.9
19	Honduras	40.7	+9.7
20	Nicaragua	38.6	-1.6
21	Uruguay	36.7	-1.4
22	Guatemala	32.5	-2.8

Small Island Developing States

RANK	COUNTRY	SCORE	10-YR Δ
1	Seychelles	63.1	+23.3
2	Dominican Republic	53.2	+4.6
3	Bahrain	52.2	+25.2
4	Saint Vincent and the Grena..	51.3	+9.4
5	Suriname	50.9	-13.7
6	Jamaica	50.0	+3.4
7	Kiribati	47.5	+9.6
8	Cuba	47.0	-0.6
9	Tonga	46.0	+3.3
10	Antigua and Barbuda	43.8	+4.0
11	São Tomé and Príncipe	43.6	+6.7
12	Dominica	43.1	+1.4
13	Belize	43.0	-4.1
14	Trinidad and Tobago	42.9	+16.6
15	Grenada	40.9	+7.7
	Group Average	*40.5*	
16	Singapore	40.2	-15.8
17	Saint Lucia	40.0	-3.0
18	Timor-Leste	39.5	-4.8
19	Guinea-Bissau	38.4	-3.2
20	Guyana	37.5	-13.7
21	Bahamas	37.0	-5.3
22	Barbados	35.6	+1.0
23	Comoros	35.3	-2.7
	Mauritius	35.3	+7.5
25	Papua New Guinea	35.1	+11.7
26	Cabo Verde	34.5	+11.1
	Micronesia	34.5	-8.8
28	Fiji	34.2	-5.4
29	Samoa	33.9	-7.0
30	Solomon Islands	30.9	-3.3
31	Haiti	30.5	+5.8
32	Vanuatu	30.4	-20.1
33	Marshall Islands	29.6	0.0
34	Maldives	27.4	+8.1

OECD Countries

RANK	COUNTRY	SCORE	10-YR Δ
1	Denmark	76.4	+8.4
2	Luxembourg	75.4	+15.5
3	United Kingdom	74.3	+12.7
4	Slovenia	74.1	+5.3
5	Austria	74.0	+5.5
6	Czech Republic	72.9	+4.2
7	Switzerland	72.5	+11.5
8	France	72.3	+5.4
9	Slovakia	70.9	+3.1
10	Hungary	70.0	+2.7
11	Germany	68.9	-0.6
12	Spain	66.0	+11.2
13	Sweden	65.6	+6.9
14	Finland	65.3	+7.6
15	Japan	65.1	-0.9
16	Belgium	64.8	-0.3
	Netherlands	64.8	0.0
18	Latvia	64.0	+3.3
19	Australia	63.8	+7.6
	Norway	63.8	+10.0
	Group Average	*63.7*	
21	Lithuania	62.7	+3.3
22	Poland	62.3	-1.3
23	Greece	61.4	+2.7
24	Italy	61.3	-1.3
25	United States of America	60.3	+1.7
26	New Zealand	60.2	+1.7
27	Estonia	60.1	+0.7
28	Ireland	58.6	+0.6
29	Canada	57.3	+4.1
30	South Korea	56.6	+2.1
31	Portugal	56.1	+2.0
32	Mexico	55.9	+10.3
33	Iceland	55.0	0.0
34	Israel	54.0	+5.7
35	Chile	49.8	+3.6
36	Turkey	36.9	-0.7

Chapter 3. Explaining Performance

1. INTRODUCTION

Perhaps the most common question posed to the EPI research team is What determines success in terms of EPI results? We have therefore devoted considerable effort to analyzing the correlates of sustainability in the 2020 EPI. As we discuss below, a number of explanatory factors can be identified including, most notably, good governance.

Over many iterations of the EPI, we and other researchers have noted that environmental performance correlates strongly with a country's wealth. Figure 3-1 illustrates that this relationship exists in the 2020 EPI, and indeed the most recent results show a stronger correlation than prior versions of the Index. As we explain in Chapter 2, this correlation may not be surprising, given that improved outcomes on many dimensions of sustainability require investments in infrastructure, administrative capacity, and human capital, which wealthier countries are better positioned to make.

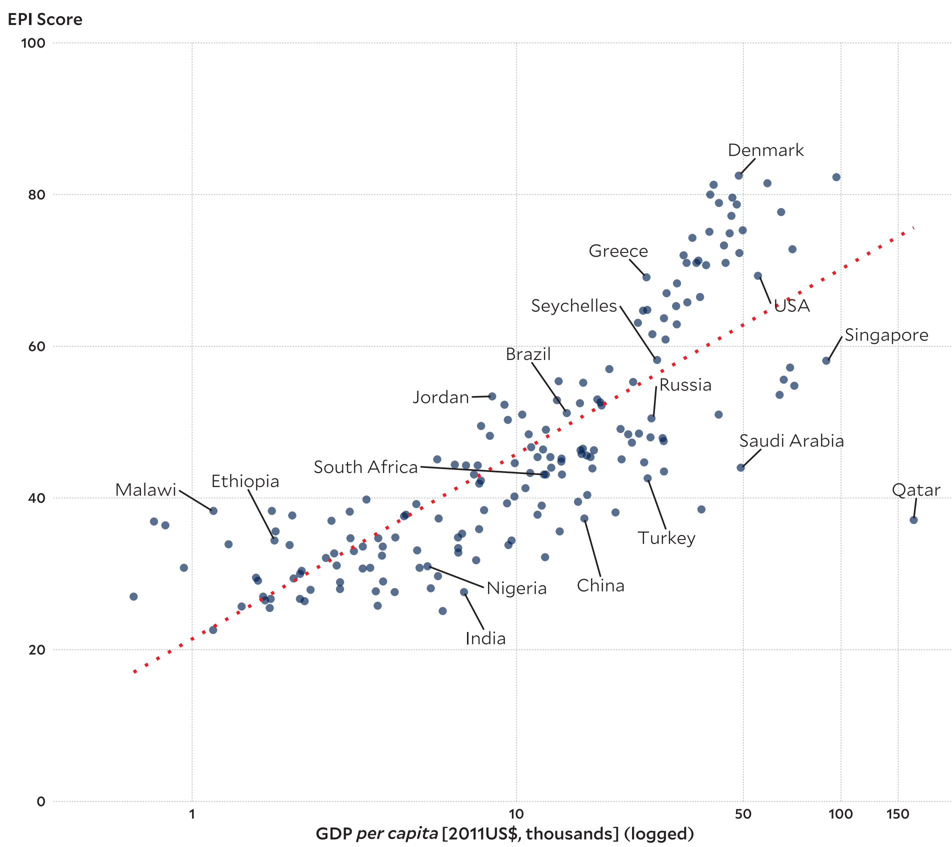
Yet country wealth does not entirely explain performance. As Figure 3-1 also shows, some countries outperform expectations based on wealth – notably those countries markedly above the dotted regression line – while others underperform projections based purely on country wealth and end up below the regression line. This chapter investigates which additional factors might account for the observed variation in 2020 EPI scores – and what lessons these explanatory factors might hold for policymakers and other stakeholders.

This chapter proceeds as follows. First, we review the literature on explanations for EPI scores, both to show the breadth of scholarship and as a foundation for our own analysis. We chose three general categories of explanatory factors: indicators of good governance, sectoral composition of the economy, and indices of economic liberalism. Second, we describe our data and statistical techniques, which rely on correlation analysis. Third, we discuss how our results largely show that good governance is strongly associated with environmental performance, though not for each issue category. Economic liberalism is moderately correlated with EPI scores, and the explanatory power of economic sectors is relatively weak. Some issue categories defy explanation in our analysis, namely, Biodiversity & Habitat, Ecosystem Services, Fisheries, and Agriculture. Finally, we conclude with some discussion of what insights our analysis might hold for decisionmakers and the wider sustainability community.

2. BACKGROUND

There is extensive literature focused on understanding the associations between the EPI and other variables including indicators that might explain success on various sustainability goals. Some analyses have used the EPI as an independent variable to explain performance on issues such as CO_2 emissions (Ponce de Leon Barido & Marshall, 2014) or as part of developing a composite sustainability index (Strezov et al., 2017). A number of studies have also used the

FIGURE 3-1. The relationship between 2020 Environmental Performance Index scores and GDP per capita in 2018 is positive and strong (r = 0.80), though there remain countries that out- or underperform expectations, given their level of wealth.



EPI as a dependent variable to explore how various factors are associated with environmental performance. These factors span a wide range of fields and include the design of a country's constitution (Cepparulo et al., 2019; Jeffords & Minkler, 2016); culture (Kumar et al., 2019); levels of income inequality (Morse, 2018); ethnic diversity (Das & DiRienzo, 2009); social capital (Grafton & Knowles, 2004); and other metrics regarding health, governance, and economic conditions (Gallego-Álvarez et al., 2014; Gorham et al., 2019; Lisciandra & Migliardo, 2017).

Given the universe of factors suggested by the literature and our own survey of data sources, we could have analyzed a long list of variables. While the factors assessed and indicators used by previous researchers may be of interest within certain academic fields, not all are policy relevant.

Our analysis is thus more sharply focused on finding explanations of performance that lead to insights for policymakers. Several studies also focus on particular regions or sets of countries, such as the European Union (Apostoaie & Maxim, 2017; Hampel et al., 2016), BRICS countries (Chowdhury & Islam, 2017), OPEC countries (Shahabadi et al., 2016), and OECD countries (Ozymy & Rey, 2013). In many cases, these studies rely on some variables only available at these smaller scales and not for the whole world. We narrowed our survey to datasets that offered complete or nearly complete global coverage. This restriction echoes the inclusion criteria for EPI datasets described in Chapter 15, and we likewise prioritized explanatory factors that are recent, open source, well documented, and available from reputable data partners. Unfortunately, these criteria excluded many variables that are potentially interesting, including measures of social and human capital, such as the World Development Indicators adult literacy rate (Cepparulo et al., 2019) or the Social Progress Index. Finally, we considered how the available explanatory factors might be redundant, either thematically overlapping or with such high correlation with other factors that they provide no further explanatory power.

Upon our initial survey, we found dozens of datasets with the potential for explaining environmental performance. These factors were grounded in the scholarly literature or otherwise available from trusted international data sources. After multiple layers of review for alignment with the purposes of this analysis, data quality, and distinct contributions to explanatory power, we arrived at a list of 11 additional explanatory factors, which fall into three categories.

2.1 GOVERNANCE

The World Bank's World Governance Indicators (WGI) capture six different aspects of *governance*. These indicators of a country's traditions and institutions include measures of a country's ability to elect, monitor, and replace authorities; a country's ability to create and institute policy initiatives; and the degree to which citizens and state figures respect governing institutions.

Kaufmann et al. (2010) score countries on six indicators:

"• **Voice and Accountability** – capturing perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

• **Political Stability and Absence of Violence/Terrorism** – capturing perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.

• **Government Effectiveness** – capturing perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

• **Regulatory Quality** – capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

• **Rule of Law** – capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

• **Control of Corruption** – capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests. (p. 4)"

The World Bank's Development Research Group generates these indicators using a number of data sources, including surveys of subject experts, households, and firms, nongovernment and public sector organizations, and commercial business information providers. Overall scores are created with a weighted average of the data from the individual sources, using an unobserved components model. This model assigns more weights to the sources that are more correlated with each other, and vice versa (Kaufmann et al., 2010). Scores range from -3 to 3.

The literature provides robust evidence that most of the WGIs are significantly correlated with the EPI and its subcomponents. Most studies focus on one or two of the WGIs and usually only as control variables in multivariate analyses. In particular, Control of Corruption has a strong and positive correlation with the EPI (Gallego-Álvarez et al., 2014; Hsu et al., 2013; Lisciandra & Migliardo, 2017). Government Effectiveness has a positive and significant relationship with the 2014 EPI and policy objectives (Eisenstadt et al., 2018); yet in a multivariate regression including other WGIs, Gallego-Álvarez et al. (2014) find a significant and negative association with the 2012 EPI. Although the authors detect no appreciable multicollinearity between the variables, a negative coefficient is hard to interpret in a multivariate setting, for both government effectiveness and political stability. Studies of the WGI and the 2012 EPI find significant positive associations for the rule of law (Jeffords & Minkler, 2016), and voice and accountability (Gallego-Álvarez et al., 2014; Hsu et al., 2013).

Below the level of policy objectives, two studies provide deeper context of the 2012 EPI through bivariate correlations between the WGIs and the issue categories. Gallego-Álvarez & Fernández-Gómez (2016) provide coefficients for every issue category and all six WGIs, and Hsu et al. (2013) use five issue categories and two WGIs – control of corruption and voice and accountability. At this more granular level, the significance and direction of the relationships are mixed. All WGIs show significant and positive relationships with the Environmental Health categories and weaker correlations with Biodiversity & Habitat and Forestry. Both studies show weak but negative relationships between the WGI and the issue categories for Fisheries and Climate Change, and Gallego-Álvarez & Fernández-Gómez (2016) report virtually no correlation with Agriculture. It appears as if correlations with higher-level scores in the EPI mask substantial variation in how the WGIs relate to the issue categories, and a fresh look at correlations across all levels with the 2020 EPI may provide insights for policymakers addressing specific environmental challenges.

2.2 SECTORAL COMPOSITION

For measures of economic sectors, we used the World Bank's data on services, manufacturing, and exports as a percent of GDP, which they define as follows:

- **Services, value added (% of GDP)** – "total value added in wholesale and retail trade, transport, and government, financial, professional, and personal services such as education, health care, and real estate services." (World Bank, 2020e)
- **Exports of goods and services (% of GDP)** – "total value of goods and services provided to other countries." (World Bank, 2020a)
- **Manufacturing, value added (% of GDP)** – "total value added by industries that fall within ISIC divisions 15–37." (World Bank, 2020b)

Previous studies have linked environmental performance to the sectoral composition of the economy. A higher share of services in a country's economy correlates with higher scores on the EPI (Apostoaie & Maxim, 2017; Chakraborty & Mukherjee, 2013) and lower CO_2 emissions (Cepparulo et al., 2019). These findings are consistent with the idea that pressures on the environment lessen as countries de-industrialize and shift to a service-based economy. Indeed, higher shares of industry and manufacturing exports are correlated with lower EPI scores (Chakraborty & Mukherjee, 2013; Kheirollahi et al., 2014; Shahabadi et al., 2016; Wen et al., 2016). However, the relationship between economic structure and environmental performance may not be the same across all countries or for all environmental issues. Apostoaie & Maxim (2017) found that a higher share of services had a significant positive correlation with Environmental Health but an insignificant negative correlation with Ecosystem Vitality. We therefore expect that these measures of countries' economies may provide information above what is suggested by their level of wealth, as measured by GDP per capita.

2.3 ECONOMIC LIBERALISM

Economic liberalism has two alternative measures: the World Bank's Ease of Doing Business Index and the Index of Economic Freedom from the Heritage Foundation. In the two previous categories, each factor measures a different dimension of its overarching construct. We might consider the two indices here, though, as alternative ways of measuring economic liberalism, with some conceptual or empirical overlap.

The Ease of Doing Business Index measures the level of a country's business regulations and their enforcement on small and medium-size companies. It consists of 41 indicators falling into 10 general categories: "starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency" (World Bank, 2020c). Like the EPI, indicators are converted to 0–100 scores using a distance-to-target technique (see Chapter 15) and aggregated into a top-level score.

The Index of Economic Freedom measures the degree to which individuals of a country have the right to control their own labor and property. It consists of 12 components falling into four general categories: rule of law, government size, regulatory efficiency, and open markets. The Index of Economic Freedom likewise gives countries a 0–100 score (Miller et al., 2020).

Including economic liberalism in our analysis contributes to the research on whether open markets may be helpful or harmful to the environment. Domestically, environmental performance may depend on rigorous enforcement of strong rules protecting human health and natural resources, even if these regulations raise costs for businesses and impede economic activity. Conversely, countries with lower burdens on firms may see higher economic growth, generating the wealth necessary for infrastructure investments, capital stock turnover, and sectoral changes that pave the way for cleaner environments. Internationally, Kumar et al. (2019, p. 1052) summarize literature supporting two competing theories regarding trade; that is, either environmental quality deteriorates as countries compete for mobile capital by loosening regulations, or multinational firms accelerate the diffusion of clean technologies and best practices. This theoretical ambivalence about economic liberalism requires empirical testing.

Research so far shows mixed results on the influence of economic liberalism on environmental performance. Shum (2009), the earliest study to test the influence, found that an apparent positive relationship between the Index of Economic Freedom and the 2008 EPI disappeared after controlling for GDP per capita, suggesting no additional explanatory value. In contrast, Mavragani et al. (2016) found a strong relationship between the Open Markets Index and the 2014 EPI that is independent of the level of economic development.

Disaggregating the EPI into its components also produces further ambiguity. Emerson et. al. (2011) tested the relationship between the 2010 EPI and various measures of economic liberalism in trade. They found positive associations of trade flows and trade liberalization with the Environmental Health policy objective but negative or unclear associations with Ecosystem Vitality, even after controlling for economic activity. Likewise, Bernauer and Böhmelt (2013) disaggregated the 2010 EPI into its two policy objectives and the Climate Change issue category. They found no statistically significant relationship between economic liberalism and either Environmental Health or Climate Change, but unlike Emerson et. al. (2011), they found a statistically weak but positive association with Ecosystem Vitality.

In the face of such disparate findings, we hope to shed further light on whether and how economic liberalism might be related to environmental performance and find clues as to what additional explanatory value they might add.

3. METHODOLOGY

3.1 DATA

Most data for this analysis are assembled and calculated by the World Bank and available from the World Bank DataBank at databank.worldbank.org. The only exception is The Index of Economic Freedom, which comes from the Heritage Foundation. The EPI team augmented values for GDP and population with estimates from the IMF and calculated GDP per capita. Before running analysis, we inspected data for outliers and skewness, choosing to take the natural log of GDP per capita, exports, and manufacturing as a percentage of GDP. Table 3-1 provides descriptive statistics. For this analysis, we used the most recent year of data available, and Table 3-1 also shows how many of the 180 EPI countries are covered by each data source. For simplicity, we impute missing values with the median world value, and our results are robust to alternative methods. The online Technical Appendix provides additional details about data sources and calculations, and all data may be downloaded from the EPI website at epi.yale.edu.

3.2 STATISTICAL TECHNIQUES

Correlations capture associations between our explanatory factors and the EPI scores in a straightforward manner. While multivariate regression seems like a promising approach, it does not suit this analysis for a number of

TABLE 3-1. Descriptive statistics and metadata for the explanatory factors of environmental performance on the 2020 EPI.

VARIABLE	YEARS	COUNTRY COVERAGE	MEAN	MEDIAN	MINIMUM	MAXIMUM
GDP per capita [2011$, PPP]	1995–2018	180	19,130	12,106	660	167,566
Voice and Accountability	2002–2018	180	-0.013	0.042	-2.176	1.732
Political Stability and Absence of Violence	2002–2018	180	-0.047	0.017	-2.746	1.541
Government Effectiveness	2002–2018	180	-0.028	-0.151	-1.909	2.231
Control of Corruption	2002–2018	180	-0.041	-0.217	-1.559	2.212
Regulatory Quality	2002–2018	180	-0.025	-0.150	-2.334	2.131
Rule of Law	2002–2018	180	-0.046	-0.217	-2.338	2.046
Services, % of GDP	1994–2018	168	55.3	55.5	28.1	78.6
Exports, % of GDP	1994–2018	170	39.4	33.1	5.9	223.6
Manufacturing, % of GDP	1994–2018	164	12.0	11.5	0.557	33.3
Ease of Doing Business Index	2016–2020	177	63.1	62.5	21.5	87.0
Index of Economic Freedom	1995–2020	175	61.7	61.5	25.2	89.4

reasons. First, there is a high degree of collinearity between the explanatory factors, which complicates the interpretation of results. Second, results are not robust between different model specifications. Changing the model even slightly often resulted in new coefficient estimates with substantially different interpretations. Third, neither theory nor automatic selection methods, such as LASSO or stepwise procedures, point to "correct" model specifications. In light of these difficulties, correlation analysis satisfies our research question with the additional benefit of simplicity. We calculated the Spearman's correlation coefficients between each of the 12 explanatory variables and the EPI score, the two policy objectives, and the 11 issue categories.

Associations between our explanatory factors and the EPI scores might be misleading in case these factors are highly correlated with GDP per capita. Our research question relates to which factors provide additional explanatory power beyond country wealth. For this reason, we also calculate correlations between GDP per capita and each of the 11 explanatory factors.

Further caution must be given that we are not attempting to show causality between the explanatory factors and the EPI scores. Proving causality would require additional data – especially time series of the EPI scores, which we explain are not currently feasible in Chapter 15. While past research explored these questions using backcasted time series from previous EPI reports (e.g., Chakraborty & Mukherjee, 2013; Wen et al., 2016), we repeat our admonition that subsequent versions of the EPI should not be appended to these series – nor should users attempt to assemble time series from multiple versions of the EPI, as methodological changes between reports make these scores incomparable. At most, this analysis shows which factors are associated with the variation in 2020 EPI scores.

4. RESULTS AND DISCUSSION

Correlation coefficients are shown in Figure 3-2, with the relationships between the explanatory factors and the environmental performance scores, and in Figure 3-3, with the relationships between GDP per capita and the other explanatory factors. In general, the results in Figure 3-2 show that EPI and Environmental Health are fairly well explained by many of the factors, though less so for Ecosystem Vitality. All of the health-related issue category scores – Air Quality, Sanitation & Drinking Water, Heavy Metals, and Waste Management – also have significant associations with many factors. Among the ecosystem-related scores, only Water Resources has comparable relationships, and the correlations are especially weak for Ecosystem Services, Fisheries, and Agriculture. This pattern is congruent with the findings of Gallego-Álvarez &

Fernández-Gómez (2016) and Hsu et al. (2013) despite the many changes to the methods since the 2012 EPI. Given the low correlations of these issue categories with the 2020 EPI as a whole (Papadimitriou et al., 2020), these weak associations are not surprising. The generalizations for the other explanatory factors also apply to GDP per capita specifically.

In Figure 3-3, the correlation coefficients between GDP per capita and the other explanatory factors are always positive but range from weak ($r = 0.28$) for manufacturing as a percentage of GDP to relatively strong ($r = 0.81$) for government effectiveness. Given this range of correlations, it is not apparent that any explanatory factors serve as near-perfect proxies for GDP per capita. We interpret their correlation coefficients in Figure 3-2, indicating additional explanatory power, when statistically significant.

4.1 WORLDWIDE GOVERNANCE INDICATORS

Across the environmental performance scores, the WGI correlations in Figure 3-2 are often comparable in strength with those for GDP per capita. Government effectiveness stands out as a relatively strong explanatory factor for the EPI score ($r = 0.83$), though it also has the highest correlation with GDP per capita ($r = 0.81$). Among the WGIs, political stability has the weakest

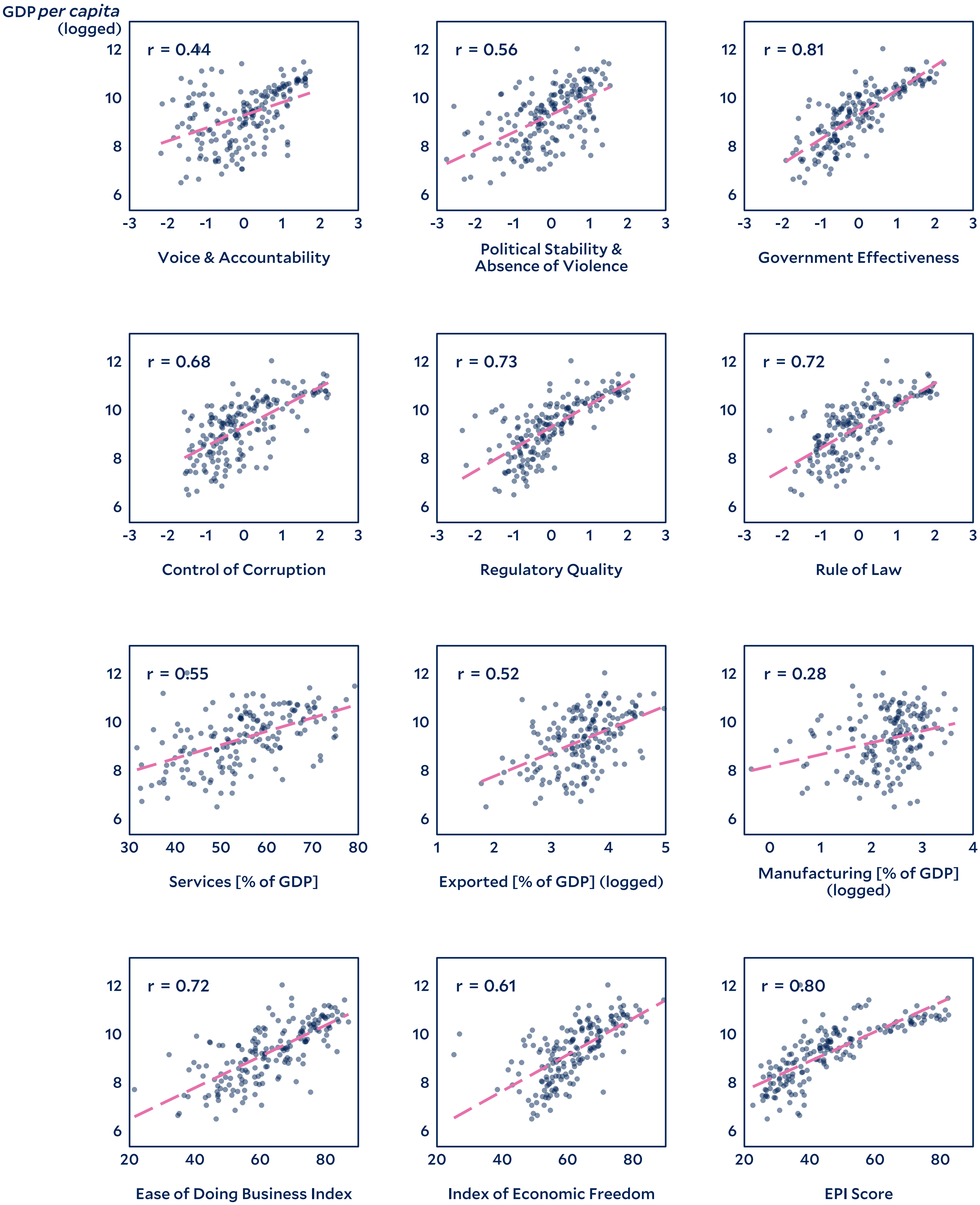
FIGURE 3-2. Correlation coefficients (Spearman's *r*) between scores for the 2020 EPI, policy objectives, and issue categories and various explanatory factors.

	EPI	Env. Health	Ecosystem Vitality	Air Quality	Sanitation & Drinking Water	Heavy Metals	Waste Mgmt.	Biodiversity & Habitat	Ecosystem Services	Fisheries	Climate Change	Pollution Emissions	Agriculture	Water Resources
GDP *per capita*	0.80	0.83	0.61	0.73	0.88	0.71	0.68	0.21	-0.01	-0.08	0.64	0.61	0.20	0.68
Voice & Accountability	0.62	0.64	0.49	0.64	0.57	0.66	0.57	0.30	-0.20	0.15	0.50	0.36	0.10	0.52
Political Stability & Absence of Violence	0.52	0.58	0.36	0.54	0.56	0.59	0.46	0.18	-0.10	0.27	0.35	0.32	-0.05	0.38
Government Effectiveness	0.83	0.86	0.64	0.80	0.85	0.82	0.72	0.30	-0.09	0.01	0.61	0.57	0.24	0.75
Control of Corruption	0.73	0.78	0.54	0.77	0.73	0.75	0.65	0.25	-0.07	0.11	0.51	0.45	0.11	0.69
Regulatory Quality	0.80	0.83	0.62	0.78	0.80	0.78	0.71	0.32	-0.16	-0.02	0.58	0.57	0.25	0.76
Rule of Law	0.78	0.81	0.59	0.78	0.77	0.78	0.70	0.26	-0.10	0.11	0.57	0.53	0.18	0.74
Services [% of GDP]	0.57	0.62	0.41	0.59	0.59	0.54	0.52	0.03	0.02	0.13	0.55	0.40	-0.10	0.46
Exports [% of GDP]	0.41	0.41	0.34	0.32	0.44	0.41	0.36	0.13	-0.03	0.10	0.31	0.37	-0.01	0.35
Manufacturing [% of GDP]	0.26	0.21	0.29	0.14	0.25	0.16	0.23	0.16	-0.20	-0.19	0.28	0.31	0.38	0.26
Ease of Doing Business Index	0.72	0.72	0.59	0.62	0.75	0.68	0.64	0.24	-0.09	-0.06	0.58	0.59	0.30	0.64
Index of Economic Freedom	0.64	0.66	0.49	0.60	0.65	0.65	0.58	0.21	-0.10	0.02	0.47	0.50	0.20	0.61

Correlation Coefficients

-1.00 1.00

FIGURE 3-3. Scatterplots between country wealth, as measured by 2018 GDP per capita [2011$, PPP], and the explanatory factors analyzed here, with correlation coefficients, *r*.



relationships with environmental performance scores ($r = 0.52$) for the overall EPI score and also has only a moderate correlation with country wealth ($r = 0.56$). Control of corruption, regulatory quality, and rule of law all show both higher correlation with performance scores and lower correlation with GDP per capita. These WGIs provide substantial additional explanatory power above what is already accounted for by GDP per capita.

These results largely support the findings of previous studies identifying a positive correlation between environmental performance and the WGIs and other indicators of good governance and institutional quality. Because environmental outcomes largely depend on policy responses, it may be unsurprising that the quality of governance in a country matters a great deal to its environmental performance scores. Previous literature has suggested that control of corruption may impact environmental performance through the government's ability to properly implement or enforce regulations, and that higher voice and accountability allows for citizens to hold public figures accountable to implement strong environmental policy (Gallego-Álvarez et al., 2014; Hsu et al., 2013; Lisciandra & Migliardo, 2017; Mukherjee & Chakraborty, 2010). Government effectiveness and rule of law appear to play a critical role in delivering environmental outcomes (Mavragani et al., 2016), though studies differ over the importance of governance as a driver of environmental performance relative to socio-economic factors like wealth, education, and inequality or political ideology (Apostoaie & Maxim, 2017; Gallego-Álvarez et al., 2014; Morse, 2018).

4.2 ECONOMIC SECTORS

Correlations between the different economic sector variables and the environmental performance scores are lower than the WGI relationships. Services as a percentage of GDP generally has stronger correlations than either exports or manufacturing, though seldom are the correlations among any of the economic sectors with environmental performance even moderately strong. The lack of strong relationships between economic composition and environmental performance implies that the service sector may put less pressure on the environment than sectors responsible for producing industrial or consumer goods. Services ($r = 0.55$) and exports ($r = 0.52$) are somewhat associated with GDP per capita, while manufacturing ($r = 0.28$) is not statistically significant.

Manufacturing has a weak relationship with most of the variables. Agriculture, however, is the only issue category with which manufacturing has a statistically significant correlation. Similar to the WGIs, service sector economies have stronger associations with Environmental Health and its issue categories than with Ecosystem Vitality. This provides some cause for optimism, as countries generally transition from more polluting sectors, such as manufacturing, to services as they develop.

There is a moderate and positive association between exports and the EPI. It should be noted, however, that the current version of the EPI does not take into consideration the impacts of spillover effects from firms transferring dirtier manufacturing processes to other countries. Our measure of exports also is limited to the aggregate value of goods and services and does not distinguish between products with different levels of environmental impacts.

Our results here agree with the previous literature that economies that are more service-oriented have higher environmental performance (Apostoaie & Maxim, 2017; Chakraborty & Mukherjee, 2013). Correlations for manufacturing and exports, however, do not show the same negative correlations as found in the reviewed studies, though our measures might be too coarse to discern where and in which issue categories these economic sectors have the most salient environmental impacts.

4.3 ECONOMIC LIBERALISM

Both indices of economic liberalism seem to capture similar results across the environmental performance scores, with the Ease of Doing Business showing slightly stronger associations than the Index of Economic Freedom. Likewise, the former is more related to GDP per capita ($r = 0.72$) than the latter ($r = 0.61$). As with the other factors, these indices show higher correlations with Environmental Health and its issue categories than with Ecosystem Vitality.

As measured by our variables, the results here give greater weight to the arguments that economic liberalism is associated with higher environmental performance, more so for Environmental Health than Ecosystem Vitality. Open markets, however, are no panacea, as the correlations are moderate and not especially distinct from the effects of GDP per capita, which may confound simple interpretation of these results. We also see that there may be weak, nonexistent, or negative effects for Biodiversity & Habitat, Ecosystem Services, Fisheries, and Agriculture. As with the other explanatory factors, deeper study is needed to tease out the mechanisms through which economic liberalism – or its constituent parts – might best support environmental performance.

5. INSIGHTS FOR ENVIRONMENTAL DECISIONMAKING

We provide this analysis in the hope that it inspires decisionmakers and other stakeholders to think broadly about factors that may be helpful in recasting their environmental policy processes. Our primary message is that governance matters. Policymakers who commit to environmental progress should make it a priority to improve on every dimension of good governance: control of corruption, support for a vibrant public debate reinforced by active NGOs and a free press, public engagement, and even-handed enforcement of scientifically informed regulations. Working to strengthen the institutions responsible for the implementation of sound policies and the protection of personal rights may unlock the potential for transformative change in environmental policy and propel countries to high levels of sustainability. Conversely, wealth in countries that grow more prosperous may go to waste if governance is unable to channel resources toward initiatives that effectively improve public health and protect natural resources. Further research is needed to determine the specific mechanisms that connect governance to environmental performance, but every country should look closely at leaders within its peer groups for inspiration on how to build state capacity, equity, and effectiveness.

From our analysis of economic sectors, we find lessons that suggest potential lines of policy insight, but we are cautious about these preliminary observations. Like previous researchers, we generally find moderate and positive relationships between the service sectors and environmental performance, which may be due to more advanced economies de-industrializing and thus the mix of economic activity becoming cleaner over time. But this trend might also suggest that these nations are off-shoring manufacturing processes and letting other countries do the “dirty work” – then importing the finished goods for consumption without incurring the environmental impacts. Our measures of exports and manufacturing are presently insufficient to discern these pathways with confidence. But the EPI team looks forward to incorporating new metrics of spillover harms and “exported pollution” into the 2020 EPI. And indeed, working with our research partners, we have such indicators already in development and expect to be putting pilot metrics and analyses out for comment in the coming year.

Finally, we find that economic liberalism is positively associated with environmental performance. While our results do not give countries *carte blanche* to pursue *laissez-faire* economic strategies without regard for the environment, they do cast doubt on the implicit tension between economic development and environmental protection. The correlation between open markets and environmental performance is moderate and may be confounded by country wealth. As additional research may illuminate in more detail, countries need not sacrifice economic security in order to be green. Indeed, they may find ways to harness the drive of the private sector to reach new levels of environmental governance, even as more traditional policy tools return diminishing marginal benefits (Esty, 2017).

Country wealth correlates strongly and positively with EPI scores, though this relationship cannot be the final word in explaining countries’ environmental performance. Within every level of GDP per capita, we observe countries that are out- and underperforming their peers. Some countries truly excel, demonstrating that no country should consider itself constrained by economic forces. Governance matters, and policymakers and stakeholders have the ability and responsibility to build and strengthen the institutions that support sustainability. Beyond this analysis, the EPI encourages the world to identify and scrutinize leaders and laggards – globally and within peer groups – yielding additional lessons about what explains performance and how those lessons might apply to each individual country that strives for sustainable development.

Chapter 4. Air Quality

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Air quality emerges as the most important environmental threat to human health in many countries and remains an urgent concern across much of the world. Dangerously low air quality accounts for over one-half of all life-years lost world-wide. Indoor and outdoor air pollution are leading threats to human health (WHO, 2006) on a global scale, but also exhibit regional and socioeconomic disparities in exposure and burden of disease (WHO, 2016). The World Health Organization (WHO) estimates that 90% of the world's population currently lives in areas that exceed WHO thresholds for air pollution (WHO, 2018a).

The EPI uses three indicators to measure air quality: *$PM_{2.5}$ exposure* (fine air particulates smaller than 2.5 micrometers), *household solid fuels*, and ground-level *ozone exposure*. These indicators capture a substantial portion of the global variation in health impacts due to air quality because of the direct threat they pose and because they are correlated with threats posed by other pollutants (WHO, 2016). Recent research suggests that around 7 million people die prematurely every year due to maladies related to air pollution – approximately one in every ten deaths (WHO, 2018a). Moreover, many of the major sources of dangerous air pollutants are also major greenhouse gas emitters. Policymakers who address sources of poor air quality both improve public health and help to mitigate climate change.

1.2 INDICATORS

1.2.1 $PM_{2.5}$ EXPOSURE [55% OF ISSUE CATEGORY]

We measure *$PM_{2.5}$ exposure* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to fine air particulate matter smaller than 2.5 micrometers ($PM_{2.5}$).

1.2.2 HOUSEHOLD SOLID FUELS [40% OF ISSUE CATEGORY]

We measure *household solid fuels* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to household air pollution (HAP) from the use of household solid fuels.

1.2.3 OZONE EXPOSURE [5% OF ISSUE CATEGORY]

We measure *ozone exposure* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to ground-level ozone pollution.

MAP 4-1. Rankings on Air Quality.

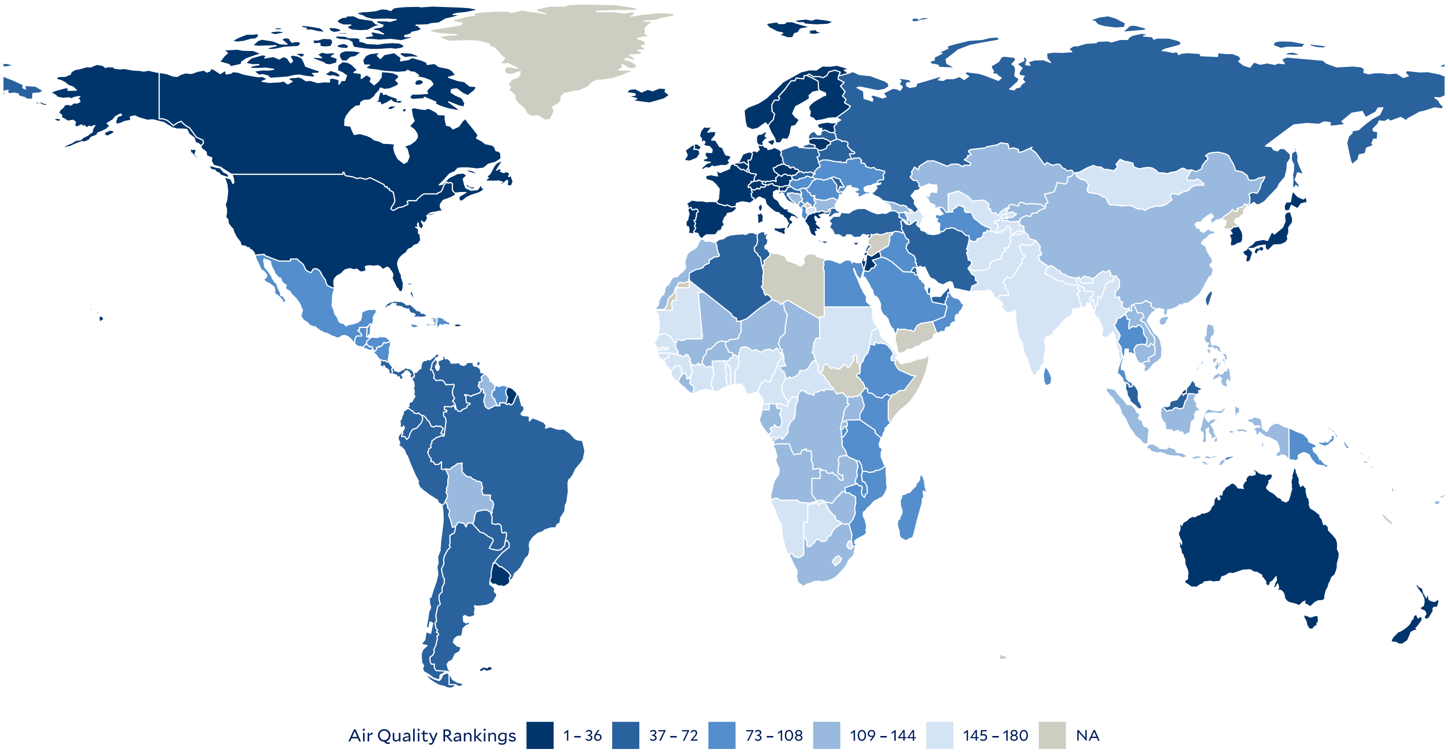


TABLE 4-1. Global rankings, scores, and regional rankings (REG) on Air Quality.

RANK	COUNTRY	SCORE	REG
1	Finland	98.8	1
2	Australia	98.2	2
	Sweden	98.2	2
4	Iceland	98.1	4
5	Norway	97.9	5
6	New Zealand	97.4	6
7	Canada	94.8	7
8	Ireland	94.0	8
9	Switzerland	90.6	9
10	France	88.1	10
11	Luxembourg	87.2	11
12	Japan	85.9	1
13	Denmark	85.5	12
14	United Kingdom	84.7	13
15	Portugal	84.4	14
16	United States of America	84.2	15
17	Netherlands	82.4	16
18	Austria	81.3	17
19	Germany	81.1	18
20	Belgium	80.7	19
21	Estonia	80.3	1
22	Spain	80.2	20
23	Malta	77.6	21
24	Singapore	76.9	2
25	Israel	76.5	1
26	Italy	75.9	22
27	Cyprus	73.1	2
28	South Korea	71.7	3
29	Brunei Darussalam	68.4	4
30	Uruguay	67.7	1
31	Greece	67.5	3
32	Barbados	66.0	2
33	Lithuania	62.7	4
34	Slovenia	60.9	5
35	Czech Republic	58.8	6
36	Jordan	58.0	2
37	Antigua and Barbuda	57.5	3
38	Trinidad and Tobago	57.2	4
39	Argentina	56.9	5
40	Costa Rica	56.2	6
	Slovakia	56.2	7
42	Chile	56.1	7
43	Panama	56.0	8
44	Bahamas	55.6	9
45	Kuwait	55.0	3
46	Latvia	54.8	8
47	Russia	54.1	1
48	Cuba	53.9	10
49	Seychelles	53.6	1
50	Taiwan	53.2	5
51	Venezuela	51.3	11
52	Maldives	51.2	1
53	Mauritius	51.1	2
54	Croatia	50.8	9
55	Malaysia	50.3	6
56	Brazil	50.0	12
57	Belarus	49.9	2
58	Turkey	49.5	10
59	Iran	49.2	4
60	Colombia	49.1	13
61	Ecuador	48.7	14
	Tunisia	48.7	5
63	Qatar	48.6	6
	United Arab Emirates	48.6	6
65	Lebanon	47.8	8
66	Paraguay	47.0	15
67	Saint Lucia	46.3	16
68	Peru	46.0	17
69	Algeria	45.3	9
70	Poland	44.7	11
71	Moldova	44.3	3
72	Dominica	44.2	18
73	Jamaica	43.6	19
	Romania	43.6	12
75	Grenada	42.9	20
76	Hungary	42.8	13
77	El Salvador	42.6	21
	St. Vincent and Grenadines	42.6	21
79	Turkmenistan	42.0	4
80	Nicaragua	41.7	23
81	Albania	41.2	14
	Bahrain	41.2	10
83	Mexico	40.8	24
84	Mozambique	40.7	3
85	Thailand	40.6	7
86	Ukraine	39.8	5
87	Malawi	39.6	4
88	Tonga	39.5	8
89	Belize	39.4	25
90	Ethiopia	38.0	5
91	Sri Lanka	37.8	2
92	Comoros	37.7	6
93	Dominican Republic	37.4	26
	Saudi Arabia	37.4	11
	Suriname	37.4	26
96	Oman	36.4	12
97	Armenia	36.3	6
	Iraq	36.3	13
99	Madagascar	36.1	7
100	Burundi	36.0	8
101	Tanzania	35.8	9
102	Honduras	35.4	28
103	Egypt	35.3	14
104	Kenya	34.9	10
105	Guatemala	34.3	29
106	Montenegro	33.9	15
	Papua New Guinea	33.9	9
108	Serbia	33.6	16
	Timor-Leste	33.6	10
110	Samoa	33.4	11
111	Bulgaria	33.0	17
112	Uganda	32.6	11
113	Marshall Islands	32.5	12
114	Bolivia	32.4	30
115	Kazakhstan	32.0	7
	Viet Nam	32.0	13
117	Guyana	31.9	31
118	Bosnia and Herzegovina	31.6	18
119	Georgia	31.1	8
	Haiti	31.1	32
121	Liberia	30.9	12
	Rwanda	30.9	12
123	Philippines	30.4	14
124	Niger	30.3	14
125	Cambodia	30.1	15
126	Fiji	30.0	16
127	Dem. Rep. Congo	29.9	15
128	Kiribati	29.2	17
	Mali	29.2	16
130	Micronesia	29.0	18
131	Burkina Faso	28.9	17
	South Africa	28.9	17
133	Vanuatu	28.6	19
134	Gabon	28.2	19
135	Laos	27.8	20
136	Zimbabwe	27.2	20
137	China	27.1	21
138	Kyrgyzstan	27.0	9
	Morocco	27.0	15
	Solomon Islands	27.0	22
	Zambia	27.0	21
142	Angola	26.8	22
	Chad	26.8	22
	Indonesia	26.8	23
145	Cabo Verde	26.5	24
	North Macedonia	26.5	19
147	Benin	25.6	25
148	Senegal	25.4	26
149	Sierra Leone	25.1	27
150	Azerbaijan	24.9	10
151	Guinea	24.7	28
152	Equatorial Guinea	24.6	29
	São Tomé and Príncipe	24.6	29
154	Bhutan	24.4	3
	Namibia	24.4	31
156	Togo	24.1	32
157	Gambia	23.9	33
158	Mauritania	22.4	34
159	Eritrea	22.1	35
	Guinea-Bissau	22.1	35
161	Central African Republic	22.0	37
162	Djibouti	21.1	38
	Eswatini	21.1	38
164	Myanmar	20.7	24
165	Côte d'Ivoire	20.3	40
166	Bangladesh	20.2	4
167	Republic of Congo	20.0	41
168	Botswana	19.7	42
169	Ghana	18.0	43
	Nigeria	18.0	43
171	Afghanistan	17.7	5
172	Sudan	17.6	16
173	Mongolia	17.4	25
174	Cameroon	16.4	45
175	Lesotho	15.3	46
176	Tajikistan	15.2	11
177	Uzbekistan	15.0	12
178	Nepal	14.6	6
179	India	13.4	7
180	Pakistan	9.9	8

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 4-2. Regional rankings, scores, and global rankings on Air Quality.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Uruguay	67.7	30
2	Barbados	66.0	32
3	Antigua and Barbuda	57.5	37
4	Trinidad and Tobago	57.2	38
5	Argentina	56.9	39
6	Costa Rica	56.2	40
7	Chile	56.1	42
8	Panama	56.0	43
9	Bahamas	55.6	44
10	Cuba	53.9	48
11	Venezuela	51.3	51
12	Brazil	50.0	56
13	Colombia	49.1	60
14	Ecuador	48.7	61
15	Paraguay	47.0	66
16	Saint Lucia	46.3	67
17	Peru	46.0	68
18	Dominica	44.2	72
19	Jamaica	43.6	73
20	Grenada	42.9	75
21	El Salvador	42.6	77
	St. Vincent and Grenadines	42.6	77
23	Nicaragua	41.7	80
24	Mexico	40.8	83
25	Belize	39.4	89
26	Dominican Republic	37.4	93
	Suriname	37.4	93
28	Honduras	35.4	102
29	Guatemala	34.3	105
30	Bolivia	32.4	114
31	Guyana	31.9	117
32	Haiti	31.1	119

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Estonia	80.3	21
2	Cyprus	73.1	27
3	Greece	67.5	31
4	Lithuania	62.7	33
5	Slovenia	60.9	34
6	Czech Republic	58.8	35
7	Slovakia	56.2	40
8	Latvia	54.8	46
9	Croatia	50.8	54
10	Turkey	49.5	58
11	Poland	44.7	70
12	Romania	43.6	73
13	Hungary	42.8	76
14	Albania	41.2	81
15	Montenegro	33.9	106
16	Serbia	33.6	108
17	Bulgaria	33.0	111
18	Bosnia and Herzegovina	31.6	118
19	North Macedonia	26.5	145

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Maldives	51.2	52
2	Sri Lanka	37.8	91
3	Bhutan	24.4	154
4	Bangladesh	20.2	166
5	Afghanistan	17.7	171
6	Nepal	14.6	178
7	India	13.4	179
8	Pakistan	9.9	180

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Finland	98.8	1
2	Australia	98.2	2
	Sweden	98.2	2
4	Iceland	98.1	4
5	Norway	97.9	5
6	New Zealand	97.4	6
7	Canada	94.8	7
8	Ireland	94.0	8
9	Switzerland	90.6	9
10	France	88.1	10
11	Luxembourg	87.2	11
12	Denmark	85.5	13
13	United Kingdom	84.7	14
14	Portugal	84.4	15
15	United States of America	84.2	16
16	Netherlands	82.4	17
17	Austria	81.3	18
18	Germany	81.1	19
19	Belgium	80.7	20
20	Spain	80.2	22
21	Malta	77.6	23
22	Italy	75.9	26

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Russia	54.1	47
2	Belarus	49.9	57
3	Moldova	44.3	71
4	Turkmenistan	42.0	79
5	Ukraine	39.8	86
6	Armenia	36.3	97
7	Kazakhstan	32.0	115
8	Georgia	31.1	119
9	Kyrgyzstan	27.0	138
10	Azerbaijan	24.9	150
11	Tajikistan	15.2	176
12	Uzbekistan	15.0	177

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Japan	85.9	12
2	Singapore	76.9	24
3	South Korea	71.7	28
4	Brunei Darussalam	68.4	29
5	Taiwan	53.2	50
6	Malaysia	50.3	55
7	Thailand	40.6	85
8	Tonga	39.5	88
9	Papua New Guinea	33.9	106
10	Timor-Leste	33.6	108
11	Samoa	33.4	110
12	Marshall Islands	32.5	113
13	Viet Nam	32.0	115
14	Philippines	30.4	123
15	Cambodia	30.1	125
16	Fiji	30.0	126
17	Kiribati	29.2	128
18	Micronesia	29.0	130
19	Vanuatu	28.6	133
20	Laos	27.8	135
21	China	27.1	137
22	Solomon Islands	27.0	138
23	Indonesia	26.8	142
24	Myanmar	20.7	164
25	Mongolia	17.4	173

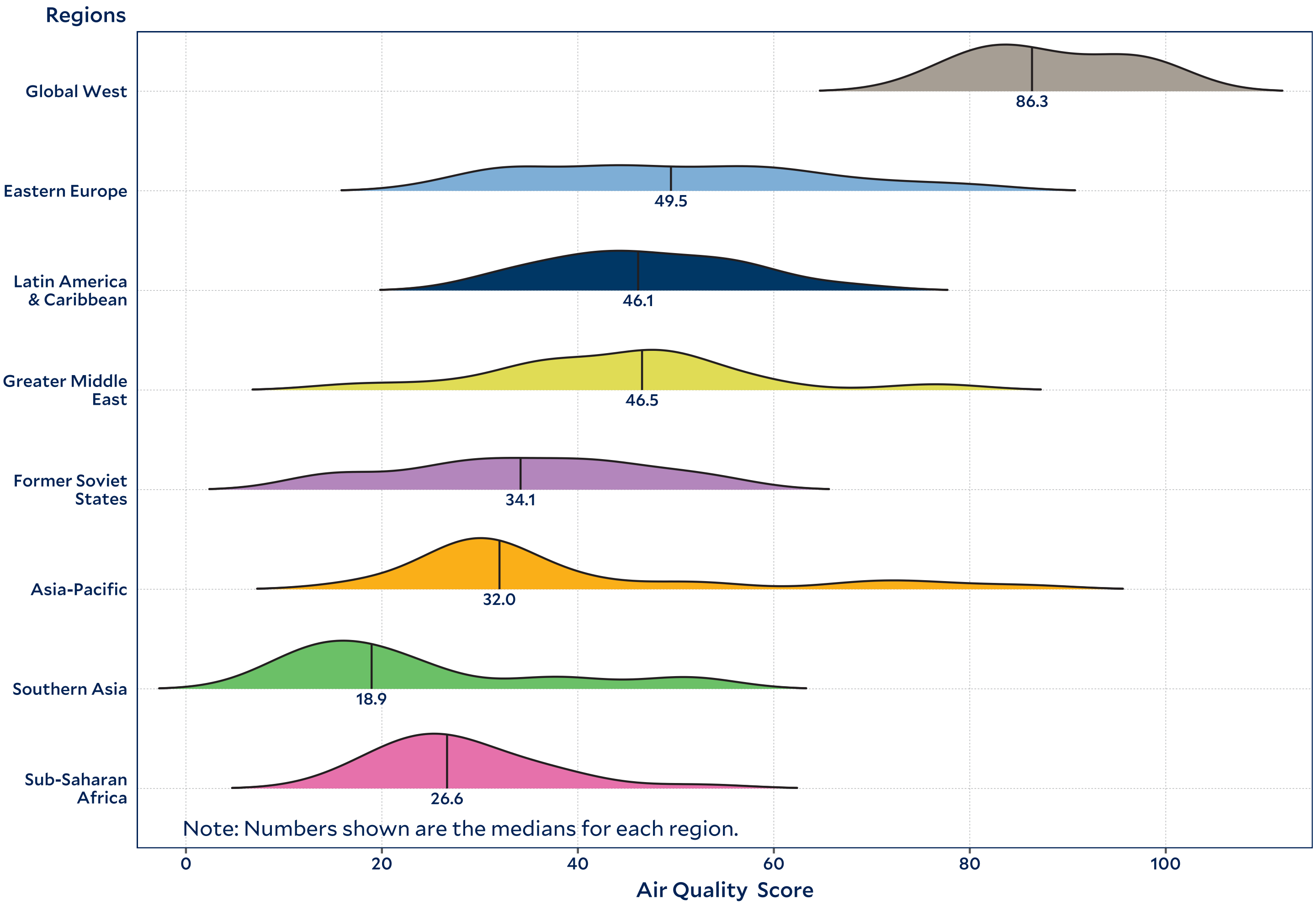
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Seychelles	53.6	49
2	Mauritius	51.1	53
3	Mozambique	40.7	84
4	Malawi	39.6	87
5	Ethiopia	38.0	90
6	Comoros	37.7	92
7	Madagascar	36.1	99
8	Burundi	36.0	100
9	Tanzania	35.8	101
10	Kenya	34.9	104
11	Uganda	32.6	112
12	Liberia	30.9	121
	Rwanda	30.9	121
14	Niger	30.3	124
15	Dem. Rep. Congo	29.9	127
16	Mali	29.2	128
17	Burkina Faso	28.9	131
	South Africa	28.9	131
19	Gabon	28.2	134
20	Zimbabwe	27.2	136
21	Zambia	27.0	138
22	Angola	26.8	142
	Chad	26.8	142
24	Cabo Verde	26.5	145
25	Benin	25.6	147
26	Senegal	25.4	148
27	Sierra Leone	25.1	149
28	Guinea	24.7	151
29	Equatorial Guinea	24.6	152
	São Tomé and Príncipe	24.6	152
31	Namibia	24.4	154
32	Togo	24.1	156
33	Gambia	23.9	157
34	Mauritania	22.4	158
35	Eritrea	22.1	159
	Guinea-Bissau	22.1	159
37	Central African Republic	22.0	161
38	Djibouti	21.1	162
	Eswatini	21.1	162
40	Côte d'Ivoire	20.3	165
41	Republic of Congo	20.0	167
42	Botswana	19.7	168
43	Ghana	18.0	169
	Nigeria	18.0	169
45	Cameroon	16.4	174
46	Lesotho	15.3	175

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Israel	76.5	25
2	Jordan	58.0	36
3	Kuwait	55.0	45
4	Iran	49.2	59
5	Tunisia	48.7	61
6	Qatar	48.6	63
	United Arab Emirates	48.6	63
8	Lebanon	47.8	65
9	Algeria	45.3	69
10	Bahrain	41.2	81
11	Saudi Arabia	37.4	93
12	Oman	36.4	96
13	Iraq	36.3	97
14	Egypt	35.3	103
15	Morocco	27.0	138
16	Sudan	17.6	172

FIGURE 4-1. Regional performance on Air Quality.



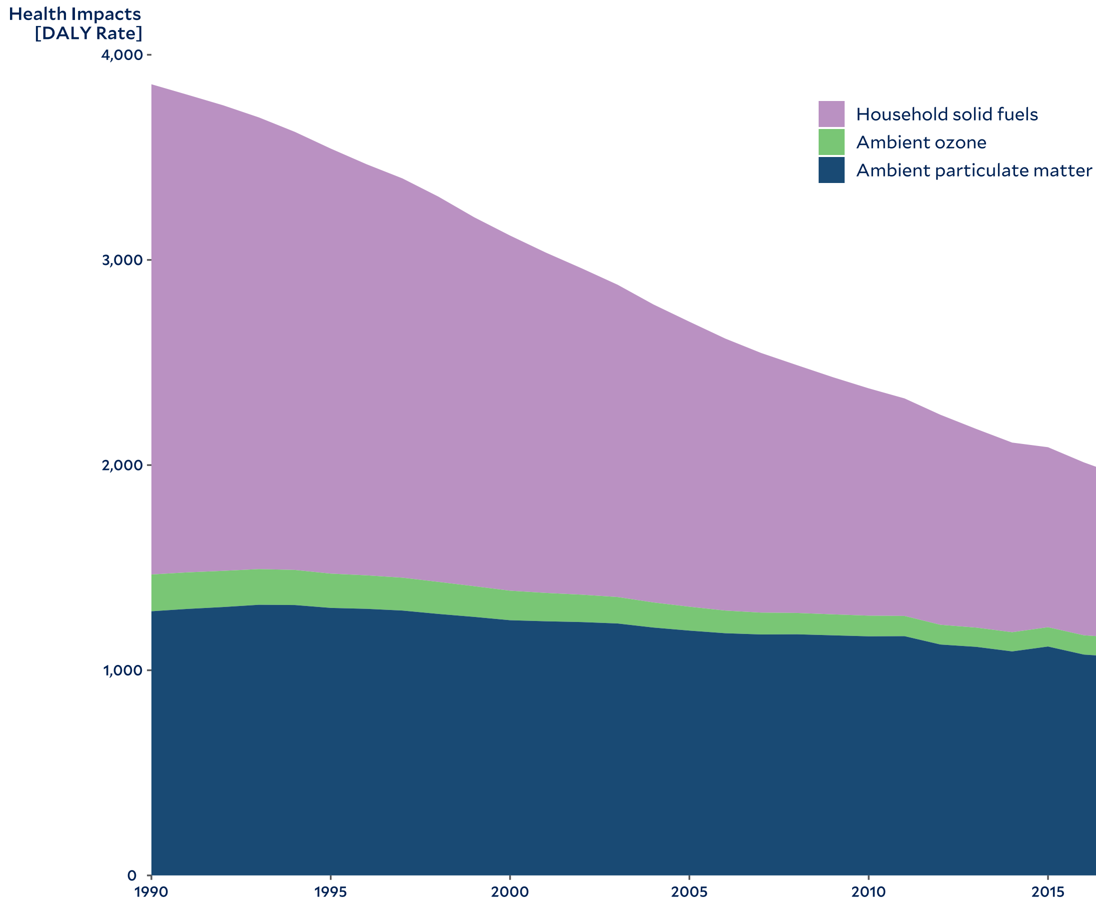
2. RESULTS

2.1 GLOBAL TRENDS

Across all global risk factors, air quality ranks fifth in terms of mortality, contributing to about 4.9 million deaths annually (HEI & IHME, 2019). Countries can measurably improve the overall health of their population by reducing exposure to air pollutants. However, many nations – such as India, Ghana, Morocco, China, and Indonesia – remain heavily reliant on coal-fired power generation to support their rapid urbanization and economic growth, which has resulted in high levels of air pollution and associated casualties (World Bank & IHME, 2016). At the global scale, DALYs lost due to air pollution have declined over the last decade, signaling a potentially positive trend and suggesting that governments in many nations are implementing policies to reduce air emissions.

However, global trends hide regional inequalities in pollution exposure, particularly to airborne particulate matter. In many developing countries, indoor air pollution arises from the use of household solid fuels for cooking and heating homes, putting low-income people at particular risk (Desai et al., 2004). Conversely, most high-income and developed countries see low levels of pollution from household solid fuels. In general, global average improvements are highest in reduced reliance on household solid fuels, though it remains a substantial problem in the Middle East, as seen in Figure 4-2. Despite these minor improvements in $PM_{2.5}$ exposure, the desperately needed large-scale reductions have remained stubbornly elusive. However, global exposure to ambient tropospheric ozone has improved by a large percentage over the last three decades.

FIGURE 4-2. Global progress on health outcomes from household solid fuels, ambient ozone, and ambient particulate matter, 1990–2017.
Note: DALY rate = age-standardized disability-adjusted life-years lost per 100,000 people.
Source: Institute for Health Metrics & Evaluation



2.2 LEADERS & LAGGARDS

In general, most of the countries that ranked very high in Air Quality were in the Global West, particularly in Nordic countries. Models suggest that 80% of ambient $PM_{2.5}$ came from outside those countries, where the primary sources were nonindustrial combustion of fossil fuels, agriculture, and traffic (Im et al., 2019). Non-Western countries that also rank high include Japan, South Korea, Israel, and Brunei Darussalam. Uruguay ranks highest in Latin America, having implemented forward-thinking policies like electrifying the bus fleet in Montevideo (BYD Company Ltd., 2020).

Countries in Southern Asia fare the worst on Air Quality, with Nepal, India, and Pakistan receiving the bottom three scores globally. South Asian countries experienced the highest ambient levels of $PM_{2.5}$ in the world in 2017, and air pollution in that year contributed to 1.2 million deaths in India and 128,000 in Pakistan (HEI & IHME, 2019). Outdoor air pollution in these countries stems from many sources, including coal plants, brick kilns and other small industries, dust from unpaved roads, motor vehicle exhaust, and trash burning (UNEP et al., 2018). Incineration of agricultural residues during the post-monsoon season also produces a significant amount of particulate air pollution (Cusworth et al., 2018).

Household air pollution from solid fuel cookstoves presents another significant health risk in Southern Asia, especially among women and children (Jindal et al., 2020; Naz et al., 2016). Fortunately, recent initiatives in India demonstrate promising strides in HAP reduction. Between 2005 and 2017, the proportion of households cooking with solid fuels in India fell from 76% to 60% (HEI & IHME, 2019), largely as a result of targeted government programs. These initiatives include the National Biomass

Cookstove and the Pradhan Mantri Ujjwala Yojana program, which have greatly expanded access to clean-burning liquid petroleum gas for low-income households (Balakrishnan et al., 2019; UNEP et al., 2018). Accelerating such initiatives could provide enormous health benefits for the citizens of India and surrounding nations.

3. METHODS

We measure air quality via health costs from environmental risks, using the number of age-standardized disability-adjusted life-years (DALYs) lost per 100,000 persons. $PM_{2.5}$ exposure is associated with significant adverse health effects when these particulates penetrate the lung, leading to higher incidences of cardiovascular disease, respiratory disease, and brain damage (de Prado Bert et al., 2018; Goldberg, 2008). Though ozone is an important and desirable gas in the upper layers of Earth's atmosphere, ground-level ozone is a dangerous pollutant and one of the main constituents of visible smog. Ozone is known to lead to respiratory irritation, reduced lung function, aggravation of asthma and lung cancers, and increased susceptibility to respiratory infections (U.S. EPA, 2015). Household solid fuel use is also a significant environmental risk factor, as incomplete combustion of solid fuels produces a substantial amount of particulate emissions (WHO, 2006). Humans exposed to HAP at high concentrations often suffer significant negative health effects (WHO, 2006). Because exposure to HAP is often higher than other forms of air pollution, reducing the use of household solid fuels may improve human health to a greater degree than other air pollution abatement efforts (Goldemberg et al., 2000).

Air pollution is not confined to any one country and is capable of travelling long distances, so harms to both people and nature occur far from where the pollutants are initially discharged (WHO, 2016). It would therefore be helpful if countries obtained data connecting emissions, ambient concentrations, and consequent harms to human health. Estimates of air pollution exposure vary by data collection technique, including both satellite and ground-based measurements (Engel-Cox et al., 2013). Ground-based measurements are generally taken in areas where large populations are exposed to $PM_{2.5}$, which provide accurate data for local planning purposes (Engel-Cox et al., 2013). Ground-level measurements, however, are not available for most of the world, with low-income regions especially lacking measurements (Health Effects Institute, 2017; Hsu et al., 2013). Satellite-based measurements provide estimates in areas where no ground-based measurements are obtainable (Engel-Cox et al., 2013). Satellite monitoring can therefore provide a more complete characterization of air pollution globally. Synthesizing these two methods may provide environmental and public health practitioners with a more comprehensive measurement of air quality globally.

3.1 INDICATOR BACKGROUND

Our three indicators utilize the Comprehensive Risk Assessment (CRA) framework in the Global Burden of Disease (GBD) study to estimate rates of exposure to hazardous air quality risks, the attributable deaths, and the DALYs (Kyu et al., 2018). First, the metrics examine estimated exposure to the risks in question for each country. IHME collects data for risk exposure based on remote sensing and satellite data for *$PM_{2.5}$ exposure* and *ozone exposure*, and with surveys for *HAP*. The second step uses statistical models to estimate the portion of deaths and DALYs attributable to those risks. Finally, measuring these metrics in DALYs allows evaluation of the likelihood of death or disease from unsafe sanitation or drinking water compared to all other potential risks.

The GBD defines exposure to $PM_{2.5}$ as the "annual average daily exposure to outdoor air concentrations of PM with an aerodynamic diameter smaller than 2.5 μm, measured in $\mu g/m^3$." The same definition applies to HAP exposure for concentrations due to solid fuel use inside households.

For exposure to ground-level ozone, the GBD looks at "seasonal (3 month) hourly maximum ozone concentrations, measured in ppb" (Forouzanfar et al., 2016, p. 1662).

Larger air particulates (PM_{10}), atmospheric lead, and carbon monoxide, among other air pollutants, have been omitted from our indicators. Despite the narrow scope, the three indicators we use serve as reasonable proxies for other air pollutants because sufficient evidence exists confirming that they correlate with threats posed by the omitted pollutants. In addition, they capture a substantial portion of the global variation in health impacts due to air quality posed by other pollutants (WHO, 2016).

3.2 DATA

Our indicators utilize the estimates for *$PM_{2.5}$ exposure*, *household solid fuels*, and *ozone exposure* from the Global Burden of Disease (GBD) study at the Institute for Health Metrics and Evaluation (IHME) (Kyu et al., 2018). Data for the *household solid fuels* indicator are gathered through nationally reported household surveys that estimate the proportion of household solid fuels that serve as the predominant fuel source in a country (Bonjour et al., 2013). Monitoring data for $PM_{2.5}$ and ozone "combined satellite-based estimates, chemical transport model simulations, and ground measurements from 79 different countries to produce global estimates of annual average fine particle ($PM_{2.5}$) and ozone concentrations at 0.1° × 0.1° spatial resolution" (Brauer et al., 2016, p. 79).

3.3. LIMITATIONS

In conducting the GBD study, IHME relies on the scientific literature to provide key assumptions and data about health risks, but knowledge gaps in the literature generate a level of uncertainty in GBD estimates. Fragmented measurements of population exposure to various sources of air pollution, as well as imperfect data for the burden of air pollution-related diseases, are two of the primary reasons why multiple assumptions are necessary for calculating health risks from exposure to household solid fuel use. Furthermore, standardization and double-counting issues, which emerge from different characterizations of data across countries, further complicate efforts to construct a global inventory of air pollution data. Finally, the type of predominant air pollution varies by regions. In urban areas, outdoor air pollution is the primary concern. Conversely, in rural regions, HAP is the predominant issue.

Comparing remote sensing measurements of $PM_{2.5}$ across multiple countries has its challenges. These include difficulty in controlling for hilly and mountainous terrain, natural sources of PM (salt spray and dust), and transboundary pollution. Measurement issues arise if these remote sensing problems disproportionately affect the same locations (Brauer et al., 2016).

TABLE 4-3. Clarification of the $PM_{2.5}$ *exposure, household solid fuels,* and *ozone exposure* metrics.

WHAT THE METRICS ARE	WHAT THE METRICS AREN'T
Age-standardized disability-adjusted life-years lost (due to death and diseases) from $PM_{2.5}$ exposure, household solid fuel use, and ozone exposure, per 100,000 persons in a country	• **Measures of ambient concentrations of air pollutants** • **Measures of the number of households using household solid fuels** • **Measures of emission of $PM_{2.5}$ or ozone**

Chapter 5. Sanitation & Drinking Water

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Safely managed sanitation and drinking water underpin public health and sustainable development, yet nearly 800 million people worldwide lack access to clean drinking water, and 2 billion people lack basic sanitation services (UNICEF & WHO, 2019). Poor sanitation and polluted water impede global efforts to eradicate preventable diseases by contributing to the spread of illnesses like diarrhea, typhoid, and cholera (WHO & UNICEF, 2017). These human health impacts exacerbate social inequalities and limit economic development (Cooley et al., 2013, p. 5). The 2020 EPI metrics for this category track diseases and deaths from exposure to unsafe sanitation and drinking water.

1.2 INDICATORS

1.2.1 UNSAFE SANITATION [40% of issue category]

We measure *unsafe sanitation* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to their exposure to inadequate sanitation facilities.

1.2.2 UNSAFE DRINKING WATER [60% of issue category]

We measure *unsafe drinking water* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to unsafe drinking water.

MAP 5-1. Rankings on Sanitation & Drinking Water.

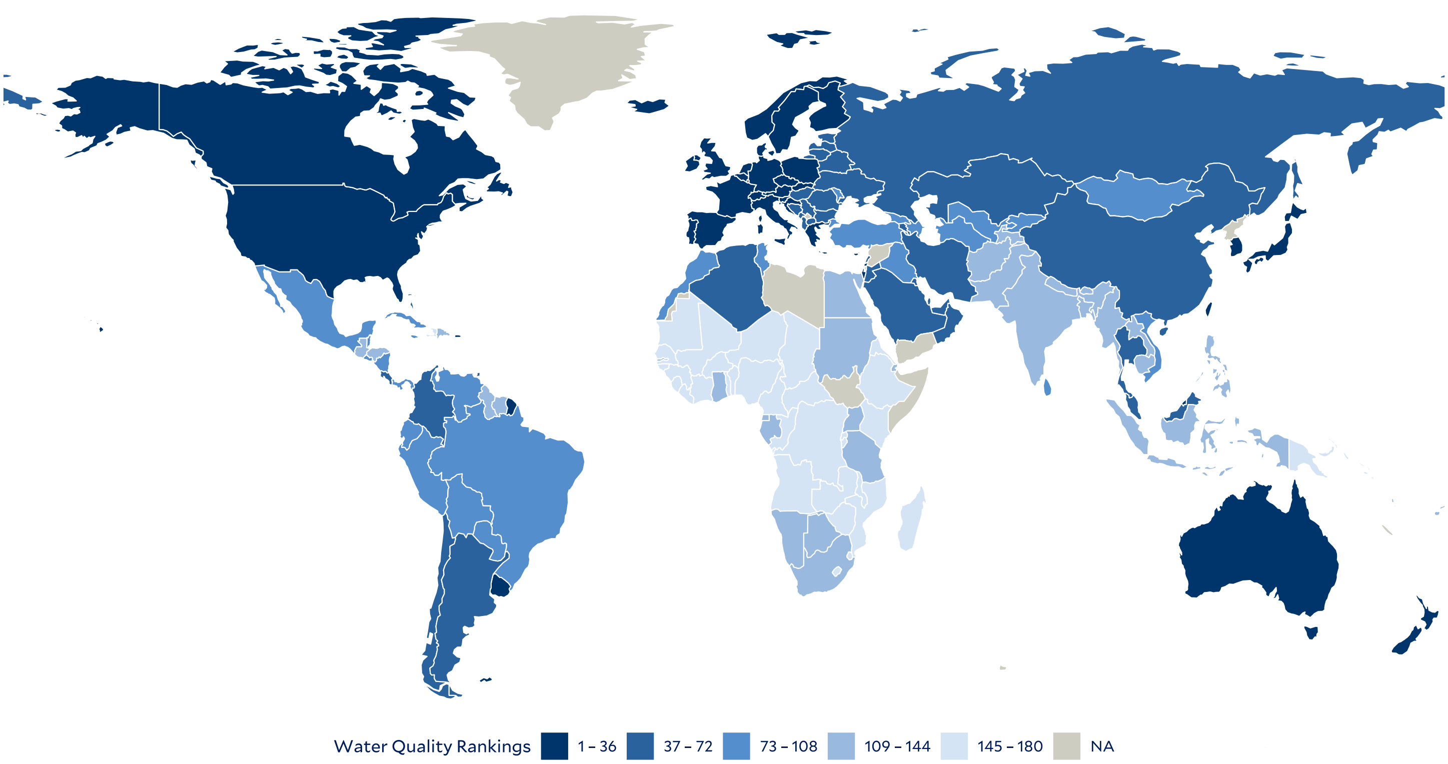


TABLE 5-1. Global rankings, scores, and regional rankings (REG) on Sanitation & Drinking Water.

RANK	COUNTRY	SCORE	REG
1	Finland	100.0	1
	Iceland	100.0	1
	Netherlands	100.0	1
	Norway	100.0	1
	Switzerland	100.0	1
	United Kingdom	100.0	1
7	Malta	99.8	7
8	Germany	99.0	8
9	Luxembourg	98.6	9
10	Sweden	98.5	10
11	Greece	98.2	1
	Italy	98.2	11
13	Denmark	97.4	12
	Ireland	97.4	12
15	Spain	96.8	14
16	France	96.2	15
17	Japan	95.0	1
18	Austria	94.7	16
19	Cyprus	93.9	2
20	Belgium	93.6	17
21	Singapore	93.2	2
22	Israel	92.8	1
23	South Korea	90.7	3
24	Canada	88.0	18
25	Australia	87.0	19
26	United States of America	86.1	20
27	Brunei Darussalam	85.6	4
28	Portugal	83.4	21
29	New Zealand	80.4	22
30	Czech Republic	76.4	3
31	Slovenia	74.7	4
32	Taiwan	72.4	5
33	Slovakia	71.8	5
34	Poland	71.7	6
35	Uruguay	70.8	1
36	Croatia	70.2	7
37	Bulgaria	68.3	8
38	Chile	68.1	2
39	Kuwait	67.4	2
40	United Arab Emirates	67.2	3
41	Qatar	66.5	4
42	Costa Rica	66.1	3
43	Montenegro	65.6	9
44	Mauritius	65.5	1
	Serbia	65.5	10
46	Argentina	64.7	4
47	Jordan	62.6	5
48	Hungary	62.2	11
49	Estonia	61.9	12
50	Bosnia and Herzegovina	61.4	13
51	North Macedonia	61.1	14
52	Belarus	60.5	1
53	Lebanon	59.7	6
54	China	59.4	6
55	Saudi Arabia	59.3	7
56	Latvia	59.0	15
57	Lithuania	58.3	16
	Oman	58.3	8
59	Malaysia	57.6	7
60	Armenia	57.2	2
61	Bahrain	56.6	9
62	Romania	55.9	17
63	Colombia	55.8	5
	Thailand	55.8	8
65	Russia	55.4	3
66	Kazakhstan	55.1	4
	Ukraine	55.1	4
68	Bahamas	55.0	6
69	Albania	54.0	18
70	Iran	53.6	10
71	Trinidad and Tobago	53.4	7
72	Algeria	53.2	11
73	Mexico	52.8	8
74	Viet Nam	52.7	9
75	Tunisia	52.6	12
	Turkey	52.6	19
77	Uzbekistan	52.0	6
78	Barbados	51.9	9
79	Georgia	51.6	7
80	Seychelles	51.4	2
81	Ecuador	50.2	10
82	Antigua and Barbuda	50.0	11
	Moldova	50.0	8
84	Cuba	49.6	12
	Iraq	49.6	13
86	Jamaica	49.3	13
87	Samoa	49.2	10
88	Sri Lanka	48.4	1
89	Maldives	47.8	2
90	Dominica	47.5	14
	Paraguay	47.5	14
92	Turkmenistan	47.3	9
93	Grenada	47.0	16
94	Venezuela	46.8	17
95	Tonga	46.4	11
96	Brazil	46.1	18
97	Azerbaijan	45.5	10
	Kyrgyzstan	45.5	10
99	Saint Lucia	45.4	19
100	Panama	43.5	20
	St. Vincent and Grenadines	43.5	20
102	Mongolia	43.1	12
103	Peru	43.0	22
104	Nicaragua	42.8	23
105	Belize	42.6	24
106	El Salvador	41.6	25
107	Morocco	40.8	14
108	Bolivia	40.0	26
109	Suriname	39.3	27
110	Philippines	39.0	13
111	Dominican Republic	38.9	28
112	Egypt	36.6	15
113	Cabo Verde	35.5	3
	Micronesia	35.5	14
115	Guyana	35.3	29
116	São Tomé and Príncipe	35.2	4
117	Fiji	34.6	15
118	Cambodia	34.2	16
119	Equatorial Guinea	33.1	5
120	Marshall Islands	32.2	17
121	Honduras	31.8	30
122	Bhutan	31.2	3
123	Tajikistan	30.9	12
124	Myanmar	30.8	18
125	Indonesia	28.4	19
126	Guatemala	28.2	31
127	Afghanistan	28.0	4
128	Gabon	27.6	6
129	Bangladesh	27.3	5
130	Nepal	27.0	6
131	Laos	26.5	20
132	Timor-Leste	25.9	21
133	South Africa	24.6	7
134	Sudan	22.3	16
135	Vanuatu	21.5	22
136	Botswana	20.8	8
	Ghana	20.8	8
138	Namibia	19.6	10
139	India	19.4	7
140	Gambia	19.1	11
141	Tanzania	18.4	12
142	Djibouti	18.3	13
143	Uganda	17.6	14
144	Pakistan	17.4	8
145	Côte d'Ivoire	17.2	15
146	Rwanda	16.9	16
147	Zimbabwe	16.8	17
148	Mozambique	16.4	18
149	Kiribati	16.3	23
150	Papua New Guinea	15.5	24
151	Comoros	15.2	19
152	Republic of Congo	14.6	20
153	Haiti	14.0	32
	Solomon Islands	14.0	25
155	Kenya	13.6	21
	Mauritania	13.6	21
157	Dem. Rep. Congo	13.5	23
158	Benin	13.4	24
	Zambia	13.4	24
160	Senegal	13.1	26
161	Angola	12.8	27
162	Eswatini	12.6	28
163	Malawi	12.0	29
164	Sierra Leone	11.5	30
165	Guinea	11.2	31
166	Ethiopia	10.9	32
167	Liberia	9.8	33
168	Mali	8.2	34
169	Burkina Faso	7.7	35
	Cameroon	7.7	35
171	Lesotho	7.2	37
172	Guinea-Bissau	6.7	38
173	Eritrea	6.3	39
174	Madagascar	5.9	40
175	Burundi	5.3	41
176	Togo	5.1	42
177	Nigeria	4.9	43
178	Niger	1.4	44
179	Central African Republic	0.0	45
	Chad	0.0	45

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 5-2. Regional rankings, scores, and global rankings on Sanitation & Drinking Water.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Uruguay	70.8	35
2	Chile	68.1	38
3	Costa Rica	66.1	42
4	Argentina	64.7	46
5	Colombia	55.8	63
6	Bahamas	55.0	68
7	Trinidad and Tobago	53.4	71
8	Mexico	52.8	73
9	Barbados	51.9	78
10	Ecuador	50.2	81
11	Antigua and Barbuda	50.0	82
12	Cuba	49.6	84
13	Jamaica	49.3	86
14	Dominica	47.5	90
	Paraguay	47.5	90
16	Grenada	47.0	93
17	Venezuela	46.8	94
18	Brazil	46.1	96
19	Saint Lucia	45.4	99
20	Panama	43.5	100
	St. Vincent and Grenadines	43.5	100
22	Peru	43.0	103
23	Nicaragua	42.8	104
24	Belize	42.6	105
25	El Salvador	41.6	106
26	Bolivia	40.0	108
27	Suriname	39.3	109
28	Dominican Republic	38.9	111
29	Guyana	35.3	115
30	Honduras	31.8	121
31	Guatemala	28.2	126
32	Haiti	14.0	153

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Greece	98.2	11
2	Cyprus	93.9	19
3	Czech Republic	76.4	30
4	Slovenia	74.7	31
5	Slovakia	71.8	33
6	Poland	71.7	34
7	Croatia	70.2	36
8	Bulgaria	68.3	37
9	Montenegro	65.6	43
10	Serbia	65.5	44
11	Hungary	62.2	48
12	Estonia	61.9	49
13	Bosnia and Herzegovina	61.4	50
14	North Macedonia	61.1	51
15	Latvia	59.0	56
16	Lithuania	58.3	57
17	Romania	55.9	62
18	Albania	54.0	69
19	Turkey	52.6	75

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Sri Lanka	48.4	88
2	Maldives	47.8	89
3	Bhutan	31.2	122
4	Afghanistan	28.0	127
5	Bangladesh	27.3	129
6	Nepal	27.0	130
7	India	19.4	139
8	Pakistan	17.4	144

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Finland	100.0	1
	Iceland	100.0	1
	Netherlands	100.0	1
	Norway	100.0	1
	Switzerland	100.0	1
	United Kingdom	100.0	1
7	Malta	99.8	7
8	Germany	99.0	8
9	Luxembourg	98.6	9
10	Sweden	98.5	10
11	Italy	98.2	11
12	Denmark	97.4	13
	Ireland	97.4	13
14	Spain	96.8	15
15	France	96.2	16
16	Austria	94.7	18
17	Belgium	93.6	20
18	Canada	88.0	24
19	Australia	87.0	25
20	United States of America	86.1	26
21	Portugal	83.4	28
22	New Zealand	80.4	29

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Belarus	60.5	52
2	Armenia	57.2	60
3	Russia	55.4	65
4	Kazakhstan	55.1	66
	Ukraine	55.1	66
6	Uzbekistan	52.0	77
7	Georgia	51.6	79
8	Moldova	50.0	82
9	Turkmenistan	47.3	92
10	Azerbaijan	45.5	97
	Kyrgyzstan	45.5	97
12	Tajikistan	30.9	123

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Japan	95.0	17
2	Singapore	93.2	21
3	South Korea	90.7	23
4	Brunei Darussalam	85.6	27
5	Taiwan	72.4	32
6	China	59.4	54
7	Malaysia	57.6	59
8	Thailand	55.8	63
9	Viet Nam	52.7	74
10	Samoa	49.2	87
11	Tonga	46.4	95
12	Mongolia	43.1	102
13	Philippines	39.0	110
14	Micronesia	35.5	113
15	Fiji	34.6	117
16	Cambodia	34.2	118
17	Marshall Islands	32.2	120
18	Myanmar	30.8	124
19	Indonesia	28.4	125
20	Laos	26.5	131
21	Timor-Leste	25.9	132
22	Vanuatu	21.5	135
23	Kiribati	16.3	149
24	Papua New Guinea	15.5	150
25	Solomon Islands	14.0	153

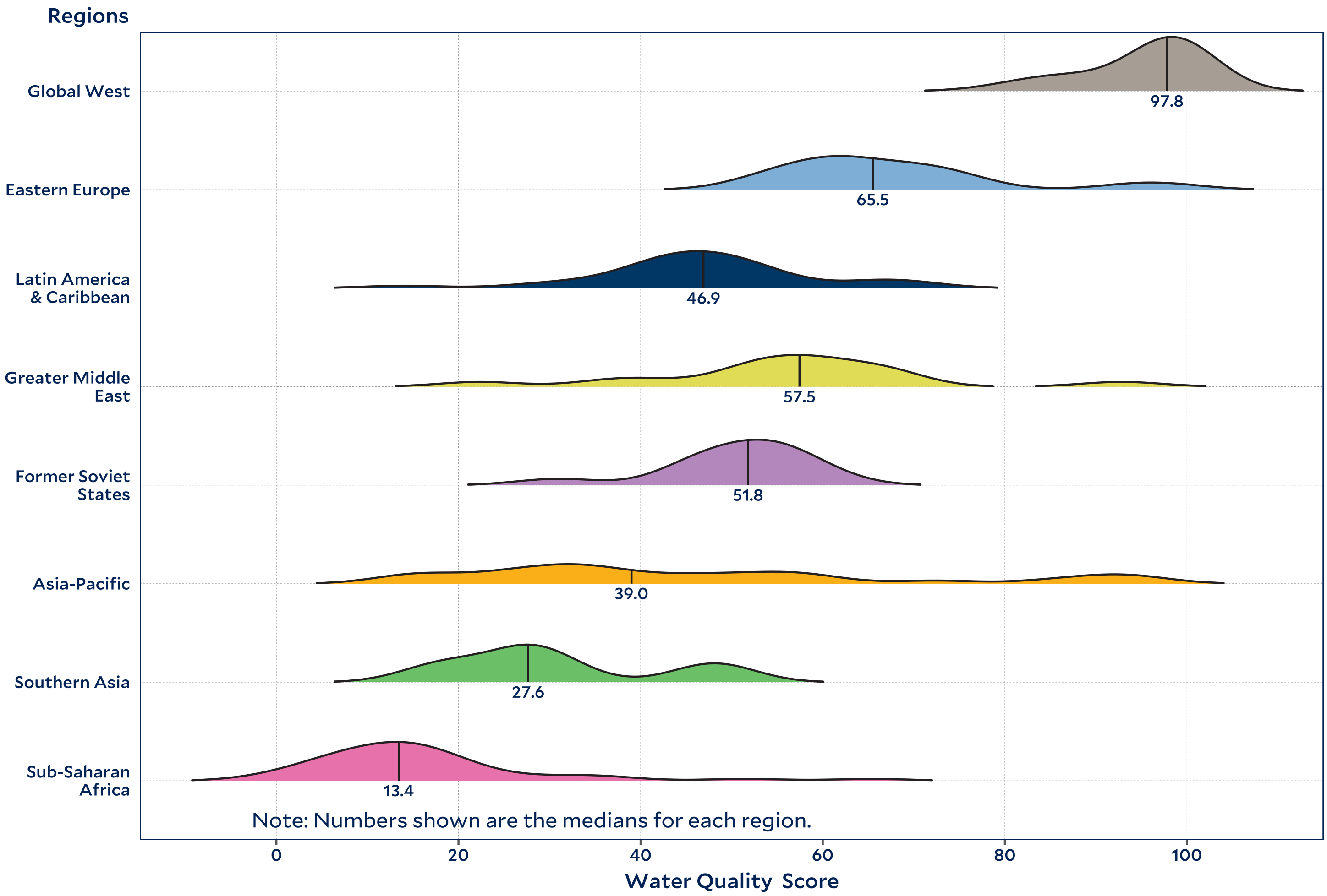
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Mauritius	65.5	44
2	Seychelles	51.4	80
3	Cabo Verde	35.5	113
4	São Tomé and Príncipe	35.2	116
5	Equatorial Guinea	33.1	119
6	Gabon	27.6	128
7	South Africa	24.6	133
8	Botswana	20.8	136
	Ghana	20.8	136
10	Namibia	19.6	138
11	Gambia	19.1	140
12	Tanzania	18.4	141
13	Djibouti	18.3	142
14	Uganda	17.6	143
15	Côte d'Ivoire	17.2	145
16	Rwanda	16.9	146
17	Zimbabwe	16.8	147
18	Mozambique	16.4	148
19	Comoros	15.2	151
20	Republic of Congo	14.6	152
21	Kenya	13.6	155
	Mauritania	13.6	155
23	Dem. Rep. Congo	13.5	157
24	Benin	13.4	158
	Zambia	13.4	158
26	Senegal	13.1	160
27	Angola	12.8	161
28	Eswatini	12.6	162
29	Malawi	12.0	163
30	Sierra Leone	11.5	164
31	Guinea	11.2	165
32	Ethiopia	10.9	166
33	Liberia	9.8	167
34	Mali	8.2	168
35	Burkina Faso	7.7	169
	Cameroon	7.7	169
37	Lesotho	7.2	171
38	Guinea-Bissau	6.7	172
39	Eritrea	6.3	173
40	Madagascar	5.9	174
41	Burundi	5.3	175
42	Togo	5.1	176
43	Nigeria	4.9	177
44	Niger	1.4	178
45	Central African Republic	0.0	179
	Chad	0.0	179

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Israel	92.8	22
2	Kuwait	67.4	39
3	United Arab Emirates	67.2	40
4	Qatar	66.5	41
5	Jordan	62.6	47
6	Lebanon	59.7	53
7	Saudi Arabia	59.3	55
8	Oman	58.3	57
9	Bahrain	56.6	61
10	Iran	53.6	70
11	Algeria	53.2	72
12	Tunisia	52.6	75
13	Iraq	49.6	84
14	Morocco	40.8	107
15	Egypt	36.6	112
16	Sudan	22.3	134

FIGURE 5-1. Regional performance on Sanitation & Drinking Water.

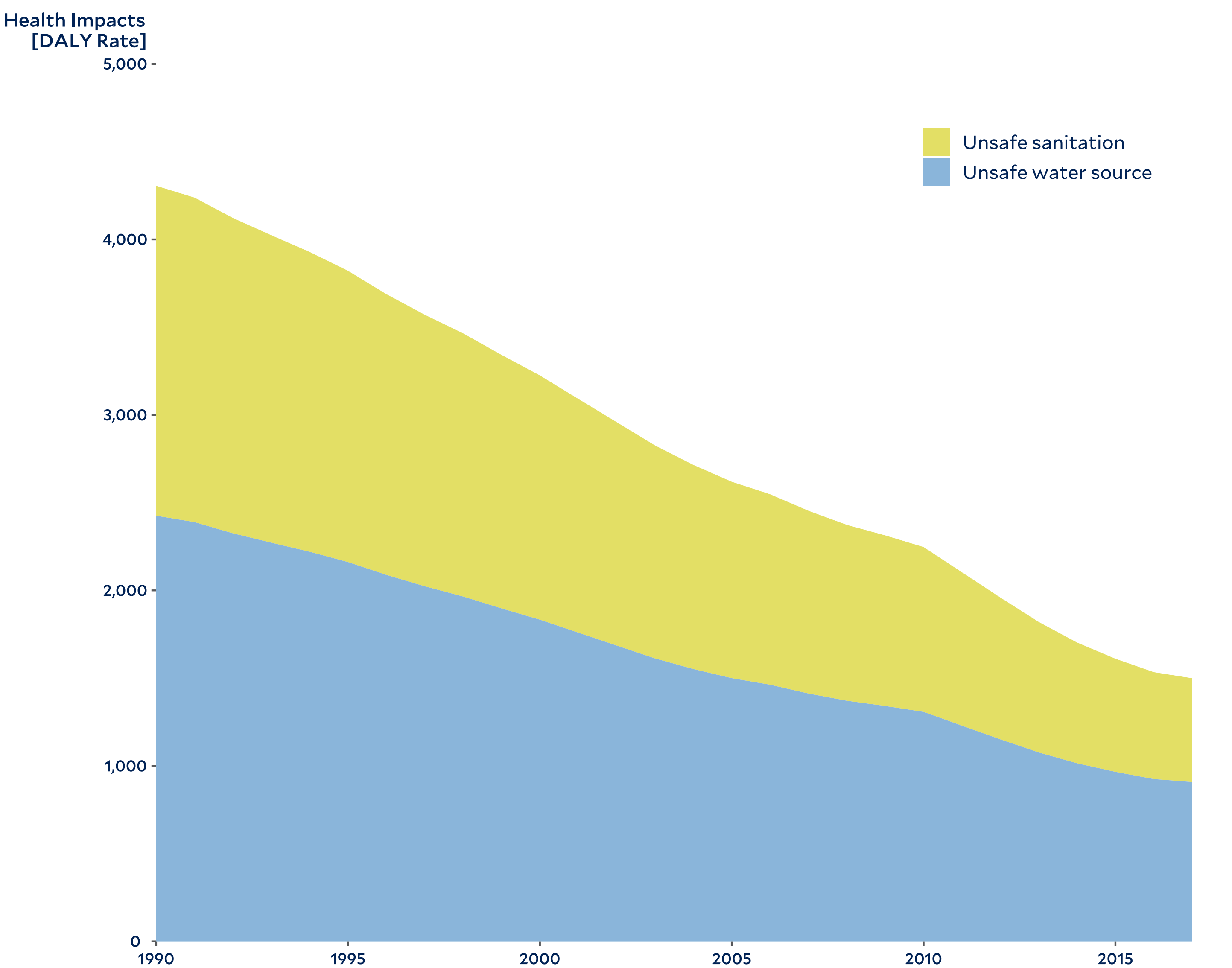


2. RESULTS

2.1 GLOBAL TRENDS

Over the past three decades, hundreds of millions of people have obtained access to adequate drinking water and improved sanitation facilities. Figure 5.2 shows that DALYs have decreased steadily for both indicators over the last 30 years. Global trends show an overall improvement in the proportion of a country's population exposed to health risks from their access to drinking water and sanitation. As the world population increases, however, the threat of deteriorating water quality remains a global concern.

FIGURE 5-2. Global progress on health outcomes from unsafe sanitation and drinking water, 1990–2017.
Note: DALY rate = age-standardized disability-adjusted life-years lost per 100,000 people.
Source: Institute for Health Metrics & Evaluation



Geographic inequalities in access to safe drinking water and sanitation services are evident, and many regions still require large investment in these basic elements of environmental public health infrastructure. While much of the world has gained access to improved sanitation and drinking water sources, these worldwide accomplishments conceal substantial regional inequalities (Prüss-Üstün et al., 2008). The World Health Organization and United Nations Children's Fund (WHO & UNICEF) Joint Monitoring Program for Water Supply, Sanitation, and Hygiene (JMP) estimated in 2019 that 785 million people lack access to improved drinking water sources, most of them located in sub-Saharan Africa and Oceania (UNICEF & WHO, 2019, p. 7).

Billions of people also lack access to basic sanitation services despite improvements in much of the world (UNICEF & WHO, 2019, p. 8). As with water quality, global trends can mask regional disparities. According to the JMP, individuals in the world's least developed countries account for one-third of those still lacking access to basic sanitary facilities (UNICEF & WHO, 2019, p. 8).

2.2 LEADERS & LAGGARDS

Economically advanced European countries once again dominate the EPI rankings with minimal exposure to *unsafe sanitation* and *unsafe drinking water*. Almost all of the countries on the leaderboard also reside in the EU, representing a continued commitment in the Union to policies directed toward sanitation infrastructure and water quality improvement. An example of this commitment is the Drinking Water Directive (98/83/EC), for which a provisional agreement was reached in 2019, to modernize its rules, further improve water quality, and provide better information to citizens.

Some less advanced European states also continue to show leadership in providing high water quality. For example, Greece scores well by monitoring its water supply on a 24-hour basis and continuing efforts to upgrade water and sanitation services (EYDAP, n.d.). Other Eastern European countries prioritize similar water quality investments in order to achieve the goals of EU directives. The Danube Water Program, launched in 2013, represents one such investment vehicle designed to help countries in the Danube watershed area meet the wider aims of the EU (World Bank, 2015a). Participating countries such as Montenegro and Bulgaria have relied on grants and international loans from groups like the World Bank to transform their water and wastewater sector (World Bank, 2015b, 2015c). Millions more people have gained access to clean water as a result, though the long-term sustainability of the projects is fraught with uncertainty, as the loans must be repaid with increases in water tariffs.

A few high-income countries in the Middle East have elevated rates of water access but suffer from water scarcity. As water demand increases in such water scarce regions, water treatment technologies and efficiency policies must keep pace. Kuwait constitutes a prime example of a country faced with this challenge. It has an extremely arid climate with sparse and rapidly depleting groundwater resources, yet water consumption in the country is among the world's highest per capita, averaging 447 liters daily (Ismail, 2015). To address this mismatch, Kuwait utilizes desalination plants to supply over 70% of the country's potable water (Darwish & Al-Najem, 2005). The majority of Kuwait's water investments, however, have been directed to the construction of water treatment plants that recycle wastewater for agriculture, which it hopes will help to conserve freshwater and reduce its water resource deficit.

Several small island developing countries score in the middle of the index for *unsafe sanitation* and *unsafe drinking water* despite increasing stress from population growth and climate change. Spatial limitations on small islands augment these pressures and make developing safe water and waste infrastructure particularly challenging (UN Commission on Sustainable Development, 1998). Micronesia, for instance, suffered a deadly cholera outbreak in 2000 due to waste contaminating its water supply. Since then, the county's implementation of the EU-funded Integrated Water Resources Management Program has helped it to make significant progress on water safety (South Pacific Applied Geoscience Commission, 2007). Improved waste management practices and infrastructure projects from 2000 to 2017 increased basic sanitation coverage in Micronesia from 25% to 88% (Micronesia Environmental Data Portal, 2019; UNICEF & WHO, 2019). The Bahamas has sought independence from outside funding by self-investing in desalination and chemical additives to reduce contaminants in its potable water supply (Troped, 2017). The Bahamas still faces the same internal and external pressures of other small island developing states, but its efforts on water quality earn it a rank among the highest of the group.

Many countries with abundant water

resources lag on water quality due to governance issues. In Panama, past and current governments have failed to adequately regulate agricultural practices, leading to runoff from farms contaminated with animal feces, among other pollutants (Greaney, 2015). Rural communities in Panama face the brunt of water pollution effects due to their proximity to agriculture, which contributes to further disparities within the country (Greaney, 2015).

Indonesia also suffers from poor governance, especially in rural areas. Basic sanitation coverage is near 90% in Indonesia's capital, but remains near 0% in other regions, one of the world's highest coverage disparities (UNICEF & WHO, 2019). Indonesia has one of the highest rates of open defecation in the world, despite a significant reduction in recent years (UNICEF & WHO, 2019). Indonesia's difficulties relate to a decentralized government that continues to struggle with corruption and diminished regulatory oversight, in addition to prioritizing private interests over public services, such as critical water infrastructure (Holzhacker et al., 2016; Rakhmat, 2018).

Countries in sub-Saharan Africa score the worst in *unsafe sanitation* and *unsafe drinking water* due to droughts, poor water quality management and monitoring, and ongoing conflict that has distracted from efforts to build basic environmental public health infrastructure. Although 25% of the population of sub-Saharan Africa has gained access to at least basic drinking water since 2000 – which represents the largest increase of any region – countries like Botswana, Eswatini, and Angola still do not provide safe drinking water to a majority of their citizens (Heller, 2016; UNICEF & WHO, 2019). In South Sudan and Angola, water infrastructure destroyed by years of conflict faces additional pressure from harsh weather conditions, forcing people to gather water from untested and unsafe sources (Alexander, 2014; Prates, 2019; Water and Sanitation Program, 2011). Many nations in sub-Saharan Africa also experience underinvestment in operations and maintenance for their existing water infrastructure, especially in rural areas (McNicholl et al., 2019). One recent study, for instance, found that approximately 25% of water pumps in the region are not operational at any given time (Foster et al., 2019). Much work remains to be done at the regional and international levels to ensure proper sanitation and drinking water access in sub-Saharan Africa and worldwide.

3. METHODS

Monitoring the world's water quality in terms of sanitation and drinking water poses an evolving challenge. The purpose of the JMP at its outset was to monitor global progress toward achieving "universal access" to safe drinking water and adequate sanitation, but has since developed to consider more than just access to these basic services (WHO & UNICEF, 1992). Starting with the 2000 assessment, WHO/UNICEF began incorporating different types of technology used for sanitation and drinking water services into their analysis of coverage. Some technologies are safer or more adequate than others, and so the distinction brings nuance to the JMP reports. This update additionally shifted facility classifications from "safe" and "adequate" to "improved," opening the analysis to further classifications that have since been implemented. The 2000 update also marked the inauguration of household survey data, versus broader census-level data, since service providers cannot generally provide the same granularity of detail that consumers can (WHO & UNICEF, 2000). All of these changes have provided a more comprehensive picture of the actual conditions within countries and regions (WHO & UNICEF, 2000).

More recently, global water quality monitoring efforts have focused on health outcomes more than simple access and use. After the Sustainable Development Goals were agreed upon, the JMP database became the baseline for estimating the global disease burden attributable to inadequate water, sanitation, and hygiene (WHO & UNICEF, 2017). For example, the JMP supported studies like Wolf et al. (2018), which aimed to determine the impact of sanitation, drinking water, and hygiene on the prevalence of diarrheal diseases in children. Such studies allow us to link health outcomes to improvements in water and sanitation (WHO & UNICEF, 2017). The Global Burden of Disease Study (GBD) from the Institute for Health Metrics and Evaluation (IHME) produces the most comprehensive of such studies, allowing for health risk assessments related to sanitation and drinking water for nearly all of the world's countries and territories.

The 2020 EPI uses two indicators to measure health risks from unsafe sanitation and drinking water globally: *unsafe sanitation* and *unsafe drinking water*. Data from IHME's latest GBD update inform the two indicators, representing the number of age-standardized disability-adjusted life-years (DALYs) lost per 100,000 persons from diseases caused by unsafe sanitation and drinking water, e.g., diarrhea and typhoid (Kyu et al., 2018). This kind of measurement provides a standard metric for comparing different countries.

3.1 INDICATOR BACKGROUND

Our *unsafe sanitation* and *unsafe drinking water* indicators utilize the Comprehensive Risk Assessment (CRA) framework developed for the GBD to estimate rates of exposure to unsafe sanitation and drinking water risks and the attributable deaths and DALYs (Kyu et al., 2018). First, the metrics examine estimated exposure to the risks in question for each country. In this case, the minimum level of exposure to *unsafe drinking water* is defined as "All households have access to water from a piped water supply that is also boiled or filtered before drinking," and for *unsafe sanitation*, minimum exposure means "All households have access to toilets with sewer connection" (Forouzanfar et al., 2016, p. 1662). The second step uses statistical models to estimate the portion of deaths and DALYs attributable to those risks. Finally, the metrics compare the likelihood of death or disease from unsafe sanitation or drinking water to all other potential risks.

3.2 DATA

Data for the *unsafe sanitation* and *unsafe drinking water* indicators come from IHME's GBD project, covering the period from 1990 to 2019 for 195 countries and territories. The GBD team developed information on relative risk and exposure from "randomized control trials, cohort studies, household surveys, census data, satellite data, and other sources" (Stanaway et al., 2018, p. 1923). These estimates were then pooled, corrected for bias, and further adjusted with other covariates.

3.3 LIMITATIONS

The GBD evaluates three adverse health outcomes from exposure to unsafe sanitation and unsafe drinking water: diarrheal diseases, typhoid fever, and paratyphoid fever. In conducting the GBD, IHME relies on the scientific literature to provide key assumptions and data about health risks. The epidemiological studies on diarrheal disease are much stronger than the studies on typhoid and paratyphoid. The gaps in the literature are an important source of uncertainty in GBD estimates.

Water quality assessments also rest on the assumption that "improved" water supplies are safe, but a significant number of water sources that meet the definition of an "improved" source still do not meet WHO guidelines (Clasen et al., 2014). Water supplied through pipes and groundwater may also be contaminated by faulty latrines, and the treatment of the water may be inadequate (Clasen et al., 2014).

Unsafe sanitation and *unsafe drinking water* are limited in scope to only measuring health outcomes resulting from exposure to biological risks, such as the various bacteria that cause diarrhea. Risks of illness or death from chemical contaminants, e.g., lead, are not considered. Despite their exclusion here, chemical contaminants still pose serious health concerns.

TABLE 5-3. Clarification of the *unsafe sanitation* and *unsafe drinking water* metrics.

WHAT THE METRICS ARE	WHAT THE METRICS AREN'T
Age-standardized disability-adjusted life-years lost (due to death and diseases) from unsafe sanitation and unsafe drinking water, per 100,000 persons in a country	• **A measure of water quality or quantity in aquatic ecosystems, e.g., rivers, lakes, and coastal areas** • **A measure of prevalence of chemical contaminants in drinking water, e.g., lead** • **A measure of wastewater treatment** • **A direct measure of the quality of sanitation facilities or drinking water sources** • **A direct measure of access to or use of sanitation facilities or drinking water sources**

Chapter 6. Heavy Metals

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

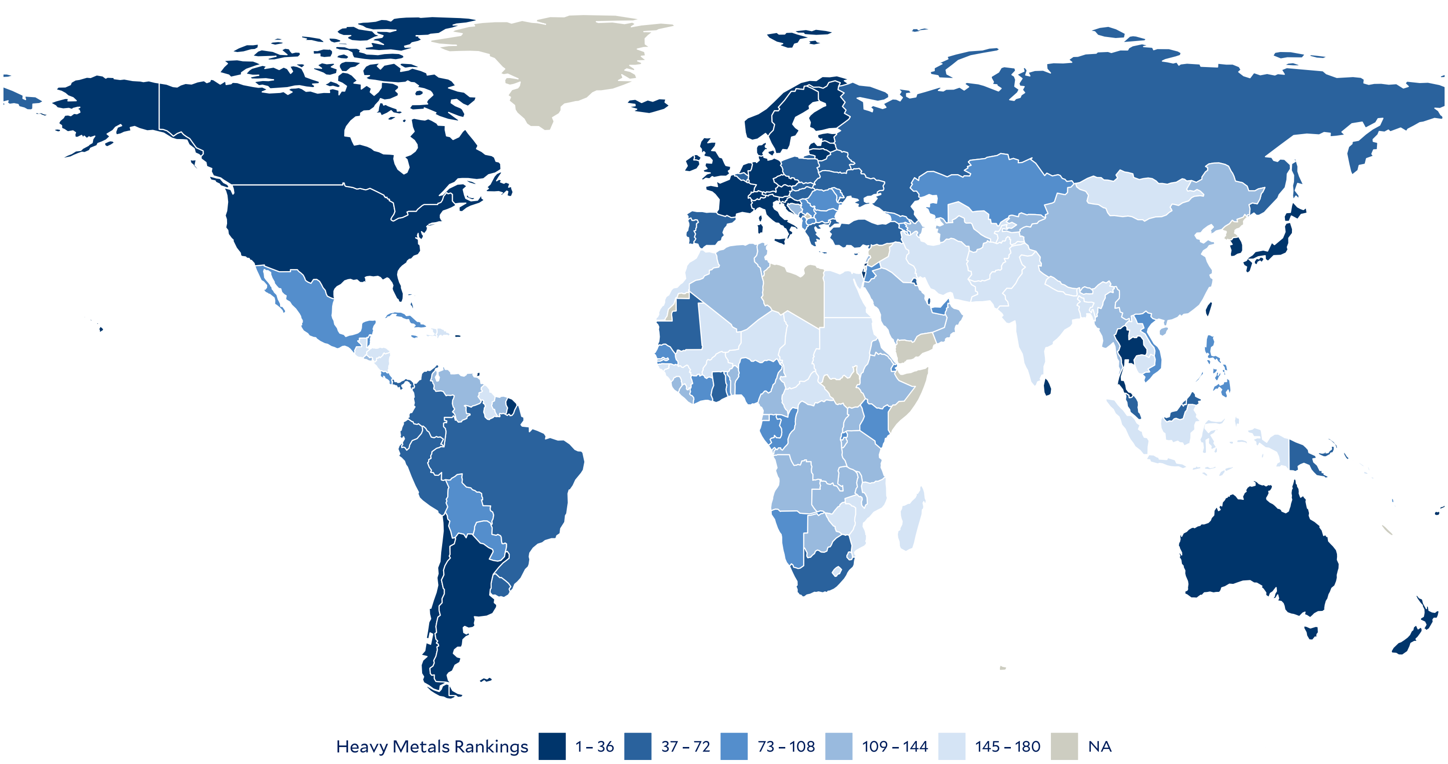
Heavy metals, such as lead, arsenic, mercury, and cadmium, are poisonous and present a significant public health risk worldwide. Lead is an especially dangerous environmental pollutant due to its severe effects on human health – particularly affecting brain development in children – and its widespread presence in water, air, dust, soil, and man-made materials. Even in minimal quantities, lead can build up in biological systems to life-threatening levels of toxicity. The World Health Organization (WHO) states that there is no known level of lead exposure that is considered safe, and lead poisoning in childhood has been linked to cognitive impairment, violent crime in adulthood, and loss of economic productivity (Landrigan et al., 2017). There are few other pollutants for which the dangers are clearer and the benefits from cleanup are higher. In light of the data available on lead globally, the EPI has chosen to use lead exposure as a representative measure of the impact of heavy metal pollution.

1.2 INDICATORS

1.2.1 LEAD EXPOSURE [100% of issue category]

We measure *lead exposure* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to this environmental risk.

MAP 6-1. Rankings on Heavy Metals.



6.

TABLE 6-1. Global rankings, scores, and regional rankings (REG) on Heavy Metals.

RANK	COUNTRY	SCORE	REG
1	Finland	100.0	1
	Iceland	100.0	1
	Netherlands	100.0	1
	Norway	100.0	1
	Switzerland	100.0	1
	United Kingdom	100.0	1
7	Malta	99.8	7
8	Germany	99.0	8
9	Luxembourg	98.6	9
10	Sweden	98.5	10
11	Greece	98.2	1
	Italy	98.2	11
13	Denmark	97.4	12
	Ireland	97.4	12
15	Spain	96.8	14
16	France	96.2	15
17	Japan	95.0	1
18	Austria	94.7	16
19	Cyprus	93.9	2
20	Belgium	93.6	17
21	Singapore	93.2	2
22	Israel	92.8	1
23	South Korea	90.7	3
24	Canada	88.0	18
25	Australia	87.0	19
26	United States of America	86.1	20
27	Brunei Darussalam	85.6	4
28	Portugal	83.4	21
29	New Zealand	80.4	22
30	Czech Republic	76.4	3
31	Slovenia	74.7	4
32	Taiwan	72.4	5
33	Slovakia	71.8	5
34	Poland	71.7	6
35	Uruguay	70.8	1
36	Croatia	70.2	7
37	Bulgaria	68.3	8
38	Chile	68.1	2
39	Kuwait	67.4	2
40	United Arab Emirates	67.2	3
41	Qatar	66.5	4
42	Costa Rica	66.1	3
43	Montenegro	65.6	9
44	Mauritius	65.5	1
	Serbia	65.5	10
46	Argentina	64.7	4
47	Jordan	62.6	5
48	Hungary	62.2	11
49	Estonia	61.9	12
50	Bosnia and Herzegovina	61.4	13
51	North Macedonia	61.1	14
52	Belarus	60.5	1
53	Lebanon	59.7	6
54	China	59.4	6
55	Saudi Arabia	59.3	7
56	Latvia	59.0	15
57	Lithuania	58.3	16
	Oman	58.3	8
59	Malaysia	57.6	7
60	Armenia	57.2	2

RANK	COUNTRY	SCORE	REG
61	Bahrain	56.6	9
62	Romania	55.9	17
63	Colombia	55.8	5
	Thailand	55.8	8
65	Russia	55.4	3
66	Kazakhstan	55.1	4
	Ukraine	55.1	4
68	Bahamas	55.0	6
69	Albania	54.0	18
70	Iran	53.6	10
71	Trinidad and Tobago	53.4	7
72	Algeria	53.2	11
73	Mexico	52.8	8
74	Viet Nam	52.7	9
75	Tunisia	52.6	12
	Turkey	52.6	19
77	Uzbekistan	52.0	6
78	Barbados	51.9	9
79	Georgia	51.6	7
80	Seychelles	51.4	2
81	Ecuador	50.2	10
82	Antigua and Barbuda	50.0	11
	Moldova	50.0	8
84	Cuba	49.6	12
	Iraq	49.6	13
86	Jamaica	49.3	13
87	Samoa	49.2	10
88	Sri Lanka	48.4	1
89	Maldives	47.8	2
90	Dominica	47.5	14
	Paraguay	47.5	14
92	Turkmenistan	47.3	9
93	Grenada	47.0	16
94	Venezuela	46.8	17
95	Tonga	46.4	11
96	Brazil	46.1	18
97	Azerbaijan	45.5	10
	Kyrgyzstan	45.5	10
99	Saint Lucia	45.4	19
100	Panama	43.5	20
	St. Vincent and Grenadines	43.5	20
102	Mongolia	43.1	12
103	Peru	43.0	22
104	Nicaragua	42.8	23
105	Belize	42.6	24
106	El Salvador	41.6	25
107	Morocco	40.8	14
108	Bolivia	40.0	26
109	Suriname	39.3	27
110	Philippines	39.0	13
111	Dominican Republic	38.9	28
112	Egypt	36.6	15
113	Cabo Verde	35.5	3
	Micronesia	35.5	14
115	Guyana	35.3	29
116	São Tomé and Príncipe	35.2	4
117	Fiji	34.6	15
118	Cambodia	34.2	16
119	Equatorial Guinea	33.1	5
120	Marshall Islands	32.2	17

RANK	COUNTRY	SCORE	REG
121	Honduras	31.8	30
122	Bhutan	31.2	3
123	Tajikistan	30.9	12
124	Myanmar	30.8	18
125	Indonesia	28.4	19
126	Guatemala	28.2	31
127	Afghanistan	28.0	4
128	Gabon	27.6	6
129	Bangladesh	27.3	5
130	Nepal	27.0	6
131	Laos	26.5	20
132	Timor-Leste	25.9	21
133	South Africa	24.6	7
134	Sudan	22.3	16
135	Vanuatu	21.5	22
136	Botswana	20.8	8
	Ghana	20.8	8
138	Namibia	19.6	10
139	India	19.4	7
140	Gambia	19.1	11
141	Tanzania	18.4	12
142	Djibouti	18.3	13
143	Uganda	17.6	14
144	Pakistan	17.4	8
145	Côte d'Ivoire	17.2	15
146	Rwanda	16.9	16
147	Zimbabwe	16.8	17
148	Mozambique	16.4	18
149	Kiribati	16.3	23
150	Papua New Guinea	15.5	24
151	Comoros	15.2	19
152	Republic of Congo	14.6	20
153	Haiti	14.0	32
	Solomon Islands	14.0	25
155	Kenya	13.6	21
	Mauritania	13.6	21
157	Dem. Rep. Congo	13.5	23
158	Benin	13.4	24
	Zambia	13.4	24
160	Senegal	13.1	26
161	Angola	12.8	27
162	Eswatini	12.6	28
163	Malawi	12.0	29
164	Sierra Leone	11.5	30
165	Guinea	11.2	31
166	Ethiopia	10.9	32
167	Liberia	9.8	33
168	Mali	8.2	34
169	Burkina Faso	7.7	35
	Cameroon	7.7	35
171	Lesotho	7.2	37
172	Guinea-Bissau	6.7	38
173	Eritrea	6.3	39
174	Madagascar	5.9	40
175	Burundi	5.3	41
176	Togo	5.1	42
177	Nigeria	4.9	43
178	Niger	1.4	44
179	Central African Republic	0.0	45
	Chad	0.0	45

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 6-2. Regional rankings, scores, and global rankings on Heavy Metals.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Chile	97.8	5
2	Trinidad and Tobago	82.0	23
3	Argentina	73.1	35
4	Barbados	70.4	39
5	Peru	68.2	47
6	Bahamas	67.1	50
7	Ecuador	63.0	55
8	Uruguay	62.3	56
9	Colombia	61.9	58
10	Antigua and Barbuda	60.5	60
11	Brazil	58.9	64
12	Panama	57.5	68
13	Belize	54.5	74
14	Costa Rica	53.8	77
15	Dominica	52.8	78
16	Saint Lucia	51.8	80
17	Paraguay	51.2	83
18	Jamaica	48.9	89
19	Cuba	48.3	90
20	Mexico	45.7	101
21	Bolivia	43.7	108
22	Suriname	43.2	114
23	Venezuela	43.1	115
24	Grenada	41.9	118
25	El Salvador	35.5	143
26	St. Vincent and Grenadines	34.7	146
27	Nicaragua	34.5	149
28	Guatemala	30.6	156
29	Dominican Republic	30.0	157
30	Guyana	24.9	169
31	Honduras	20.7	175
32	Haiti	12.1	178

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Slovenia	88.1	17
2	Estonia	87.4	18
3	Lithuania	83.9	21
4	Latvia	78.4	27
5	Czech Republic	76.4	30
6	Croatia	75.1	33
7	Cyprus	69.4	40
	Greece	69.4	40
9	Slovakia	69.2	43
10	Hungary	68.2	47
11	Poland	65.3	52
12	Montenegro	65.2	54
13	Turkey	61.5	59
14	Romania	51.4	82
15	Serbia	51.1	84
16	North Macedonia	46.7	95
17	Albania	46.1	99
18	Bulgaria	45.8	100
19	Bosnia and Herzegovina	42.9	116

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Sri Lanka	72.4	36
2	Maldives	55.4	71
3	Bhutan	43.3	113
4	Nepal	27.2	166
5	Bangladesh	23.2	172
6	Pakistan	23.0	173
7	India	21.0	174
8	Afghanistan	0.0	180

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Denmark	100.0	1
	Finland	100.0	1
3	Sweden	98.0	4
4	Canada	96.6	6
5	Iceland	96.1	7
	Luxembourg	96.1	7
7	Netherlands	95.1	9
8	Switzerland	95.0	10
9	United Kingdom	94.6	11
10	Norway	94.0	12
11	Austria	91.7	14
12	Germany	90.7	15
13	France	84.0	20
14	Ireland	82.7	22
15	Italy	81.5	25
16	Australia	77.2	28
17	United States of America	75.9	31
18	New Zealand	75.5	32
19	Spain	71.3	38
20	Belgium	67.4	49
21	Portugal	65.3	52
22	Malta	50.6	86

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Russia	72.2	37
2	Ukraine	69.3	42
3	Belarus	57.7	67
4	Moldova	54.7	73
5	Kazakhstan	52.8	78
6	Armenia	50.8	85
7	Georgia	49.9	88
8	Turkmenistan	43.5	112
9	Azerbaijan	41.0	121
10	Kyrgyzstan	40.8	122
11	Uzbekistan	27.8	163
12	Tajikistan	15.7	176

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Japan	100.0	1
2	South Korea	89.4	16
3	Singapore	85.4	19
4	Thailand	81.6	24
5	Tonga	78.8	26
6	Fiji	77.0	29
7	Taiwan	73.6	34
8	Samoa	68.6	44
9	Brunei Darussalam	68.4	46
10	Malaysia	62.1	57
11	Papua New Guinea	60.3	61
12	Philippines	48.0	91
13	Viet Nam	47.8	92
14	Marshall Islands	46.6	97
15	Vanuatu	45.6	102
16	Micronesia	41.5	120
17	Myanmar	38.2	128
18	China	37.6	129
19	Kiribati	37.0	135
20	Cambodia	35.0	145
21	Laos	34.7	146
22	Indonesia	34.6	148
23	Timor-Leste	34.3	150
24	Mongolia	33.2	151
25	Solomon Islands	25.5	167

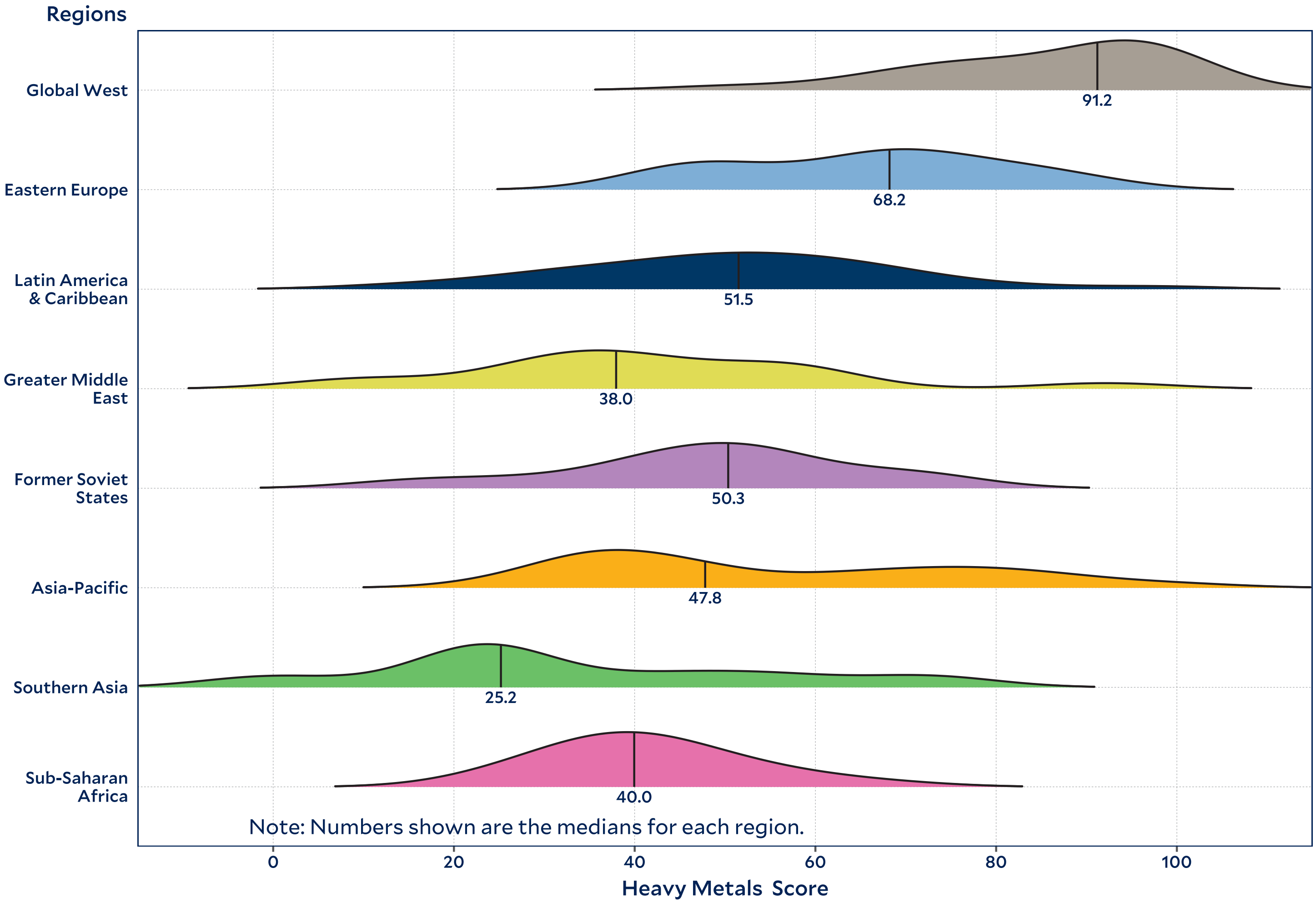
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Seychelles	68.6	44
2	Mauritius	66.8	51
3	Cabo Verde	59.5	62
4	South Africa	58.8	65
5	Mauritania	55.8	70
6	Ghana	55.3	72
7	Gabon	54.1	76
8	Nigeria	51.5	81
9	Kenya	50.6	86
10	Senegal	47.7	93
11	Comoros	47.1	94
12	Djibouti	46.2	98
13	Rwanda	45.2	103
14	Republic of Congo	45.1	104
15	São Tomé and Príncipe	45.0	105
16	Côte d'Ivoire	44.9	106
17	Namibia	44.5	107
18	Togo	43.7	108
19	Tanzania	43.6	110
20	Zambia	42.4	117
21	Uganda	41.9	118
22	Eswatini	40.2	123
23	Equatorial Guinea	40.1	124
24	Botswana	39.8	125
25	Eritrea	38.3	127
26	Malawi	37.4	130
	Sierra Leone	37.4	130
28	Angola	37.3	132
	Liberia	37.3	132
30	Gambia	37.1	134
31	Benin	36.8	137
32	Cameroon	36.1	139
	Dem. Rep. Congo	36.1	139
34	Burundi	35.8	141
	Ethiopia	35.8	141
36	Madagascar	33.0	152
37	Guinea	32.9	153
38	Zimbabwe	32.6	154
39	Mali	32.5	155
40	Burkina Faso	29.7	158
41	Chad	29.1	160
42	Guinea-Bissau	28.5	162
43	Niger	27.3	165
44	Lesotho	25.0	168
45	Central African Republic	24.0	170
46	Mozambique	23.7	171

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Israel	92.1	13
2	Qatar	59.2	63
3	Bahrain	58.7	66
4	Kuwait	56.8	69
5	United Arab Emirates	54.3	75
6	Jordan	46.7	95
7	Lebanon	43.6	110
8	Algeria	38.9	126
9	Oman	37.0	135
10	Tunisia	36.5	138
11	Saudi Arabia	35.4	144
12	Iraq	29.6	159
13	Morocco	28.9	161
14	Iran	27.4	164
15	Egypt	13.5	177
16	Sudan	7.1	179

FIGURE 6-1. Regional performance on Heavy Metals.



2. RESULTS

2.1 GLOBAL TRENDS

Heavy metal exposure remains a pressing environmental public health issue worldwide – with several regions still exhibiting high levels of lead pollution despite policy commitments to abate lead in almost every nation. Since human activity, particularly energy production, generates most heavy metal pollution, its prevalence has increased tenfold in the last few decades, and this trend is likely to continue in the future (Mamtani et al., 2011). The main sources of lead pollution are household goods, the burning of fossil fuels, and the disposal of batteries. Middle- and low-income countries like Indonesia (Haryanto, 2016) and Pakistan (Basit et al., 2015) must also contend with lead-acid car battery recycling facilities operating with low operational health standards.

Lead poses a particular danger because the sources can be difficult to determine or avoid, and the symptoms at low levels of accumulation may be commonplace and misattributed to other factors. The health risks linked to lead overexposure include depression, anemia, nausea, high blood pressure, heart disease, kidney disease, and reduced fertility/miscarriages. Young children can also suffer from issues with neurological and nervous system development (U.S. Centers for Disease Control, 2018). Since no level of lead exposure is safe for humans, the associated health impacts are often underreported, as primary care workers tend to exclude occupational and environmental factors from their health evaluations (Mamtani et al., 2011). Despite global recognition of heavy metal toxicity, the Institute for Health Metrics and Evaluation (IHME) estimated that lead exposure resulted in 1.06 million deaths around the world in 2017 (Roth et al., 2018).

In an effort to mitigate the effects of lead poisoning, the WHO, United Nations Environment Programme (UNEP), and Global Environmental Facility spearhead the Global Alliance to Eliminate Lead Paint. By 2019, seventy-three countries had adopted legally binding controls for lead paint (UNEP, 2019b). Adoption has increased from previous years but remains alarmingly low, given the high risk of continuing to use lead paint.

Though the world has made significant progress on air and water quality worldwide over the last three decades, Figure 6-2 shows reductions in lead pollution have been much slower. Global DALY rates from air and water pollution declined by 49% and 65%, respectively, but DALY rates from *lead exposure* only declined by 24%.

2.2 LEADERS & LAGGARDS

Leaders in the Heavy Metals issue category are predominantly members of the European Union, such as Denmark, Finland, and Sweden, but other countries show strong performance as well, including Canada, Japan, and Chile. This success can be attributed to the phaseout of leaded gasoline in the 1970s and stringent regulatory and public health monitoring mechanisms, such as medical blood lead level studies. In the European Union and most other high-income countries, regulations ban the residential use of lead paint (Gottesfeld, 2015). In Japan, policies for waste incineration facilities in the late 1990s further decreased atmospheric lead concentration (Yoshinaga, 2012). New Zealand has recently undertaken significant measures, reducing the allowable levels of lead in water, food, soil, and workplace environments and removing lead from paint, petrol, and all materials that come into contact with food and beverages (Mannetje et al., 2018). In an effort equally as important as tackling the threat of lead exposure, New Zealand has expanded efforts on data collection about this critical health risk through biomonitoring of the population's blood lead levels (Mannetje et al., 2020).

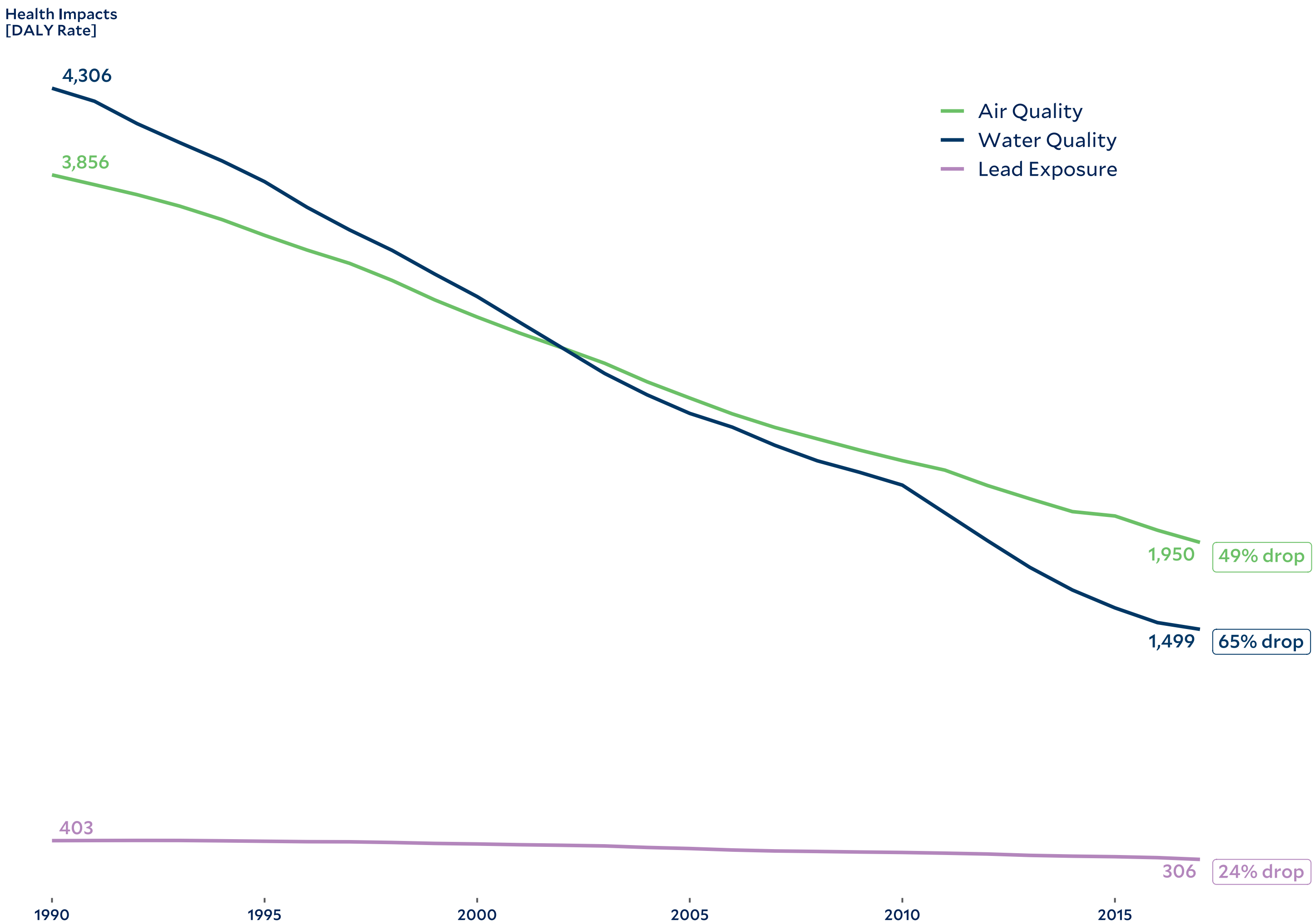
Laggards include mainly middle- and low-income countries that lack sufficient regulation on lead exposure and implement few industrial safety measures. While some countries are tightening their health standards for heavy metals, others are undergoing growth and industrialization without incorporating those measures. Countries listed as laggards in lead exposure do not have routine screening processes, detailed investigation into risks, or lead poisoning prevention strategies (Landrigan et al., 2017, p. 27).

Historically, a major source of lead exposure has been leaded gasoline. Several decades ago, the widespread presence of leaded gasoline around the world led to high levels of air pollution and resource contamination. South Africa, for example, faced some of the highest blood lead levels on the continent in the 1990s, which greatly diminished with the introduction of lead-free gasoline (WHO, 2015). Today, initiatives such as the UN Partnership for Clean Fuel and Vehicles have phased out the use of leaded gasoline. As of 2019, only two countries continue to allow the use of leaded gasoline, Algeria and Iraq (Li, 2019; UNEP, 2019a).

In many countries, leaded paint remains a source of toxic pollution – both from continued use and from older, peeling fragments. According to the WHO, as of 2019 only 38% of countries

6.

FIGURE 6-2. Global progress on health outcomes from air quality, water quality, and lead exposure.
Note: DALY rate = age-standardized disability-adjusted life-years lost per 100,000 persons.
Source: Institute for Health Metrics & Evaluation



controlled or outlawed the production, sale, and use of leaded paint (2019). Nepal, for example, saw sustained blood lead levels in children despite a lead gasoline phase-out. These results suggest that lead poisoning, particularly for young children, may be largely due to chipped paint, lead acid batteries, toys, traditional cosmetics, and water sources (Gautam et al., 2017).

The majority of current lead pollution stems from lead smelting and battery recycling. According to the WHO, 85% of the world's lead consumption is used in battery production (WHO, 2017a). A 2016 report identified the recycling of used lead-acid car batteries, which occurs in nearly every city in the developing world, as the leading source of chemical pollution in low- and middle-income countries (Pure Earth & Green Cross Switzerland, 2016). Southeast Asia, Africa, and Latin America contain hotspots for lead-acid battery recycling. Egypt is a prime example, where battery recycling and smelting plants are the leading sources of lead contamination, especially for houses with increased exposure (Safar et al., 2014). Certain programs have been put in place to reduce heavy metal exposure, such as the Egyptian Environmental Policy Program and coöperation between lead-smelting plants and USAID to install safe practices (Safar et al., 2014).

Other countries further illustrate the many ways that populations are exposed to lead. In Pakistan, lead in drinking water is a pervasive challenge. A World Bank study of Karachi found that 89% of sampled water sources exceeded the WHO's recommended lead concentration limit of 10 µg/L (Sanchez-Triana, 2016). Experts suggest that the government should implement programs and legislative measures to control lead exposure, monitor high-risk groups, and invest in nutritional support programs for children to reduce lead poisoning (Kazmi & Omair, 2005). Despite phasing out leaded petrol in 2000, population-wide blood lead levels in India remain high (Garnåsjordet et al., 2012). Indian children are at risk from battery casings, battery smelting plants, and lead released from petrol and paint (Moawad et al., 2016). The Dominican Republic faces severe challenges with lead contamination, exacerbated by a lack of government intervention. The town of Haina hosted an abandoned lead-smelting plant for decades, which leaked into the surrounding environment and affected the entire population of the city from the 1990s to 2009 (Kaul & Mukerjee, 1999). Only after the toxic waste was eliminated did scientists see a notable decrease in blood lead levels (Ericson et al., 2018). Policymakers around the world should be attentive to all potential sources of lead exposure, which robust testing and tracking systems can help to identify and monitor.

3. METHODS

Obstacles to measuring and ultimately eliminating lead pollution include the metal's widespread presence in the environment, its ability to travel long distances within environmental systems, and weak or unenforced control measures (WHO, 2011). Every country should implement standardized monitoring and data collection systems for lead contaminants in high-risk zones, especially in low- and middle-income countries where significant exposure persists (Attina & Trasande, 2013). Information on nonpoint sources of lead is especially inadequate, as diffuse origins like leaded aviation fuel, battery recycling, craft making, and electronic waste recovery are difficult to monitor (WHO, 2010b). Identifying high-risk areas can also be a challenge, and diagnosis can be difficult when exposure goes unnoticed and symptoms are relatively nonspecific (Haefliger, 2011).

Laboratories primarily assess lead exposure through blood concentration. Although lead poisoning can also be measured using hair, teeth, bone, and urine, measuring the blood lead level (BLL) is widely viewed as the most reliable tool (Haefliger, 2011). This is particularly true for screening young children, whose BLL can indicate recent, acute exposure (WHO, 2010a). Less developed countries lack the resources to conduct comprehensive surveillance, though, and lead poisoning's geographic and socioeconomic factors have yet to be fully understood (Meyer et al., 2008). Nonetheless, lead is one of the most thoroughly documented and researched pollutants among the heavy metals and affects the greater number of people worldwide (Caribbean Environment Programme, 2008).

3.1 INDICATOR BACKGROUND

Lead exposure is classified in two ways: acute and chronic lead poisoning. Acute toxicity is indicative of severe short-term exposure, whereas chronic toxicity describes repeated exposure, often at lower levels. Acute lead exposure is relevant to disease burden in children because their brains and nervous systems can absorb four to five times as much lead as adults (WHO, 2017b). This sensitivity is further exacerbated by children's innate exploratory behavior, which results in greater ingestion of lead from soil, dust, paint, and other lead-contaminated substances (WHO, 2017b).

Chronic lead exposure is more pervasive in adults due to long-term occupational exposure. Long-term exposure is not measured by BLL but instead by micrograms of lead per gram of bone. While the half-life of lead in blood is only about one month in adults, lead that accumulates in the body over time is stored in an individual's bones (Payne et al., 2010). Concentrations in tissue give evidence of how widespread lead exposure is in a population, from which epidemiologists infer the risks of death and disease.

3.2 DATA DESCRIPTION

Data on *lead exposure* come from the Institute for Health Metrics and Evaluation's Global Burden of Disease Study (GBD) (Kyu et al., 2018), which is the most comprehensive worldwide epidemiological study of lead exposure. The GBD examines mortality and morbidity trends based on major diseases, injuries, and risk factors from lead exposure. Data for the GBD are drawn from 332 different studies on blood and bone samples. In 2015, the spatial-temporal modeling methodology was improved to more accurately predict blood lead levels in countries and years with insufficient data (Shaffer et al., 2019). The 2020 EPI uses GBD estimates of DALY rates from 1990 to 2019.

3.3 LIMITATIONS

While the GBD is the leading epidemiological study on environmental risks, this indicator has several limitations. First, measuring lead exposure requires intense effort to collect and analyze human tissue, and the GBD must draw on sparse datasets of blood and bone samples. Interpolation of exposure levels introduces uncertainty into the final DALY rate estimates. Second, the collection of tissue samples poses a number of challenges, including unknown contaminants, lack of quality assurance, and the short half-life of lead in blood (Haefliger, 2011; M. Payne et al., 2010). Finally, the GBD makes assumptions when linking lead exposure to actual health outcomes and the incidence of disease and death across populations. The *lead exposure* indicator is the best available metric on this important environmental health risk, and improvements in measurement – including better techniques, more frequent data collection, and more widespread testing – can provide better insight into this critical issue category.

TABLE 6-3. Clarification of the *lead exposure* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
Age-standardized disability-adjusted life-years lost (due to death and diseases) from lead exposure, per 100,000 persons in a country	• **A measure of ambient lead concentrations** • **A measure of prevalence of lead sources** • **A measure of natural sources of lead** • **A measure of the toxicity or nature of the industrial sector** • **A direct measure of lead in drinking water** • **A perfect proxy for other heavy metals such as mercury and cadmium that present separate health risks**

Chapter 7. Waste Management

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

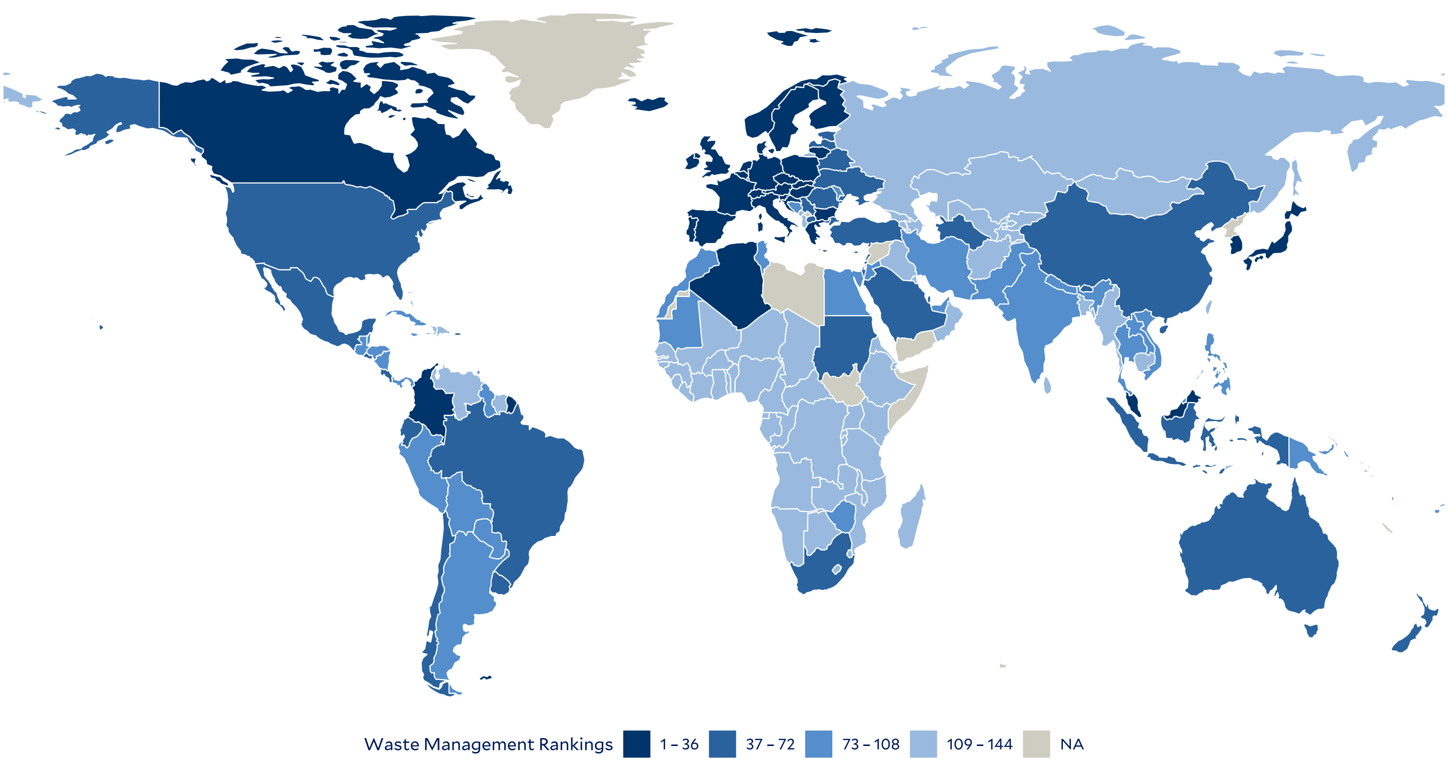
Waste Management joins the 2020 EPI as a new metric covering an important sustainability issue that has long been seen as a notable gap in the EPI framework. Prior to the 2020 EPI, no methodologically consistent data on how nations manage solid waste had been available across the broad scope of EPI country coverage. Uncontrolled waste disposal generates air and water pollution, soil contamination, and an increased risk of exposure to pathogens and toxic substances. Poorly managed waste also contributes to climate change through methane off-gassing and can, in some circumstances, threaten biodiversity. The new Waste Management metric tracks the final destination of waste materials as a measure of the waste's direct impact on the environment. Globally in 2016, the most recent year for which we have comprehensive data, less than 42% of waste gets disposed of according to controlled management approaches.

1.2 INDICATORS

1.2.1 Controlled Solid Waste [100% of issue category]

Controlled solid waste refers to the percentage of household and commercial waste (not toxic materials) generated in a country that is collected and treated in a manner that controls environmental risks. This metric counts waste as "controlled" if it is treated through recycling, composting, anaerobic digestion, incineration, or disposed of in a sanitary landfill.

MAP 7-1. Rankings on Waste Management.



7.

TABLE 7-1. Global rankings, scores, and regional rankings (REG) on Waste Management.

RANK	COUNTRY	SCORE	REG
1	Colombia	100.0	1
	Netherlands	100.0	1
3	Denmark	99.8	2
	Sweden	99.8	2
5	Singapore	99.6	1
6	Switzerland	99.0	4
7	Mauritius	98.0	1
8	Germany	97.9	5
9	Finland	97.7	6
10	Belgium	97.6	7
	Norway	97.6	7
12	Austria	97.2	9
13	Malta	96.7	10
	South Korea	96.7	2
15	Luxembourg	96.2	11
16	France	94.8	12
17	United Kingdom	92.9	13
18	Algeria	91.6	1
19	Poland	91.1	1
20	Portugal	90.2	14
21	Czech Republic	89.5	2
22	Hungary	89.2	3
23	Spain	89.0	15
24	Lithuania	87.8	4
25	Japan	86.5	3
26	Iceland	84.8	16
27	Canada	84.7	17
28	Slovenia	83.8	5
29	Italy	83.7	18
30	Bulgaria	83.6	6
31	Greece	83.0	7
32	Ireland	81.7	19
33	Malaysia	81.4	4
34	Slovakia	80.6	8
35	Croatia	80.0	9
36	Grenada	78.8	2
37	Belarus	77.5	1
	Cyprus	77.5	10
	Saint Lucia	77.5	3
40	Australia	77.3	20
41	South Africa	77.0	2
42	Antigua and Barbuda	75.1	4
43	Estonia	74.4	11
44	Mexico	74.3	5
45	Ukraine	73.1	2
46	St. Vincent and Grenadines	72.8	6
47	Israel	72.2	2
48	North Macedonia	72.1	12
49	New Zealand	68.0	21
50	Barbados	67.2	7
51	Brazil	65.8	8
	Romania	65.8	13
53	Chile	65.7	9
54	Costa Rica	64.8	10
55	Dominica	62.4	11
56	Latvia	61.4	14
	Lebanon	61.4	3
	Saudi Arabia	61.4	3
59	Bahrain	60.4	5
60	Qatar	60.2	6
61	Bhutan	59.7	1
62	Turkmenistan	59.2	3
63	El Salvador	55.5	12
64	Sudan	53.8	7
65	Ecuador	53.6	13
66	China	51.8	5
67	Samoa	51.7	6
68	Indonesia	49.8	7
69	Uruguay	48.9	14
70	Turkey	48.5	15
71	United States of America	48.3	22
72	Serbia	44.7	16
73	Argentina	44.6	15
74	Guyana	44.2	16
75	Papua New Guinea	43.9	8
76	Jordan	43.1	8
77	Brunei Darussalam	42.5	9
78	Panama	42.0	17
79	Honduras	40.3	18
80	Fiji	40.0	10
81	Morocco	39.6	9
	Tunisia	39.6	9
83	Paraguay	35.0	19
84	Thailand	32.9	11
85	Jamaica	31.7	20
86	Vanuatu	31.4	12
87	Bolivia	31.1	21
	Pakistan	31.1	2
89	Nepal	30.5	3
90	Peru	30.0	22
91	Bosnia and Herzegovina	27.9	17
92	Tonga	27.2	13
93	United Arab Emirates	26.8	11
94	Cuba	25.9	23
95	Viet Nam	22.8	14
96	Marshall Islands	22.1	15
97	Iran	19.0	12
98	Laos	18.7	16
99	Philippines	17.4	17
100	Belize	17.0	24
101	Guatemala	16.6	25
102	Egypt	16.3	13
103	India	16.1	4
104	Moldova	13.8	4
105	Mauritania	12.5	3
106	Nicaragua	11.4	26
107	Zimbabwe	11.0	4
108	Trinidad and Tobago	10.4	27
109	Burkina Faso	10.2	5
	Cameroon	10.2	5
111	Maldives	9.6	5
112	Nigeria	7.7	7
113	Benin	5.8	8
114	Dominican Republic	5.7	28
115	Kenya	5.5	9
116	Montenegro	5.3	18
117	Bangladesh	5.0	6
118	Uganda	4.9	10
119	Sri Lanka	4.4	7
120	Namibia	4.2	11
121	Dem. Rep. Congo	3.5	12
122	Russia	3.2	5
123	Guinea	2.5	13
124	Kazakhstan	2.2	6
125	Côte d'Ivoire	2.1	14
126	Niger	1.0	15
	Togo	1.0	15
128	Haiti	0.9	29
	Senegal	0.9	17
130	Botswana	0.7	18
	Mozambique	0.7	18
132	Madagascar	0.6	20
133	Afghanistan	0.0	8
	Albania	0.0	19
	Angola	0.0	21
	Armenia	0.0	7
	Azerbaijan	0.0	7
	Bahamas	0.0	30
	Burundi	0.0	21
	Cabo Verde	0.0	21
	Cambodia	0.0	18
	Central African Republic	0.0	21
	Chad	0.0	21
	Comoros	0.0	21
	Djibouti	0.0	21
	Equatorial Guinea	0.0	21
	Eritrea	0.0	21
	Eswatini	0.0	21
	Ethiopia	0.0	21
	Gabon	0.0	21
	Gambia	0.0	21
	Georgia	0.0	7
	Ghana	0.0	21
	Guinea-Bissau	0.0	21
	Iraq	0.0	14
	Kiribati	0.0	18
	Kuwait	0.0	14
	Kyrgyzstan	0.0	7
	Lesotho	0.0	21
	Liberia	0.0	21
	Malawi	0.0	21
	Mali	0.0	21
	Micronesia	0.0	18
	Mongolia	0.0	18
	Myanmar	0.0	18
	Oman	0.0	14
	Republic of Congo	0.0	21
	Rwanda	0.0	21
	São Tomé and Príncipe	0.0	21
	Seychelles	0.0	21
	Sierra Leone	0.0	21
	Solomon Islands	0.0	18
	Suriname	0.0	30
	Taiwan	0.0	18
	Tajikistan	0.0	7
	Tanzania	0.0	21
	Timor-Leste	0.0	18
	Uzbekistan	0.0	7
	Venezuela	0.0	30
	Zambia	0.0	21

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 7-2. Regional rankings, scores, and global rankings on Waste Management.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Colombia	100.0	1
2	Grenada	78.8	36
3	Saint Lucia	77.5	37
4	Antigua and Barbuda	75.1	42
5	Mexico	74.3	44
6	St. Vincent and Grenadines	72.8	46
7	Barbados	67.2	50
8	Brazil	65.8	51
9	Chile	65.7	53
10	Costa Rica	64.8	54
11	Dominica	62.4	55
12	El Salvador	55.5	63
13	Ecuador	53.6	65
14	Uruguay	48.9	69
15	Argentina	44.6	73
16	Guyana	44.2	74
17	Panama	42.0	78
18	Honduras	40.3	79
19	Paraguay	35.0	83
20	Jamaica	31.7	85
21	Bolivia	31.1	87
22	Peru	30.0	90
23	Cuba	25.9	94
24	Belize	17.0	100
25	Guatemala	16.6	101
26	Nicaragua	11.4	106
27	Trinidad and Tobago	10.4	108
28	Dominican Republic	5.7	114
29	Haiti	0.9	128
30	Bahamas	0.0	133
	Suriname	0.0	133
	Venezuela	0.0	133

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Poland	91.1	19
2	Czech Republic	89.5	21
3	Hungary	89.2	22
4	Lithuania	87.8	24
5	Slovenia	83.8	28
6	Bulgaria	83.6	30
7	Greece	83.0	31
8	Slovakia	80.6	34
9	Croatia	80.0	35
10	Cyprus	77.5	37
11	Estonia	74.4	43
12	North Macedonia	72.1	48
13	Romania	65.8	51
14	Latvia	61.4	56
15	Turkey	48.5	70
16	Serbia	44.7	72
17	Bosnia and Herzegovina	27.9	91
18	Montenegro	5.3	116
19	Albania	0.0	133

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Bhutan	59.7	61
2	Pakistan	31.1	87
3	Nepal	30.5	89
4	India	16.1	103
5	Maldives	9.6	111
6	Bangladesh	5.0	117
7	Sri Lanka	4.4	119
8	Afghanistan	0.0	133

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Netherlands	100.0	1
2	Denmark	99.8	3
	Sweden	99.8	3
4	Switzerland	99.0	6
5	Germany	97.9	8
6	Finland	97.7	9
7	Belgium	97.6	10
	Norway	97.6	10
9	Austria	97.2	12
10	Malta	96.7	13
11	Luxembourg	96.2	15
12	France	94.8	16
13	United Kingdom	92.9	17
14	Portugal	90.2	20
15	Spain	89.0	23
16	Iceland	84.8	26
17	Canada	84.7	27
18	Italy	83.7	29
19	Ireland	81.7	32
20	Australia	77.3	40
21	New Zealand	68.0	49
22	United States of America	48.3	71

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Belarus	77.5	37
2	Ukraine	73.1	45
3	Turkmenistan	59.2	62
4	Moldova	13.8	104
5	Russia	3.2	122
6	Kazakhstan	2.2	124
7	Armenia	0.0	133
	Azerbaijan	0.0	133
	Georgia	0.0	133
	Kyrgyzstan	0.0	133
	Tajikistan	0.0	133
	Uzbekistan	0.0	133

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Singapore	99.6	5
2	South Korea	96.7	13
3	Japan	86.5	25
4	Malaysia	81.4	33
5	China	51.8	66
6	Samoa	51.7	67
7	Indonesia	49.8	68
8	Papua New Guinea	43.9	75
9	Brunei Darussalam	42.5	77
10	Fiji	40.0	80
11	Thailand	32.9	84
12	Vanuatu	31.4	86
13	Tonga	27.2	92
14	Viet Nam	22.8	95
15	Marshall Islands	22.1	96
16	Laos	18.7	98
17	Philippines	17.4	99
18	Cambodia	0.0	133
	Kiribati	0.0	133
	Micronesia	0.0	133
	Mongolia	0.0	133
	Myanmar	0.0	133
	Solomon Islands	0.0	133
	Taiwan	0.0	133
	Timor-Leste	0.0	133

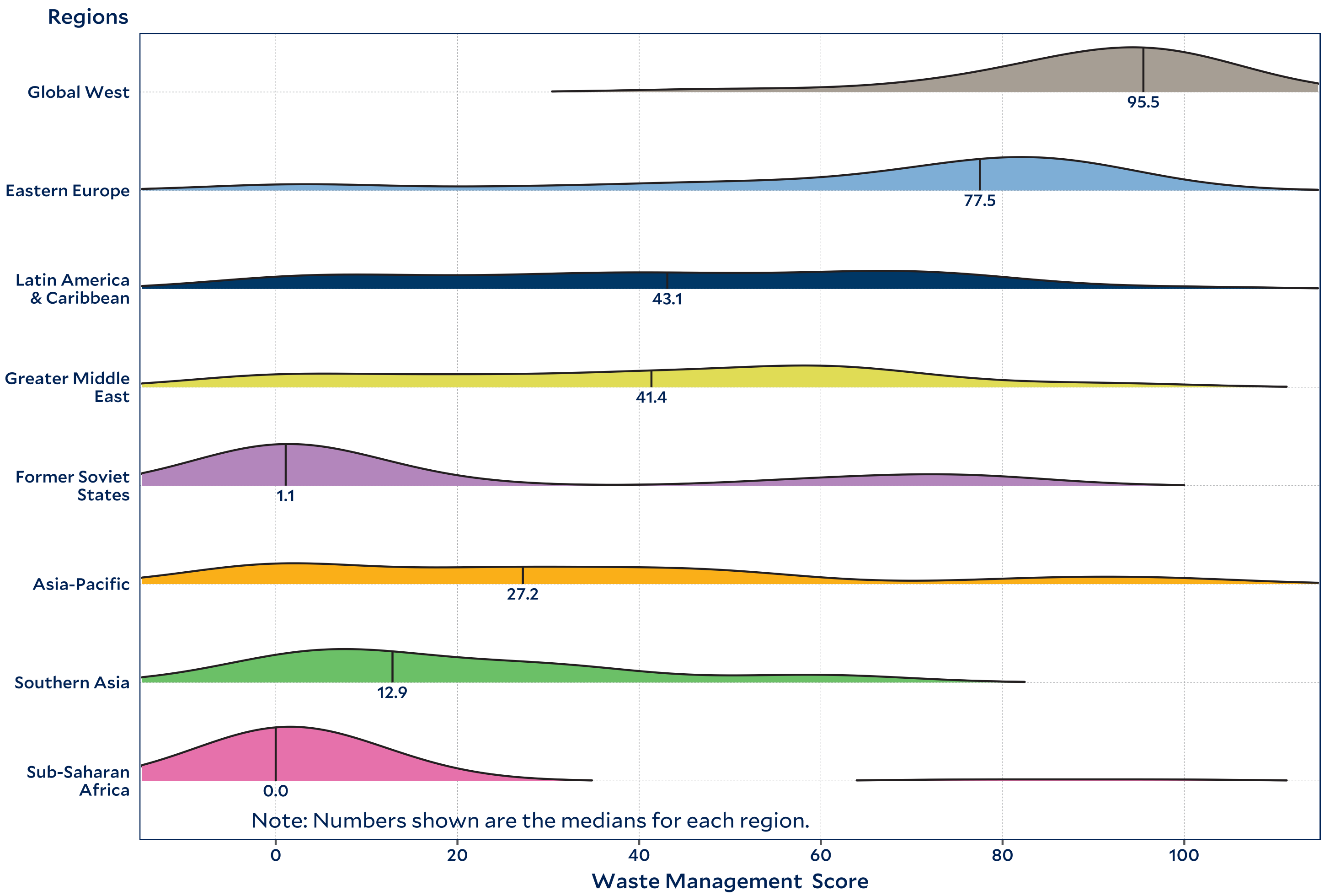
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Mauritius	98.0	7
2	South Africa	77.0	41
3	Mauritania	12.5	105
4	Zimbabwe	11.0	107
5	Burkina Faso	10.2	109
	Cameroon	10.2	109
7	Nigeria	7.7	112
8	Benin	5.8	113
9	Kenya	5.5	115
10	Uganda	4.9	118
11	Namibia	4.2	120
12	Dem. Rep. Congo	3.5	121
13	Guinea	2.5	123
14	Côte d'Ivoire	2.1	125
15	Niger	1.0	126
	Togo	1.0	126
17	Senegal	0.9	128
18	Botswana	0.7	130
	Mozambique	0.7	130
20	Madagascar	0.6	132
21	Angola	0.0	133
	Burundi	0.0	133
	Cabo Verde	0.0	133
	Central African Republic	0.0	133
	Chad	0.0	133
	Comoros	0.0	133
	Djibouti	0.0	133
	Equatorial Guinea	0.0	133
	Eritrea	0.0	133
	Eswatini	0.0	133
	Ethiopia	0.0	133
	Gabon	0.0	133
	Gambia	0.0	133
	Ghana	0.0	133
	Guinea-Bissau	0.0	133
	Lesotho	0.0	133
	Liberia	0.0	133
	Malawi	0.0	133
	Mali	0.0	133
	Republic of Congo	0.0	133
	Rwanda	0.0	133
	São Tomé and Príncipe	0.0	133
	Seychelles	0.0	133
	Sierra Leone	0.0	133
	Tanzania	0.0	133
	Zambia	0.0	133

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Algeria	91.6	18
2	Israel	72.2	47
3	Lebanon	61.4	56
	Saudi Arabia	61.4	56
5	Bahrain	60.4	59
6	Qatar	60.2	60
7	Sudan	53.8	64
8	Jordan	43.1	76
9	Morocco	39.6	81
	Tunisia	39.6	81
11	United Arab Emirates	26.8	93
12	Iran	19.0	97
13	Egypt	16.3	102
14	Iraq	0.0	133
	Kuwait	0.0	133
	Oman	0.0	133

FIGURE 7-1. Regional performance on Waste Management.

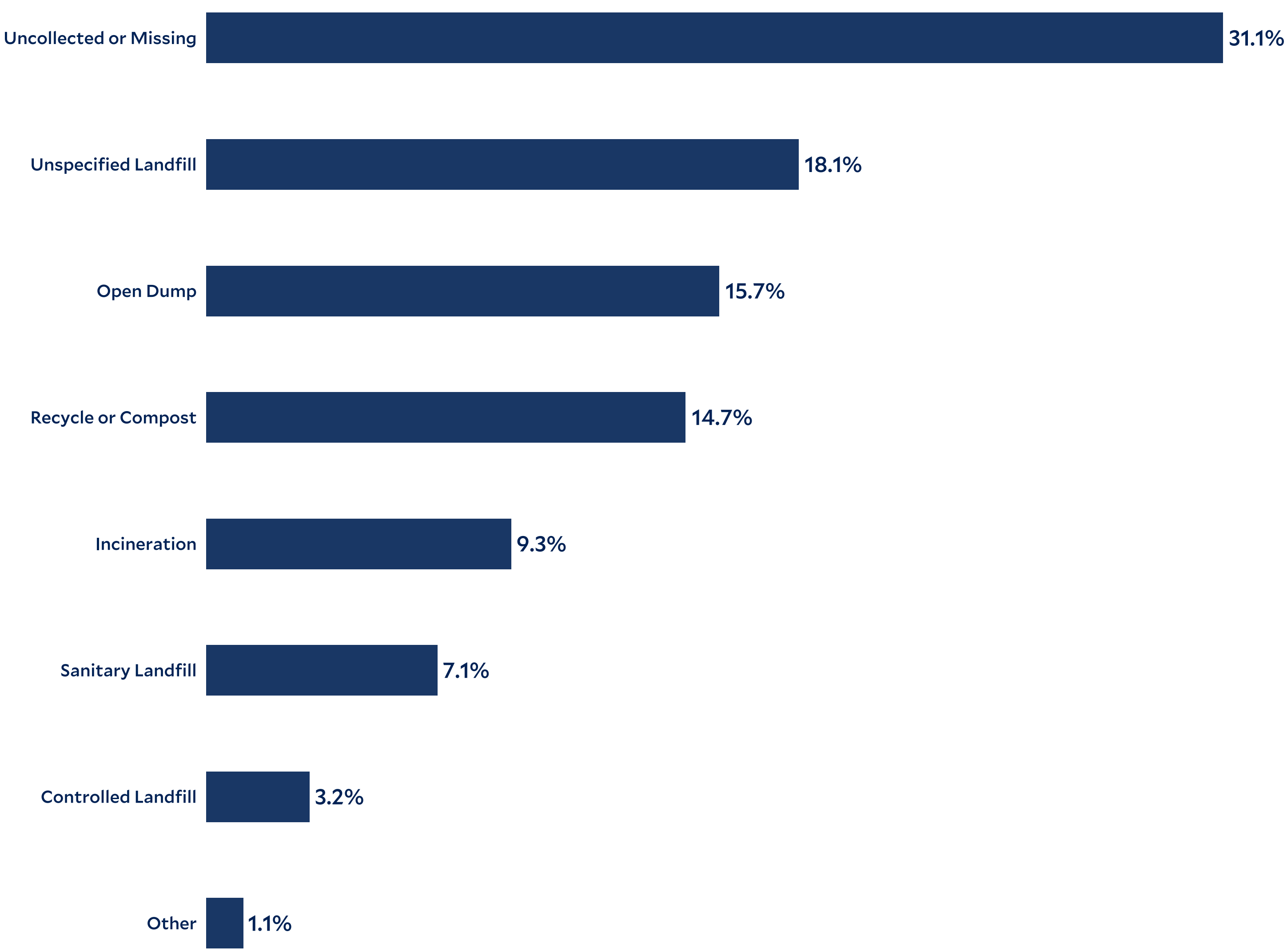


2. RESULTS

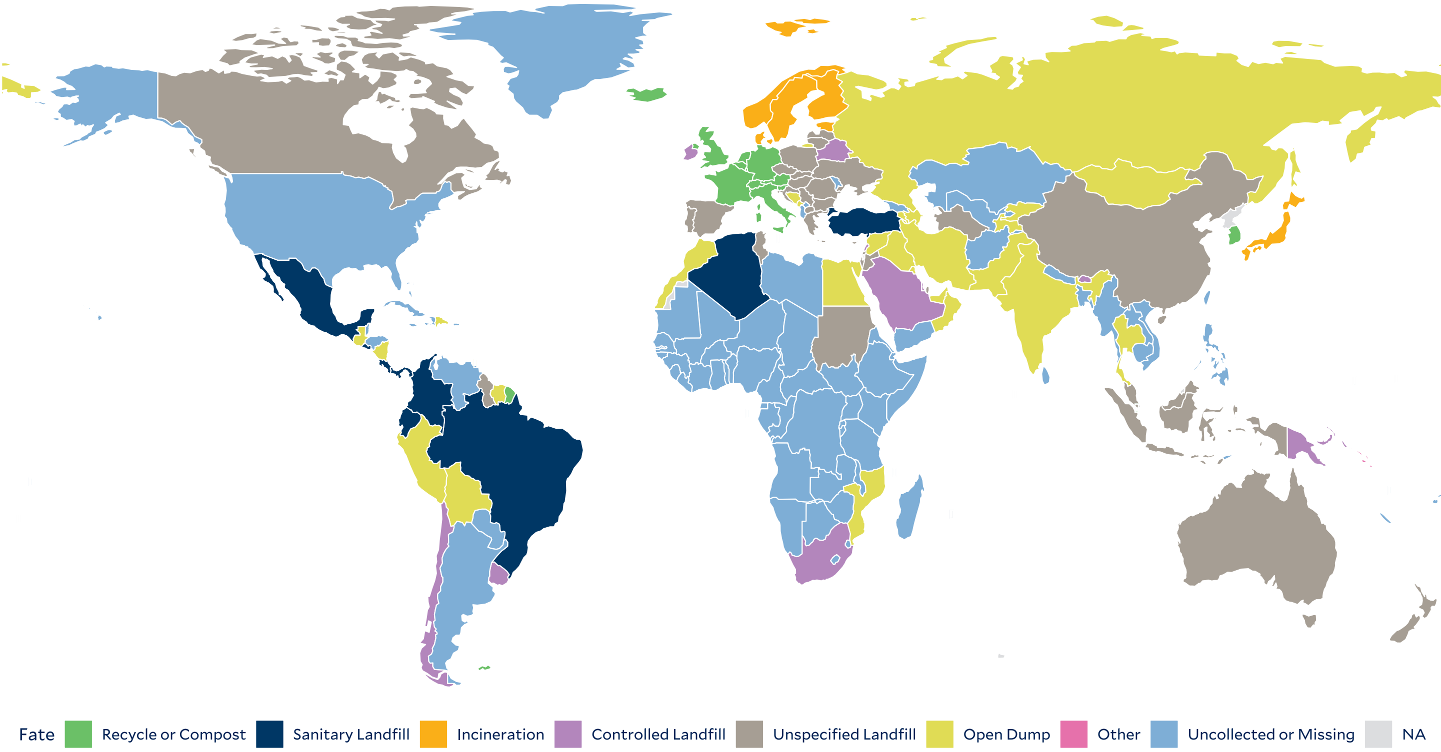
2.1 GLOBAL TRENDS

Waste management presents a pressing global problem with environmental implications that are both global and highly localized. Our 2016 dataset reveals that global municipal solid waste generation topped two billion tonnes (Kaza et al., 2018), of which only 41.75% was managed in a controlled manner. Uncontrolled waste may be burned or buried in open dumps or simply thrown in the street or other improper places. Waste that gets no treatment at all can endanger public health by exposing people to vermin or pathogens and may end up in waterways or the ocean – posing risks to marine life or other animals and, in some cases, threatening biodiversity. Plastic waste in the ocean has become a significant issue in this regard. Waste that is haphazardly incinerated or put into sub-standard landfills can lead to air and water pollution as well as greenhouse gas emissions from leaking methane and inefficient combustion (Bhada-Tata & Hoornweg, 2016; Giusti, 2009; Jambeck et al., 2015). Environmental and public health risks from uncontrolled waste tend to be most acute in low-income and developing countries and in rural areas (Kaza et al., 2018) that have not invested in waste management infrastructure including sanitary landfills or high temperature incinerators. Waste management approaches, however, vary substantially both across and within individual countries.

FIGURE 7-2. Global distribution of fates for solid waste.



MAP 7-2. Most common fate for solid waste in each country.



2.2 LEADERS & LAGGARDS

Highly developed countries in Europe and North America tend to score highly on the *controlled solid waste* metric, with seven of the top ten scoring countries located in Western Europe and Scandinavia. Leading countries have adopted robust waste management policies and infrastructure enabling high levels of value recovery from waste materials through recycling, composting, and waste-to-energy incineration. For example, the Netherlands reduced the amount of waste sent to landfill from 35% in 1985 to 2% in 2016 by implementing a volume-based landfill tax, banning landfill disposal for 35 waste streams, and incorporating the waste management hierarchy ("Lasink's Ladder") into its waste legislation (Kaza et al., 2018; Milios, 2013; The Netherlands Rijkswaterstaat Environment, n.d.). Most EU Member states, including top-ten ranked countries Denmark and Finland, have adopted or are in the process of adopting national strategies in line with the EU Circular Economy Action Plan (Denmark Ministry of Environment and Food, 2018; European Commission, 2019a; Finland Ministry of the Environment, 2020).

The United States poses an exception to the trend of high performance in high-income countries. Due to the diffuse and highly localized nature of waste management and a lack of comprehensive data collection at the federal level, nearly 50% of U.S. waste was unaccounted for in our dataset. We highlight this example to emphasize the need for countries to have strong national statistical collection programs able to funnel high-quality data to a central location where policymakers can use it to inform decisionmaking. We expand upon the importance of data collection below in the Methods section.

Several low- and middle-income countries perform much higher than their peers on the *controlled solid waste* metric. In Colombia, 100% of waste is controlled, in part due to the government's formal recognition of and support for informal waste pickers. Municipal governments in several Colombian cities provide infrastructure and equipment for waste picker coöperatives (Medina, 2008), and a series of court rulings have mandated that waste management policies must "integrate, recognize, and remunerate" waste pickers as public service providers (Parra, 2017). Informal waste collectors form an integral part of waste management systems in many developing countries, often providing recycling and composting services, which contribute to positive environmental outcomes but are not captured in national waste management statistics. Formalizing informal waste pickers can improve data collection, enhance waste control, and enable waste pickers' access to social benefits (Kaza et al., 2018).

Some small island developing states also exhibit higher than expected rates of waste control. Small island developing states face a unique set of waste management challenges, including high energy and operating costs, vulnerability to extreme weather, increasing levels of waste generation from tourism, small markets that limit potential economies of scale, and limited land availability and financial and institutional resources (Agamuthu & Herat, 2014; Eckelman et al., 2014; Mohee et al., 2015). Some of these island nations, however, have found unique solutions to overcome such obstacles. Mauritius controls 98% of its waste, collecting waste through a system of transfer stations and sending it to the island's sanitary landfill or its large-scale composting facility (Mauritius Ministry of Environment, Solid Waste Management, and Climate Change, n.d.; Mohee et al., 2015). Vanuatu, on the other hand, has made strides towards relieving the pressure on two controlled landfills through a comprehensive ban on single-use plastics (Jacob, 2019; McVeigh, 2019; Vanuatu Department of Environmental Protection and Conservation, 2016).

Most countries remain in the early stages of developing basic controlled waste treatment and disposal infrastructure (Powell et al., 2018). In 48 countries, waste management was either 100% uncontrolled or not reported. Over half of these countries are located in Sub-Saharan Africa, where about 69% of waste ends up in open dumps. Governments in these countries lack the resources and infrastructure to effectively manage rapidly increasing volumes of waste, which are projected to quadruple by 2050 due to urbanization and population growth (Kaza et al., 2018).

Though not included among the worst performers, Persian Gulf states like Oman, Kuwait, Qatar, Bahrain, and Saudi Arabia exhibit low scores on the *controlled solid waste* metric. Some of these countries, like Qatar, have experienced rapid economic growth and immigration that have outpaced the government's ability to increase waste disposal capacity (Al-Maaded et al., 2012). Although reported collection rates in this region are close to 100%, the collected waste mostly ends up in un-engineered landfills akin to open dumps (Kaza et al., 2018; Nizami, 2019; Al Sabbagh et al., 2012). Although these countries are located in dry climates where sanitary landfill elements that prevent rainwater infiltration into the waste are less imperative, more controlled waste management is still needed in these countries to protect public health and the environment from leachate and air emissions.

3. METHODS

Waste management data are notoriously challenging to collect and even more challenging to synthesize. Lack of measurement in many areas of the world, as well as the absence of standard measurement methodologies, reporting systems, and even definitions and classifications of waste, have hampered past attempts to develop waste-related environmental indicators reliable enough to facilitate global comparison (UNEP, 2015). Waste management systems involve a sequence of processes or subsystems, including economic consumption, waste generation, collection, treatment, and disposal. High performance in one process may not indicate high performance in another, resulting in zero-sum situations that further complicate evaluation of waste management systems as a whole.

Of the many steps in the waste management process, the waste's final destination serves as the major determinant of environmental outcomes. Optimal waste treatment and disposal strategies depend on local economic, environmental, and social conditions. For example, one nation may have an abundance of land to construct landfill with gas capture, while another is more land restricted, or lacks domestic energy resources and chooses to implement waste-to-energy incineration. Characteristics of the waste itself also inform waste management strategies. A country producing large quantities of organic waste may benefit from investing in composting or anaerobic digestion facilities, while another country generating mostly metal, glass, or plastic waste might focus on recycling. All waste management technologies involve environmental tradeoffs, such as air pollution from incineration or methane emissions from landfills. Waste materials that escape controlled pathways, however, allow the resulting environmental and human health damages to become both unmanageable and widespread. While different countries, provinces, and cities will choose different methods of waste disposal appropriate for local conditions, controlled pathways are always preferred over uncontrolled pathways because they allow for harms to be managed and minimized.

Acknowledging the challenges involved with collecting and synthesizing quality waste management data, and asserting that environmental and human health damages are best mitigated through increased control over material fate, the 2020 EPI uses the indicator *controlled solid waste* to represent the percentage of generated waste that is controlled.

3.1 INDICATOR BACKGROUND

We measure *controlled solid waste* as the percentage of generated waste collected and treated in a manner that controls environmental outcomes. Table 7-3 defines 12 possible waste material fates as either controlled or uncontrolled. Controlled wastes are those that are collected and go to anaerobic digestion, compost, sanitary landfill with gas capture, waste-to-energy incineration, or recycling. Uncontrolled wastes are those that are not collected at all or those that are collected and go to an open dump, a water/marine environment, other treatment, or are unaccounted for.

TABLE 7-3. Waste materival fates.

CONTROLLED	UNCONTROLLED
Anaerobic digestion	Ocean dump
Compost	Unaccounted for
Sanitary landfill with gas capture	Uncollected
Incineration	Water/marine
Recycling	Other

Calculation of the *controlled solid waste* metric requires an additional step for the categories of "controlled" or "unspecified" landfills. Landfill practices vary widely around the world, and the engineering and design required for a landfill to be considered "controlled" often vary from site to site based on physical, environmental, and hydrogeological features. In general, landfills are considered sanitary when "waste is isolated from the environment until it is safe" (Thurgood et al., 1998, p.5). It is reasonable to assume that not all landfills reported as "controlled" actually mitigate exposure to environmental harm. Similarly, we acknowledge that the "unspecified" landfill category may include sanitary landfills, even though the distinction was not made through the data reporting process. Considering these issues, we apply a scaling factor of 50% to both "controlled" and "unspecified" landfill wastes to indicate that not 100% of these landfill wastes are indeed protected against environmental harm.

3.2 DATA

This metric integrates data from the World Bank *What a Waste 2.0* report (Kaza et al., 2018) and from Wiedinmyer et al. (2014). The *What a Waste 2.0* report relies on data from 2011-2017, but each data point is scaled to a single year (2016) for all metrics and all countries. Its data sources include United Nations Statistics Division survey data, OECD data, and regional and national reports. We use the Wiedinmyer study strictly for its estimates on waste collection, which augments the collection figure for countries whose waste collection is not included in *What a Waste 2.0*. This study uses data from the 2006 IPCC National Greenhouse Gas Inventories as well as national administrative reports and surveys to estimate collection rates based on population, collection coverage per capita, and total waste generation figures (Wiedinmyer et al., 2014).

3.3 LIMITATIONS

We acknowledge that waste management is a complicated "system of systems" that cannot be fully represented by a single metric. A key limitation of this indicator is the coarseness of the data. The localized nature of waste management largely prohibits comprehensive data collection, particularly in low-income countries but even in countries with high levels of development. For example, in the United States nearly 50% of waste was unaccounted for. With no unifying national policy for nonhazardous waste management, solid waste control in the United States is conducted by municipal governments and private companies on a highly local scale (Louis, 2004). Top-down analyses fail to capture data on such diffuse waste management activities. For example, Powell, Townsend, et al. (2016) estimated that actual municipal solid waste disposal rates in 2012 were more than double the national disposal figure reported by the U.S. EPA.

The wide range of reporting systems utilized by the data sources, each using variable definitions of waste and waste management, make these data useful only as a generalized or directional indicator. The data sources also report waste management amounts across different years, making it difficult to discern trends over time.

The main limitation is that, in classifying final waste material fate as "controlled" or "uncontrolled," "management" becomes a black box which, in reality, could indicate vastly different environmental outcomes. Though each method of "controlled" management has a variable lifecycle that depends both on the waste handling process or technology and on geography-specific factors, some methods, like recycling, can be considered as environmentally superior to others, like landfill without gas capture. At present, our metric does not differentiate between these methods. It also fails to account for waste composition, which varies widely among countries (Kaza et al., 2018) and which can influence the effectiveness and environmental outcomes of treatment and disposal (Powell & Chertow, 2019). The metric also does not differentiate between countries which generate large amounts of waste and those which generate very little. Table 7-4 indicates information which our metric is not yet able to capture, but which would be useful for future comparison of waste management across countries.

Despite these limitations, opportunities to refine and expand the scope of the Waste Management issue category will likely proliferate as more countries begin to focus on waste management as a critical element of sustainable development and climate change mitigation. As of 2018, 137 countries have included waste-sector actions in their Nationally Determined Contributions under the Paris Climate Agreement (Powell et al., 2018). Fulfilling these commitments will bring higher proportions of waste under controlled management and enable the development of improved data collection and management systems. Bottom-up approaches using subnational and facility-level waste data, such as those pioneered in Powell, Pons, et al. (2016), Powell, Townsend, et al. (2016), and Powell & Chertow (2019) can help countries overcome data collection challenges and facilitate context-specific waste planning and policy development.

TABLE 7-4. Clarification of the *controlled solid waste* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
Percentage of generated municipal solid waste that is collected and treated in a controlled manner	• **A measure of the amount of waste generated (gross or per capita)** • **A measure of the amount of waste collected (gross or as a percentage of waste generated)** • **A measure of waste composition** • **A ranking of different waste treatment methods (i.e. recycling vs. incineration vs. landfill)** • **Inclusive of construction & demolition, hazardous, industrial, medical, or electronic waste (to the extent possible)**

Chapter 8. Biodiversity & Habitat

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Biodiversity underpins all ecosystem services and acts as the foundation of all human activities, economies, and well-being. Natural ecosystems and species pollinate crops, build healthy soils, cycle and replenish freshwater, protect against extreme weather events like storms and floods, maintain climatic stability, and provide food, energy, medicines, raw materials, and cultural and spiritual benefits for all people on the planet. The full economic value of biodiversity and ecosystem services equals an estimated $125 trillion per year (Costanza et al., 2014). Despite this high value, recent analyses have reported worldwide deterioration in biodiversity and natural habitats due to human activity, with an estimated one million species at risk of extinction in the next few decades (Diaz et al., 2019). Biodiversity loss reduces the provisioning of ecosystem services and undermines progress toward achieving the Sustainable Development Goals. The Biodiversity & Habitat issue category assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders.

1.2 INDICATORS

1.2.1 Terrestrial biome protection (national & global weights) [40% of issue category]

Two indicators of *terrestrial biome protection* measure the proportion of 14 important biomes covered by protected areas within a country, weighted according to the prevalence of each biome both within that country and globally.

1.2.2 Marine protected areas [20% of issue category]

Marine protected area measures the percentage of a country's exclusive economic zone (EEZ) that is covered by marine protected areas (MPAs).

1.2.3 Protected Area Representativeness Index (PARI) [10% of issue category]

Protected Area Representativeness Index measures the extent to which a country's terrestrial protected areas are ecologically representative of the species within that country.

1.2.4 Species Habitat Index (SHI) [10% of issue category]

Species Habitat Index measures the average proportion of species' suitable habitat remaining within a country relative to the baseline year 2001.

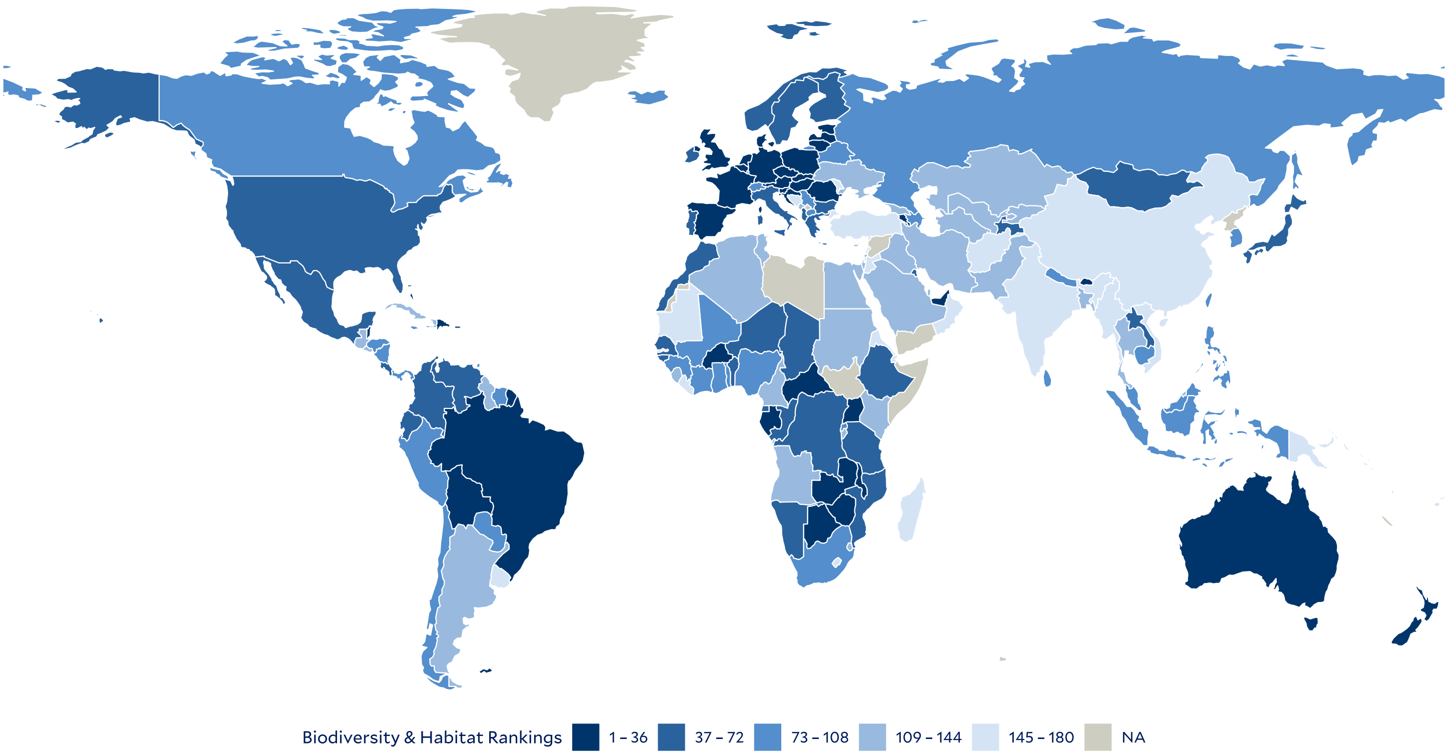
1.2.5 Species Protection Index (SPI) [10% of issue category]

Species Protection Index measures the average proportion of suitable habitat for all of a country's species located within protected areas.

1.2.6 Biodiversity Habitat Index (BHI) [10% of issue category]

Biodiversity Habitat Index estimates the change in biological diversity retained within a country as a function of habitat loss, degradation, and fragmentation across that country.

MAP 8-1. Rankings on Biodiversity & Habitat.



8.

TABLE 8-1. Global rankings, scores, and regional rankings (REG) on Biodiversity & Habitat.

RANK	COUNTRY	SCORE	REG
1	Botswana	91.6	1
2	Zambia	90.4	2
3	Poland	89.0	1
4	Germany	88.8	1
5	France	88.3	2
6	United Kingdom	88.0	3
7	Belize	87.9	1
8	Spain	87.6	4
9	Lithuania	87.5	2
10	Belgium	87.4	5
11	Bhutan	87.2	1
12	Estonia	87.0	3
	Zimbabwe	87.0	3
14	Latvia	86.7	4
15	Slovenia	86.4	5
16	Gabon	86.0	4
17	Czech Republic	85.7	6
18	Austria	85.5	6
	Luxembourg	85.5	6
20	Romania	85.0	7
	Slovakia	85.0	7
22	Central African Republic	84.7	5
23	Malawi	84.2	6
24	New Zealand	84.0	8
25	Australia	83.7	9
	Netherlands	83.7	9
27	Bolivia	83.6	2
28	Croatia	82.6	9
29	Kiribati	82.1	1
30	Hungary	82.0	10
31	Denmark	81.7	11
32	Dominican Republic	81.6	3
33	Uganda	81.4	7
34	United Arab Emirates	80.9	1
35	Armenia	79.2	1
36	Seychelles	78.9	8
37	Bahamas	78.8	4
38	Brazil	78.1	5
39	Burkina Faso	77.8	9
40	Bulgaria	77.7	11
41	Niger	77.6	10
42	Ecuador	77.3	6
43	Colombia	76.8	7
44	Japan	76.6	2
	Namibia	76.6	11
46	Italy	75.6	12
47	Finland	75.5	13
48	Malta	75.1	14
	Venezuela	75.1	8
50	Dem. Rep. Congo	73.3	12
51	Mongolia	73.1	3
52	Portugal	73.0	15
53	Mexico	72.9	9
54	Greece	72.6	12
55	Sweden	72.5	16
56	Ethiopia	72.2	13
	Guinea-Bissau	72.2	13
58	Republic of Congo	71.7	15
59	Norway	71.5	17
60	Tanzania	70.7	16
61	Costa Rica	70.1	10
62	Laos	69.7	4
63	Chad	69.0	17
64	Senegal	68.7	18
65	Albania	68.2	13
66	Trinidad and Tobago	67.8	11
67	United States of America	67.5	18
68	Morocco	67.4	2
	Mozambique	67.4	19
70	Benin	67.0	20
71	Equatorial Guinea	66.0	21
	Kuwait	66.0	3
73	Ireland	65.8	19
	Tajikistan	65.8	2
75	Chile	65.3	12
76	Taiwan	65.0	5
77	Timor-Leste	64.5	6
78	Togo	64.2	22
79	Suriname	63.6	13
80	Iceland	63.2	20
	South Africa	63.2	23
82	Switzerland	63.0	21
83	Paraguay	62.8	14
84	Nepal	62.6	2
	South Korea	62.6	7
86	North Macedonia	62.1	14
87	Côte d'Ivoire	62.0	24
88	Belarus	61.2	3
89	Sri Lanka	61.1	3
90	Canada	60.5	22
91	Panama	60.4	15
92	Cambodia	60.1	8
93	Guinea	59.9	25
	Honduras	59.9	16
95	Mali	59.6	26
	Nicaragua	59.6	17
97	Peru	59.5	18
98	Brunei Darussalam	59.2	9
99	Ghana	58.9	27
100	São Tomé and Príncipe	58.4	28
101	Jamaica	58.2	19
102	Rwanda	57.4	29
	Serbia	57.4	15
104	Azerbaijan	56.9	4
105	Philippines	56.6	10
106	Cyprus	56.5	16
107	Dominica	56.3	20
	Indonesia	56.3	11
109	Antigua and Barbuda	55.7	21
110	Malaysia	55.1	12
111	Russia	54.1	5
112	Nigeria	53.6	30
113	Kenya	53.5	31
114	Thailand	53.0	13
115	Sierra Leone	52.9	32
116	Burundi	52.3	33
117	Cuba	51.1	22
118	Guyana	51.0	23
119	Egypt	50.6	4
120	Argentina	49.1	24
121	Cameroon	48.6	34
122	Israel	47.6	5
	St. Vincent and Grenadines	47.6	25
124	Bangladesh	46.8	4
125	Sudan	46.6	6
126	Georgia	46.2	6
127	Pakistan	46.1	5
128	Kazakhstan	41.6	7
129	Guatemala	41.3	26
	Qatar	41.3	7
131	Iraq	40.5	8
132	Turkmenistan	39.7	8
133	Angola	39.3	35
134	Kyrgyzstan	39.2	9
135	Algeria	39.0	9
136	Saudi Arabia	38.8	10
137	Eswatini	38.4	36
	Iran	38.4	11
139	Ukraine	37.7	10
140	Uzbekistan	37.6	11
141	Tonga	37.3	14
142	Tunisia	37.1	12
143	Saint Lucia	36.9	27
144	Montenegro	36.6	17
145	Comoros	36.3	37
146	El Salvador	35.8	28
147	Haiti	34.5	29
148	Eritrea	33.7	38
	India	33.7	6
150	Viet Nam	33.3	15
151	Bosnia and Herzegovina	32.9	18
152	Gambia	32.6	39
	Liberia	32.6	39
154	Jordan	32.2	13
155	Grenada	31.5	30
156	Myanmar	31.0	16
157	Vanuatu	30.0	17
158	Samoa	29.9	18
159	Oman	28.2	14
160	Moldova	27.9	12
161	Papua New Guinea	27.3	19
162	Fiji	25.1	20
163	Madagascar	25.0	41
	Uruguay	25.0	31
165	Djibouti	23.0	42
166	Lesotho	22.5	43
167	Afghanistan	21.9	7
168	Lebanon	21.8	15
169	Singapore	20.9	21
170	Mauritius	19.3	44
171	Mauritania	19.2	45
172	China	19.0	22
173	Bahrain	18.9	16
174	Solomon Islands	15.3	23
175	Turkey	15.1	19
176	Cabo Verde	14.3	46
177	Barbados	12.6	32
178	Marshall Islands	11.4	24
179	Micronesia	6.9	25
180	Maldives	6.5	8

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 8-2. Regional rankings, scores, and global rankings on Biodiversity & Habitat

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Belize	87.9	7
2	Bolivia	83.6	27
3	Dominican Republic	81.6	32
4	Bahamas	78.8	37
5	Brazil	78.1	38
6	Ecuador	77.3	42
7	Colombia	76.8	43
8	Venezuela	75.1	48
9	Mexico	72.9	53
10	Costa Rica	70.1	61
11	Trinidad and Tobago	67.8	66
12	Chile	65.3	75
13	Suriname	63.6	79
14	Paraguay	62.8	83
15	Panama	60.4	91
16	Honduras	59.9	93
17	Nicaragua	59.6	95
18	Peru	59.5	97
19	Jamaica	58.2	101
20	Dominica	56.3	107
21	Antigua and Barbuda	55.7	109
22	Cuba	51.1	117
23	Guyana	51.0	118
24	Argentina	49.1	120
25	St. Vincent and Grenadines	47.6	122
26	Guatemala	41.3	129
27	Saint Lucia	36.9	143
28	El Salvador	35.8	146
29	Haiti	34.5	147
30	Grenada	31.5	155
31	Uruguay	25.0	163
32	Barbados	12.6	177

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Poland	89.0	3
2	Lithuania	87.5	9
3	Estonia	87.0	12
4	Latvia	86.7	14
5	Slovenia	86.4	15
6	Czech Republic	85.7	17
7	Romania	85.0	20
	Slovakia	85.0	20
9	Croatia	82.6	28
10	Hungary	82.0	30
11	Bulgaria	77.7	40
12	Greece	72.6	54
13	Albania	68.2	65
14	North Macedonia	62.1	86
15	Serbia	57.4	102
16	Cyprus	56.5	106
17	Montenegro	36.6	144
18	Bosnia and Herzegovina	32.9	151
19	Turkey	15.1	175

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Bhutan	87.2	11
2	Nepal	62.6	84
3	Sri Lanka	61.1	89
4	Bangladesh	46.8	124
5	Pakistan	46.1	127
6	India	33.7	148
7	Afghanistan	21.9	167
8	Maldives	6.5	180

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Germany	88.8	4
2	France	88.3	5
3	United Kingdom	88.0	6
4	Spain	87.6	8
5	Belgium	87.4	10
6	Austria	85.5	18
	Luxembourg	85.5	18
8	New Zealand	84.0	24
9	Australia	83.7	25
	Netherlands	83.7	25
11	Denmark	81.7	31
12	Italy	75.6	46
13	Finland	75.5	47
14	Malta	75.1	48
15	Portugal	73.0	52
16	Sweden	72.5	55
17	Norway	71.5	59
18	United States of America	67.5	67
19	Ireland	65.8	73
20	Iceland	63.2	80
21	Switzerland	63.0	82
22	Canada	60.5	90

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Armenia	79.2	35
2	Tajikistan	65.8	73
3	Belarus	61.2	88
4	Azerbaijan	56.9	104
5	Russia	54.1	111
6	Georgia	46.2	126
7	Kazakhstan	41.6	128
8	Turkmenistan	39.7	132
9	Kyrgyzstan	39.2	134
10	Ukraine	37.7	139
11	Uzbekistan	37.6	140
12	Moldova	27.9	160

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Kiribati	82.1	29
2	Japan	76.6	44
3	Mongolia	73.1	51
4	Laos	69.7	62
5	Taiwan	65.0	76
6	Timor-Leste	64.5	77
7	South Korea	62.6	84
8	Cambodia	60.1	92
9	Brunei Darussalam	59.2	98
10	Philippines	56.6	105
11	Indonesia	56.3	107
12	Malaysia	55.1	110
13	Thailand	53.0	114
14	Tonga	37.3	141
15	Viet Nam	33.3	150
16	Myanmar	31.0	156
17	Vanuatu	30.0	157
18	Samoa	29.9	158
19	Papua New Guinea	27.3	161
20	Fiji	25.1	162
21	Singapore	20.9	169
22	China	19.0	172
23	Solomon Islands	15.3	174
24	Marshall Islands	11.4	178
25	Micronesia	6.9	179

SUB-SAHARAN AFRICA

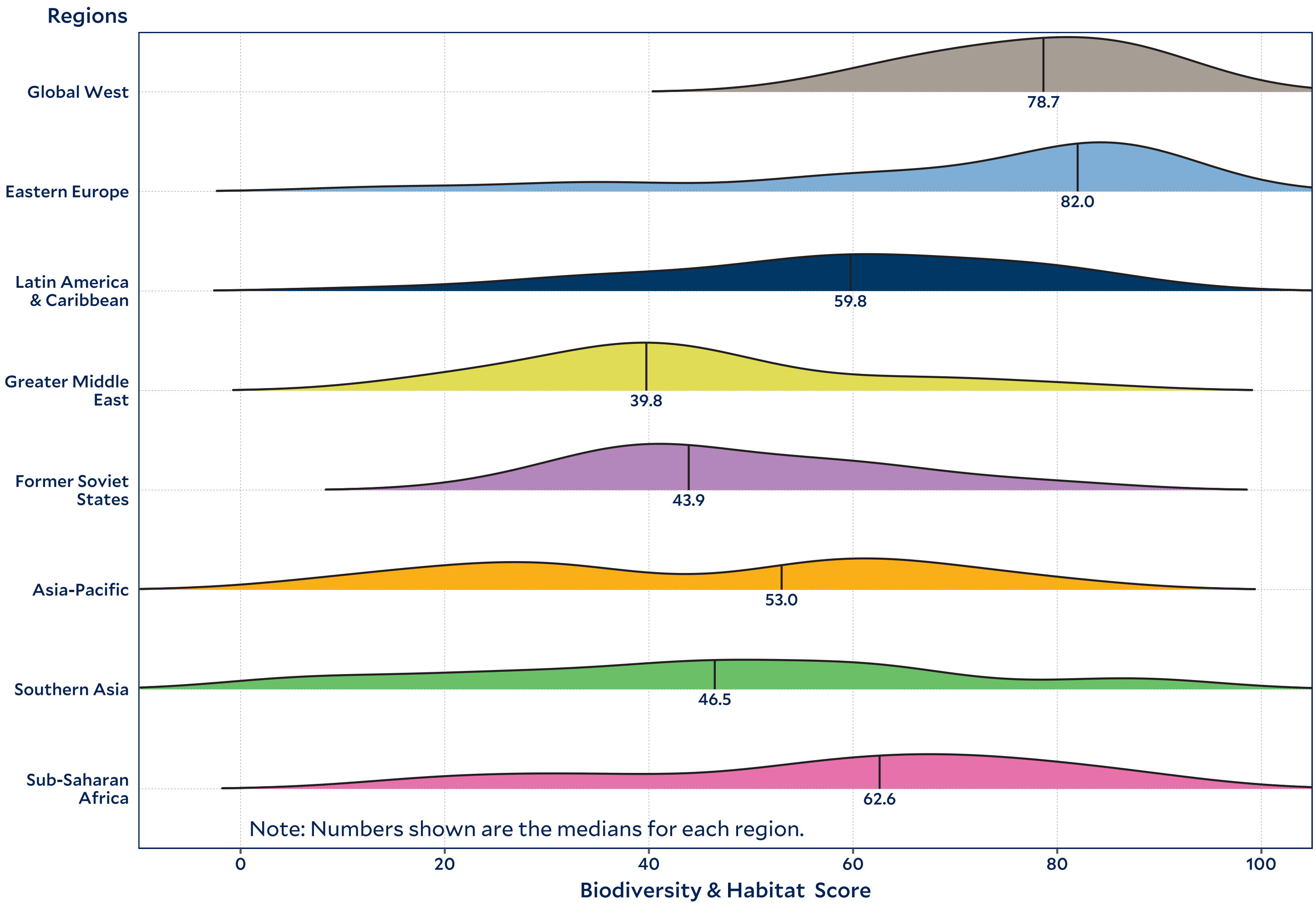
Reg Rank	Country	Score	Global Rank
1	Botswana	91.6	1
2	Zambia	90.4	2
3	Zimbabwe	87.0	12
4	Gabon	86.0	16
5	Central African Republic	84.7	22
6	Malawi	84.2	23
7	Uganda	81.4	33
8	Seychelles	78.9	36
9	Burkina Faso	77.8	39
10	Niger	77.6	41
11	Namibia	76.6	44
12	Dem. Rep. Congo	73.3	50
13	Ethiopia	72.2	56
	Guinea-Bissau	72.2	56
15	Republic of Congo	71.7	58
16	Tanzania	70.7	60
17	Chad	69.0	63
18	Senegal	68.7	64
19	Mozambique	67.4	68
20	Benin	67.0	70
21	Equatorial Guinea	66.0	71
22	Togo	64.2	78
23	South Africa	63.2	80
24	Côte d'Ivoire	62.0	87
25	Guinea	59.9	93
26	Mali	59.6	95
27	Ghana	58.9	99
28	São Tomé and Príncipe	58.4	100
29	Rwanda	57.4	102
30	Nigeria	53.6	112
31	Kenya	53.5	113
32	Sierra Leone	52.9	115
33	Burundi	52.3	116
34	Cameroon	48.6	121
35	Angola	39.3	133
36	Eswatini	38.4	137
37	Comoros	36.3	145
38	Eritrea	33.7	148
39	Gambia	32.6	152
	Liberia	32.6	152
41	Madagascar	25.0	163
42	Djibouti	23.0	165
43	Lesotho	22.5	166
44	Mauritius	19.3	170
45	Mauritania	19.2	171
46	Cabo Verde	14.3	176

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	United Arab Emirates	80.9	34
2	Morocco	67.4	68
3	Kuwait	66.0	71
4	Egypt	50.6	119
5	Israel	47.6	122
6	Sudan	46.6	125
7	Qatar	41.3	129
8	Iraq	40.5	131
9	Algeria	39.0	135
10	Saudi Arabia	38.8	136
11	Iran	38.4	137
12	Tunisia	37.1	142
13	Jordan	32.2	154
14	Oman	28.2	159
15	Lebanon	21.8	168
16	Bahrain	18.9	173

8.

FIGURE 8-1. Regional performance on Biodiversity & Habitat.



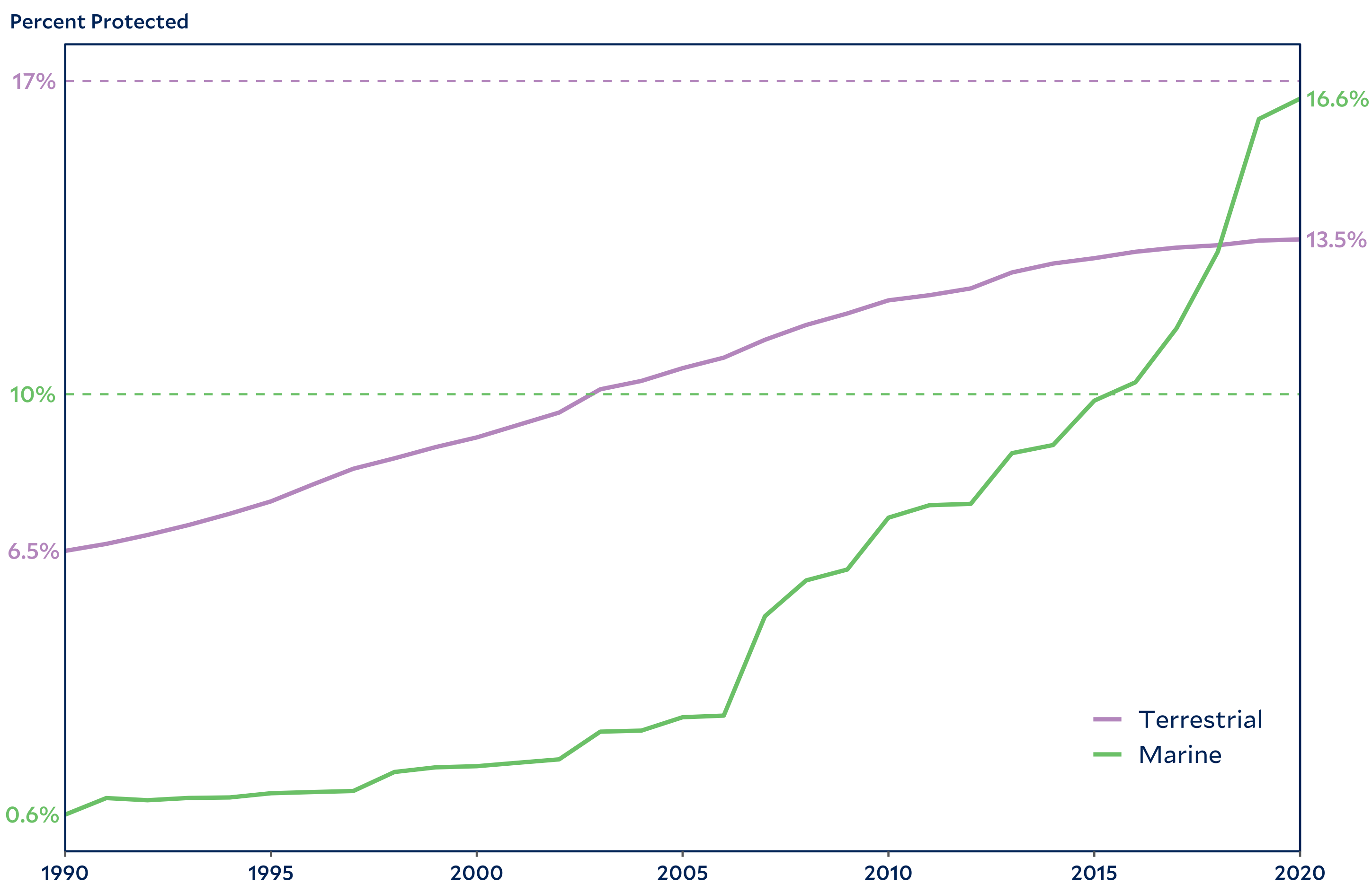
2. RESULTS

2.1 GLOBAL TRENDS

Recent analyses reveal shocking deterioration in global biodiversity over the past few decades. In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) reported that around one million species now face extinction worldwide, many within decades, and over 500,000 terrestrial species lack sufficient habitat area for long-term survival (Diaz et al., 2019). According to the World Wildlife Fund's *Living Planet Report*, species extinction is currently occurring at 100 to 1,000 times the natural rate (2018). Over 50% of biodiversity loss stems from overexploitation and habitat loss due to land use change (Diaz et al., 2019). Given these declines, IPBES determined that the world is *not* on track to fulfill major international environmental targets like the Aichi Biodiversity Targets and the Sustainable Development Goals.

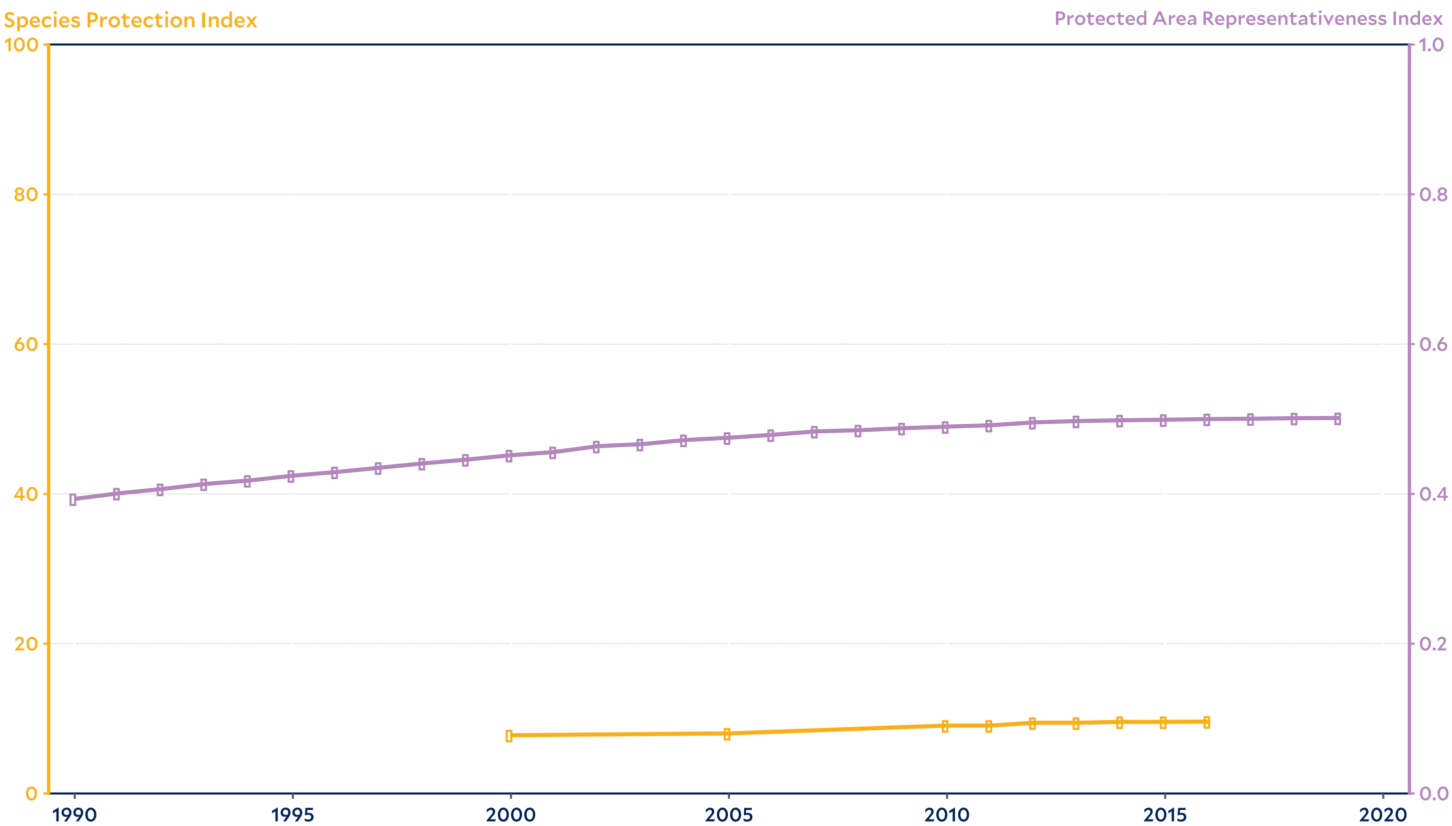
However, these reports also reveal that concerted conservation actions are working in many areas of the world. IPBES estimates that extinction risks for bird, mammal, and amphibian species would be 20% higher without the conservation efforts of recent decades (Diaz et al., 2019). Global protected area coverage continues to expand and now includes 13.5% of terrestrial areas and 16.6% of coastal and marine areas under national jurisdiction. Forty-four percent of terrestrial ecoregions and 50.4% of marine ecoregions now meet the protection goals established in Aichi Biodiversity Target 11. Four of the planet's 14 terrestrial biomes have 17% of their global extent covered by protected areas, as shown in Table 8-3. Mangrove ecosystems receive the highest levels of protection, while temperate grasslands, savannas, and shrublands receive the lowest.

FIGURE 8-2. Global trends in terrestrial and marine protected areas, 1990–2020, with global targets denoted by dashed lines.
Source: World Database of Protected Areas, with analysis by EPI.



Ecological representativeness within these protected areas, however, has stagnated at both the species and community levels, as shown in Figure 8-3. To build momentum, halt the loss of biodiversity, and ensure that natural areas can continue to sustain the well-being of both people and the planet, scientists have proposed a "Global Deal for Nature" aiming for 30% of the Earth to be formally protected by 2030. The proposal calls for an additional 20% of the Earth to be designated as climate stabilization areas, defined as ecosystems with high carbon storage kept under various forms of sustainable land management (Dinerstein et al., 2019). Table 8-3 shows that mangrove ecosystems and flooded grasslands and savannas are already protected across nearly 30% of their global extent, demonstrating that this level of protection is indeed possible when biodiversity and ecosystem service values are fully recognized. In addition to expanding protected areas, countries can protect biodiversity by strengthening governance, implementing sustainable management of multifunctional landscapes and seascapes, and formally recognizing and safeguarding the rights, knowledge, and institutions of indigenous peoples (Diaz et al., 2019).

FIGURE 8-3. Global trends in ecological representativeness of protected areas
Sources: CSIRO for PARI and Map of Life for SPI.



2.2 LEADERS & LAGGARDS

Biodiversity & Habitat scores for the 2020 EPI indicate that many countries have made significant progress toward meeting some of the goals of the Aichi Biodiversity Targets. Forty-three countries have achieved at least 17% coverage in each of their terrestrial biomes, and 74 have achieved at least 10% coverage in their coastal and marine territories.

Botswana, with the highest overall Biodiversity & Habitat score, conserves over 29% of its territory within formal protected areas and has over 17% coverage in all but one of its seven terrestrial ecoregions (Botswana Department of Environmental Affairs, 2016; UNEP-WCMC et al., 2020a). In addition to its 22 formally designated protected areas, Botswana also has a well-established network of community-based natural resources management programs, covering an estimated 11% of the country's land surface. These areas are operated by at least 53 active community-based organizations (Centre for Applied Research, 2016; Mbaiwa, 2015). Though outcomes vary among organizations, many of these programs have succeeded in expanding wildlife monitoring, reducing poaching, and heightening national awareness and commitment to wildlife conservation (Mbaiwa, 2015). Conservation professionals, however, should continue to monitor biodiversity populations in Botswana, especially after the country's 2019 decision to lift its ban on elephant hunting in order to reduce human-wildlife conflicts (Solly, 2019).

Countries in Europe exhibit high Biodiversity & Habitat scores. About 25% of the EU's land area is protected (Fischer et al., 2018). Under the Birds Directive and Habitats Directive, EU Member States are required to designate core breeding and resting areas for rare and threatened species as Natura 2000 sites (European Commission, 2020). The Natura 2000 network currently protects 18% of land area and 6% of marine territory in the EU (European Commission, 2020). Germany, France, the United Kingdom, Spain, and Belgium all receive top ten scores in this issue category. In Eastern Europe, Croatia achieved one of the biggest increases in its national Biodiversity & Habitat score globally since 2010, in part by designating over 29% of its territory as Natura 2000 protected areas upon its admission to the EU in 2013 (Vasilijevic et al., 2018). In Slovenia, Natura 2000 sites represent 37% of the country's territory, the highest coverage in the EU (Gallo et al., 2018). These designations – and a history of sustainable forest management – allowed Slovenia to achieve the highest national levels of protection of temperate broadleaf forest and Mediterranean forest biomes of any country, as shown in Table 8-3.

Several countries have made great strides in protecting coastal and marine biodiversity through the establishment of new marine protected areas (MPAs). In 2019, South Africa established a network of 20 new MPAs covering 5% of the country's marine territory across 87% of South Africa's different marine ecosystems (South African National Biodiversity Institute, 2019). Chile has added several massive MPAs in the past three years, including the 740,000 km^2 Rapa Nui Marine Protected Area in 2018 and the 144,390 km^2 Diego Ramírez-Drake Passage Marine Park in 2019 (Germani, 2019; Neslen, 2017). The Rapa Nui MPA protects the habitat of 142 endemic and 27 threatened and endangered species, including humpback and blue whales and four sea turtle species (Neslen, 2017). Most notably, its establishment process involved extensive coördination with the indigenous Rapa Nui people of Easter Island, who will possess exclusive fishing rights within the territory and have a majority vote on the MPA's council of regulators (Wei-Haas, 2018).

Countries of the Middle East, central and southern Asia, and the Asia-Pacific region exhibit the lowest average regional Biodiversity & Habitat scores. Countries in these regions have experienced extensive habitat loss due to agricultural expansion, palm oil and biofuel plantations, timber and rubber extraction, and rapid infrastructure development (Karki et al., 2018). Natural ecosystems in countries like Thailand, Viet Nam, and the Philippines face increasing pressure from a massive swell in tourism, mainly coming from China and India (Coca, 2019). Overfishing, unsustainable aquaculture, plastic pollution, and dam building threaten freshwater and marine ecosystems. Protected area coverage increased by 0.3% in terrestrial areas and 13.8% in coastal and marine areas across Asia and the Pacific between 2004 and 2017, but has often failed to target areas that are most important for biodiversity (Karki et al., 2018).

Many small island developing states, including Maldives, Micronesia, the Marshall Islands, Barbados, the Solomon Islands, and Mauritius, earned bottom rankings on the Biodiversity & Habitat issue category. These islands' limited land resources face intense pressure from population growth and economic development. Coastal areas on small islands are increasingly converted to aquaculture, urban areas, and marine infrastructure like harbors and seawalls.

TABLE 8-3. Leaders and laggards in protecting the planet's 14 terrestrial biomes, among countries with substantial areas of each biome. *Source: World Database of Protected Areas, with analysis by EPI.*

BIOME	GLOBAL AREA [KM², '000S]	GLOBAL PROTECTED AREA [KM², '000S]	GLOBAL PROTECTION	LEADER	PROTECTION	LAGGARD	PROTECTION
Tropical & subtropical moist broadleaf forests	19,922.6	4,526.3	23%	Venezuela	71%	Tuvalu	0%
Tropical & subtropical dry broadleaf forests	3,023.5	312.4	10%	France	64%	Guatemala	1%
Tropical & subtropical coniferous forests	712.3	101.0	14%	Dominican Republic	50%	India	3%
Temperate broadleaf & mixed forests	12,858.4	1,510.9	12%	Slovenia	53%	Turkey	0%
Temperate conifer forests	4,102.1	579.6	14%	Czech Republic	69%	China	0%
Boreal forests/taiga	15,079.3	1,477.6	10%	Mongolia	55%	Russia	8%
Tropical & subtropical grasslands, savannas & shrub	20,303.8	3,264.4	16%	Tanzania	41%	Argentina	6%
Temperate grasslands, savannas & shrublands	10,107.4	415.4	4%	Russia	64%	USA	2%
Flooded grasslands & savannas	1,099.3	310.5	28%	Zambia	59%	Egypt	4%
Montane grasslands & shrublands	5,203.9	450.1	9%	New Zealand	63%	South Africa	4%
Tundra	8,334.5	1,569.6	19%	USA	43%	Canada	12%
Mediterra-nean forests, woodlands & scrub	3,225.5	506.6	16%	Greece	33%	Turkey	0%
Deserts & xeric shrublands	27,983.8	2,677.9	10%	Australia	25%	Kazakhstan	2%
Mangroves	351.3	106.9	30%	Brazil	65%	Myanmar	1%

Inundation and coastal erosion due to climate change-driven sea level rise couple with habitat loss in a phenomenon known as "coastal squeeze," which is rapidly diminishing valuable ecosystems like mangroves, reefs, and wetlands (UNEP, 2014). On small islands, species have limited opportunity to shift their distribution in response to habitat loss or climatic changes (S. Taylor & Kumar, 2016). As a result, the Secretariat of the Convention on Biological Diversity considers species in small island developing states to face the greatest risk of extinction of all species worldwide (UN-OHRLLS, 2017).

Turkey, the lowest-ranking Eastern European country and one of the bottom ten overall, stands out for its failure to protect biodiversity within its borders. Turkey protects only 0.22% of its land area and 0.11% of its marine territory, despite being home to three biodiversity hotspots and many unique species (Şekercioğlu et al., 2011; UNEP-WCMC, 2020b). Turkey continues to pursue massive infrastructure projects like the Ilisu Dam on the Tigris River, which will endanger native and already threatened species like the Eurasian otter and Euphrates soft-shelled turtle (Hockenos, 2019). The dam will also threaten ecosystems and restrict water supply downstream in Syria, Iran, and Iraq. Countries like Turkey must ensure that their development pathways are compatible with human rights and biodiversity protection.

Madagascar is also experiencing a biodiversity crisis, with threats stemming from habitat loss, climate change, bushmeat hunting, and the illegal wildlife trade. Any amount of biodiversity loss in Madagascar is concerning for global biodiversity, as up to 90% of the country's species exist nowhere else in the world (Morelli et al., 2020). Madagascar lost approximately 44% of its natural forest between 1953 and 2014 (Vieilledent et al., 2018), largely driven by mining, logging, charcoal production, shifting cultivation, and agricultural expansion (CBD Secretariat, 2020). The rate of deforestation increased from an average 1.1% per year during 2010–2014 to 2% in 2018 (Vieilledent et al., 2018; Weisse & Goldman, 2019). Under current trends, Madagascar could lose the entirety of its highly biodiverse eastern rainforest ecoregion by 2080 (Morelli et al., 2020). Though the country quadrupled its protected area coverage between 2003 and 2016, at least 13 protected areas representing 8% of the country's coverage are considered "paper parks" with no active management. Many of the remaining protected areas suffer from continued extractive resource use and a lack of funding and enforcement (C.J. Gardner et al., 2018).

Habitat destruction and degradation remain leading causes of biodiversity loss in many countries. Paraguay exhibits one of the highest rates of habitat loss in the 2020 EPI. Paraguay lost 91% of its Atlantic Forest ecoregion due to past deforestation activities. Though the rate of forest loss has declined in recent years, the remaining forest is highly fragmented, threatening species like jaguars that require high habitat connectivity (Da Ponte et al., 2017; Paviolo et al., 2016). Meanwhile, land conversion and habitat loss have expanded into Paraguay's Gran Chaco, a dry forest and savanna ecoregion where nearly 250,000 hectares per year were converted to cattle and soy production between 2001 and 2014 (Sax, 2020).

3. METHODS

In 2010, parties to the Convention on Biological Diversity (CBD) adopted the Aichi Biodiversity Targets, which set 20 ambitious goals aimed at conserving biodiversity and enhancing environmental benefits for all people. Three of these goals serve as the basis on which the 2020 EPI assesses countries' performance for the Biodiversity & Habitat issue category, namely:

- Aichi Biodiversity Target 5: "By 2020, the rate of loss of all natural habitats, including forests, is halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced."
- Aichi Biodiversity Target 11: "By 2020, at least 17 percent of terrestrial and inland water areas and 10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes."
- Aichi Biodiversity Target 12: "By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained." (CBD Secretariat, 2018)

The EPI's seven Biodiversity & Habitat metrics place particular focus on the establishment of protected areas as an indicator of countries' performance in biodiversity conservation. While alternative strategies like landscape and *ex situ* conservation play an important role, protected areas remain a mainstay of global conservation activity, with demonstrated benefits for biodiversity. Protected areas are widely used as an indicator for global targets, including Targets 14.5, 15.1, and 15.4 of the Sustainable Development Goals.

Recognizing the importance of protected areas in achieving global biodiversity goals, we also acknowledge that the mere presence of protected areas may not be a sufficient indicator of actual conservation outcomes. The world currently lacks a globally accepted metric for protected area management effectiveness (Chape et al., 2005). Many protected areas remain vulnerable to unsustainable resource use and human disturbance stemming from both illicit activities, such as illegal logging and poaching, and unfavorable governance, like the scaling-back of environmental restrictions (Schulze et al., 2018). Protected area downgrading, downsizing, and degazettement – or loss of legal protection – (PADDD) has been increasing since 2000, according to PADDDtracker.org (Conservation International & WWF, 2020). Given these challenges, conservation outcomes are extremely difficult to monitor, especially on a global scale. There are many species for which there is insufficient or a complete lack of data, even within trusted indices like the Living Planet Index and the IUCN Red List of Threatened Species.

Ideally, a comprehensive Biodiversity & Habitat metric would include credible data on governance, management effectiveness, species population data, genetic diversity, economic impacts, and the effects of climate change. In the meantime, spatial data on protected areas remain the most widely accessible and nationally specific indicators of progress for this issue category. Countries can utilize the following seven indicators to understand the status of their protected area networks in the context of the Aichi Biodiversity Targets. These indicators should serve as a foundation from which countries can develop area-specific conservation strategies.

3.1 TERRESTRIAL BIOME PROTECTION: NATIONAL AND GLOBAL WEIGHTS

Our two indicators on *terrestrial biome protection* assess countries' progress toward protecting 17% of the planet's 14 terrestrial and freshwater biomes, as set out in Aichi Biodiversity Target 11. The *terrestrial biome protection* indicators recognize the importance of protecting the full range of ecologically distinctive habitats, both on a national and global level.

3.1.1 INDICATOR BACKGROUND

We derive the *terrestrial biome protection* indicators by first calculating the proportions of the area of each of a country's biome types that are covered by protected areas and then constructing a weighted sum of the protection percentages for all biomes within that country. For the *terrestrial biome protection (national weights)* indicator, protection percentages are weighted according to the prevalence of each biome type within that country. This indicator evaluates a country's efforts to achieve 17% protection for all biomes within its borders, as per Aichi Target 11. For the *terrestrial biome protection (global weights)* indicator, protection percentages are weighted according to the global prevalence of each biome type. This indicator evaluates a country's contribution toward the global 17% protection goal.

3.1.2 DATA

Data on terrestrial protected areas come from the World Database on Protected Areas (WDPA), a joint initiative of UNEP's World Conservation Monitoring Centre (WCMC) and the IUCN. The WDPA is the world's most comprehensive protected area dataset, containing data on protected areas in 245 countries and territories for the years 1990 to 2020. The database receives monthly updates and is publicly available on its free online platform, https://www.protectedplanet.net/. *Terrestrial biome protection* scores are based on WDPA data from the February 2020 update. Biome and ecoregion boundary data are derived from the World Wildlife Fund's "Terrestrial Ecoregions of the World" dataset, based on the work of Olson et al. (2001). Country boundary data come from the Gridded Population of the World version 4.11 boundary file, which was released in 2019 by Center for International Earth Science Information Network (CIESIN). This update has helped CIESIN to refine the methods by which they intersect country boundaries and biome boundaries, allowing for more accurate biome classification near country borders than in previous iterations of the EPI.

3.1.3 LIMITATIONS

We recognize that the establishment of protected areas is often a necessary but insufficient condition for successful biodiversity conservation. Ongoing threats to protected areas are difficult to monitor using remote sensing, and evaluation of biodiversity outcomes requires repeated, consistent

TABLE 8-4. Clarification of the *terrestrial biome protection* metrics.

WHAT THE METRICS ARE	WHAT THE METRICS AREN'T
The proportion of the area of each biome type that is covered by protected areas within a country, weighted according to: • **the proportion of the country's total area covered by each biome type *(national weights)*** • **the proportion of global terrestrial area covered by each biome type *(global weights)***	• **A measure of protected area coverage of individual ecoregions** • **A measure of the conservation status of individual species within a country or within biomes** • **Indicative of protected area management effectiveness or outcomes**

assessment. Only about 9.1% of the protected areas in the WDPA have been evaluated for management effectiveness, corresponding to only 20% of total protected area coverage (UNEP-WCMC et al., 2018). Protected area coverage thus serves as an incomplete proxy for realized biome protection. Table 8-4 elaborates on the full scope of the *terrestrial biome protection* indicators.

3.2 MARINE PROTECTED AREAS (MPAS)

Marine protected areas evaluates countries' progress toward the Aichi Biodiversity Target 11 goal of protecting 10% of coastal and marine areas. MPAs represent a critical tool for protecting marine ecosystems from unsustainable fishing practices, pollution, and human disturbance. They provide refuge for vulnerable species to spawn and replenish their populations and also benefit local cultures and economies (Reuchlin-Hugenholtz & McKenzie, 2015).

3.2.1 INDICATOR BACKGROUND

We calculate the *marine protected areas* indicator as the percentage of a country's exclusive economic zone (EEZ) covered within marine protected areas. We aggregate across all of a country's EEZs if it has more than one. Protected areas that overlap coastlines are counted as MPAs if 75% or more of the site falls within the marine environment.

3.2.2 DATA

Data on marine protected areas come from the WDPA. EEZ boundaries come from the Flanders Marine Institute's Maritime Boundaries Database.

3.2.3 LIMITATIONS

Though the WDPA represents the best available data on marine protected areas, the MPA indicator has several limitations. *Marine protected areas* only takes into account MPAs within a country's EEZs and does not include MPAs in Areas Beyond National Jurisdiction (ABNJ), which comprise the majority of the world's oceans. While we calculate that 16% of EEZs are protected by MPAs, only 1.2% of ABNJ waters fall under this kind of protection (UNEP-WCMC et al., 2020). Designating and managing MPAs in international waters is inherently more difficult than within national boundaries, and increased protection of ABNJ will be necessary to meet the 10% protection goal of Aichi Target 11.

Like the *terrestrial biome protection* metrics, the *marine protected area* metric cannot indicate management effectiveness or outcomes for biodiversity, although new initiatives like ProtectedSeas may provide novel avenues for mapping management effectiveness, as detailed in Focus 8-1. MPA management varies between countries and regions, and many MPAs continue to face threats from overexploitation due to poor enforcement. Even well-managed coastal MPAs may experience adverse effects from nearby terrestrial land use and pollution.

Additionally, the exact definition of an MPA has been misinterpreted in recent years, with some marine areas being listed as MPAs despite the fact that they still allow industrial activities or destructive fishing practices, such as oil extraction or bottom trawling, or are managed primarily for a purpose other than conservation, such as tourism (Sala et al., 2018; UNEP-WCMC et al., 2018). The IUCN published new guidelines in 2019 on the definition and classification of MPAs (Day et al., 2019). These guidelines should serve as a powerful tool for decisionmakers involved in MPA establishment and management planning and should allow for more detailed tracking and analysis of MPA progress and performance.

TABLE 8-5. Clarification of the *marine protected areas* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
The percentage of a country's exclusive economic zone that is covered by marine protected areas	• **A measure of the conservation status of individual species within a country's coastal or marine ecosystems** • **Indicative of marine protected area management effectiveness or outcomes** • **Inclusive of marine protected areas outside EEZs**

3.3 PROTECTED AREA REPRESENTATIVENESS INDEX

Protected Area Representativeness Index (PARI) reflects the provision within Aichi Biodiversity Target 11 that requires protected area networks to be ecologically representative. Past conservation efforts often focused on low-hanging fruit, introducing protections in areas where they did not conflict with other human uses rather than in critical, biodiverse regions (Pressey et al., 2015). The *PARI* indicator seeks to communicate the urgent need for countries to ensure fair and representative protection of the ecosystems and biological communities within their borders in order to help conserve the full diversity of life on Earth.

3.3.1 INDICATOR BACKGROUND

The *PARI* indicator measures ecological representativeness as the proportion of biologically scaled environmental diversity included in a country's terrestrial protected areas. The measure relies on remote sensing, biodiversity informatics, and global modeling of fine-scaled variation in biodiversity composition for plant, vertebrate, and invertebrate species (GEO BON, 2015). It is worth nothing that this indicator measures the representativeness of species composition in different spatial locations, ecosystems, and biological communities, as opposed to the representativeness of all individual species, which is addressed by the *Species Protection Index*.

3.3.2 DATA

The *Protected Area Representativeness Index* is calculated by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia's national science agency, using protected area boundary data from the WDPA and land use data from NASA's MODIS Land Cover Change dataset. CSIRO's data cover the entire world's terrestrial areas at a 1 km grid resolution (GEO BON, 2015). Biodiversity informatics utilized in calculating the metric include over 300 million location records for over 400,000 plant, vertebrate, and invertebrate species. EPI's 2020 metric relies on data from 2016.

3.3.3 LIMITATIONS

While ecological representativeness within protected area networks has the potential to improve conservation outcomes for a wider diversity of species, coverage alone does not guarantee that all species are prioritized by protected area management plans or that protections are effective and enforced. Though recent advances in remote sensing technologies have greatly improved their accuracy, these technologies still have limited ability to collect fine-scaled ecological data. Policymakers and managers working at the level of individual protected areas and protected area networks still require field data to accurately monitor and assess local biodiversity conservation outcomes.

3.4 SPECIES HABITAT INDEX

Species Habitat Index (SHI) estimates potential population losses, as well as regional and global extinction risks of individual species, using habitat loss as a proxy. Habitat loss due to land use change represents the biggest driver of species extinction in terrestrial and freshwater ecosystems (Diaz et al., 2019), accounting for two-thirds of all threats to vertebrate populations (WWF, 2018). This indicator evaluates countries' progress toward fulfilling Aichi Biodiversity Target 5, which aims to at least halve the rate of global habitat loss and significantly reduce habitat degradation and fragmentation, as well as Aichi Biodiversity Target 12, which aims to prevent species extinction.

TABLE 8-6. Clarification of the *Protected Area Representativeness Index* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
A measure of the extent to which a country's protected areas are ecologically representative, calculated as the proportion of biologically scaled environmental diversity included in a country's terrestrial protected areas	**• A measure of the conservation status or protection of individual species** **• Inclusive of coastal and marine species or marine protected areas** **• Indicative of protected area management effectiveness or outcomes**

3.4.1 INDICATOR BACKGROUND

The *SHI* indicator measures the proportion of suitable habitat within a country that remains intact for each species in that country relative to a baseline set in the year 2001. The index is calculated as the average of the proportion of habitat retained for each species in the country, with species weighted according to the proportion of their global range that is found within the country. This weighting scheme encourages countries to take special care to ensure the protection of rare or endemic species.

3.4.2 DATA

Calculation of this metric utilizes data on suitable habitat ranges for over 20,000 terrestrial plant, vertebrate, and invertebrate species. The *SHI* indicator comes from the Map of Life, a biodiversity mapping and monitoring tool with an online interface developed with Google Earth Engine, available at https://mol.org/ (Jetz et al., 2012). Maps of species habitats are constructed from 1 km resolution remote sensing data and modeled using literature- and expert-based data, published MODIS and Landsat land cover products, and local observations. Data are validated using a growing pool of over 300 million location records (GEO BON, 2015) and field ata sourced from surveys and citizen science.

3.4.3 LIMITATIONS

The *SHI* pairs highly resolved global remote sensing data with field-based biodiversity observations and transparent modeling frameworks to arrive at a detailed characterization of threats to species from habitat loss. Remote sensing tools still face limitations in their ability to accurately detect land use and land cover change. A 2016 survey of over 300 geospatial data sources found that existing tools still cannot produce a global standardized view of landscape change on a timescale that allows for appropriate conservation action (Joppa et al., 2016). Table 8-7 further delineates the full scope of the *SHI* metric.

TABLE 8-7. Clarification of the *Species Habitat Index* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
An indicator of potential population losses and regional and global extinction risk of individual terrestrial species due to habitat loss, measured as the proportion of habitat that remains intact within a country relative to the baseline year 2001	**• A direct count or proportion of individual species experiencing population loss or extinction** **• An indicator of species population loss or extinction risk due to drivers other than habitat loss, such as hunting or pollution** **• Inclusive of coastal or marine species**

TABLE 8-8. Clarification of the *Species Protection Index* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
A measure of the extent to which a country's protected areas are ecologically representative on the species level, calculated as the average proportion of the suitable habitat of a country's species included in the country's terrestrial protected areas	• Indicative of protected area management effectiveness or outcomes • Inclusive of coastal or marine species

3.5 SPECIES PROTECTION INDEX

Species Protection Index (SPI) evaluates the species-level ecological representativeness of each country's protected area network. Whereas the *PARI* measures the representativeness of a country's protected area coverage of ecosystems and biological communities, the *SPI* measures representativeness of coverage for a country's individual species. To meet the goals of Aichi Biodiversity Target 11, countries should strive to protect the full ranges and habitats of species within their borders.

3.5.1 INDICATOR BACKGROUND

The *SPI* metric uses remote sensing data, global biodiversity informatics, and integrative models to map suitable habitat for over 30,000 terrestrial vertebrate, invertebrate, and plant species at high resolutions. We map the suitable range for each species within a country and calculate the proportion of that range's area that is covered by protected areas. This value is then averaged equally over all species within the country.

3.5.2 DATA

The *SPI* indicator is produced through the Map of Life and is available at its online interface. Maps of species' distributions and suitable habitat derive from Landsat and MODIS satellite annual species and environmental data, collected at 30 meter and 1 km grid resolution. These data are validated using over 350 million location records from surveys and citizen science (GEO BON, 2015). Protected area boundary data come from the WDPA.

3.5.3 LIMITATIONS

The *Species Protection Index* uses highly resolved global remote sensing data and field data on species' locations to construct a detailed and transparent map of species habitat ranges and to assess the representativeness of protective coverage. However, remote sensing technologies still experience challenges in collecting ecological data, especially at the species level. Even with extensive field verification, the full suitable habitat ranges of many species remain unknown. Finally, representative protected area coverage does not guarantee effective management or improved species conservation outcomes.

3.6 BIODIVERSITY HABITAT INDEX

We introduce the *Biodiversity Habitat Index (BHI)* to the 2020 EPI as a new indicator within the Biodiversity & Habitat issue category. *BHI* estimates the effects of habitat loss, degradation, and fragmentation on the expected retention of terrestrial biodiversity.

Aichi Biodiversity Target 5 aims to halve the rate of global habitat loss and significantly reduce habitat degradation and fragmentation. The *Species Protection Index* discussed above measures the impact of habitat loss on individual species. *BHI* goes a few steps further by examining how the spatial distribution of habitat loss, degradation, and fragmentation impacts assemblages of species. In doing so, it seeks to measure the consequences of local-level loss and degradation on the global diversity of communities and ecosystems.

3.6.1 INDICATOR BACKGROUND

This indicator uses data covering the entire terrestrial area of the world at 1 km grid resolution. Statistical models predicting ecological similarity between any pair of grid cells as a function of geographical and abiotic environmental attributes were developed using generalized dissimilarity modeling. Ecological similarity values ranging from 0 (no species in common) to 1 (all species in common) were generated for all pairs of grid cells. CSIRO then combines these ecological similarity data with data on land cover change or habitat condition. For each individual cell, CSIRO estimates the average

TABLE 8-9. Clarification of the *Biodiversity Habitat Index* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
A measure of the impacts of the spatial distribution of habitat loss, degradation, and fragmentation on the expected retention of distinct terrestrial species assemblages	• **A measure of the expected retention of individual species** • **Inclusive of coastal or marine species**

condition of all cells that are ecologically similar to the cell of interest. Thus, the BHI score for a given cell equals the average habitat condition of all ecologically similar cells. The BHI score for a country equals the weighted geometric mean for all cells within the country, weighted according to each cell's ecological uniqueness. This score represents a country's proportional retention of habitat supporting distinct assemblages of species across the full range of environments within that country.

3.6.2 DATA

CSIRO calculates the BHI in partnership with the Global Biodiversity Information Facility, Map of Life, the Projecting Responses of Ecological Diversity In Changing Terrestrial Systems (PREDICTS) Project, and the Group on Earth Observations Biodiversity Observation Network. Mapping of habitat change incorporates the Hansen et al. (2013) Global Forest Change dataset and NASA's MODIS Land Cover Change dataset.

3.6.3 LIMITATIONS

The indicator is limited by the spatial resolution of the underlying datasets. Data on non-forest ecosystems are only available at 1 km grid resolution and cannot detect mixing of multiple ecosystem types at a finer spatial scale.

Focus 8.

PROTECTEDSEAS.

ProtectedSeas offers a free, global, easy-to-use, comprehensive database of marine protected area (MPA) information. An initiative of the Anthropocene Institute, this resource provides details on allowed and restricted activities, regulations, and management documents, and also links to official websites, among other MPA features. Data are available in multiple formats, including direct download, Esri feature service via ArcGIS Online, and an interactive online map at https://mpa.protectedseas.net.

The ProtectedSeas MPA mapping project began in early 2015 with the goal of becoming a one-stop resource for ocean users to find out not only where MPAs are located but also which marine activities are managed and how. The database provides area-specific information for over 25 different activities, including fishing, anchoring, and diving, and lists whether these activities are allowed, prohibited, or restricted. It also includes activity restriction indicators for several fishing methods. The ProtectedSeas team assigns to each area an overall level of protection score based on a standardized decision tree assessing restrictions on marine life extraction, with scores ranging from 1, with no restrictions on marine life removal, to 5, where no extractive activity or marine life removal is allowed.

ProtectedSeas also offers information on other marine managed areas, such as fishery management areas and boating areas, which differ from officially designated MPAs but still have conservation benefits. These areas are derived from place-based regulations on marine extraction, boating, dumping, and other activities. Documenting these areas provides a more comprehensive picture of management practices and the actual status of ocean protections.

Currently, the database and accompanying online map services cover the following regions:

- in North America: U.S. marine and coastal areas including the Great Lakes and U.S. territories, Canada, Mexico, and the Caribbean;
- in Europe: the Baltic States, Norway, the United Kingdom, and parts of the Mediterranean;
- in the Pacific Islands: Palau, Indonesia, and Micronesia; and
- in Central and South America: Belize and Chile.

ProtectedSeas also maintains a map of the high seas, which features all marine managed Areas Beyond National Jurisdiction (ABNJ) and their associated management regulations, rules, guidelines, and nonbinding measures. Efforts to document additional countries and regions is ongoing, with estimated completion of a global database by 2022.

A public-private partnership with the National Oceanic and Atmospheric Administration (NOAA) Marine Protected Areas Center supports ProtectedSeas' maintenance of U.S. data and expanded coverage to other parts of the world. In addition to mapping marine protection, ProtectedSeas also participates in the MPA Guide Committee and International Hydrographic Organization Nautical Information Provision Working Group. Management data from ProtectedSeas and similar initiatives may allow future iterations of the EPI to more accurately characterize the state of global marine biodiversity protection.

8.

FIGURE 8-3. ProtectedSeas interactive map shows all managed areas in southwest California at a particular location. Darker blue and red areas indicate higher levels of protection on the 1–5 scale.

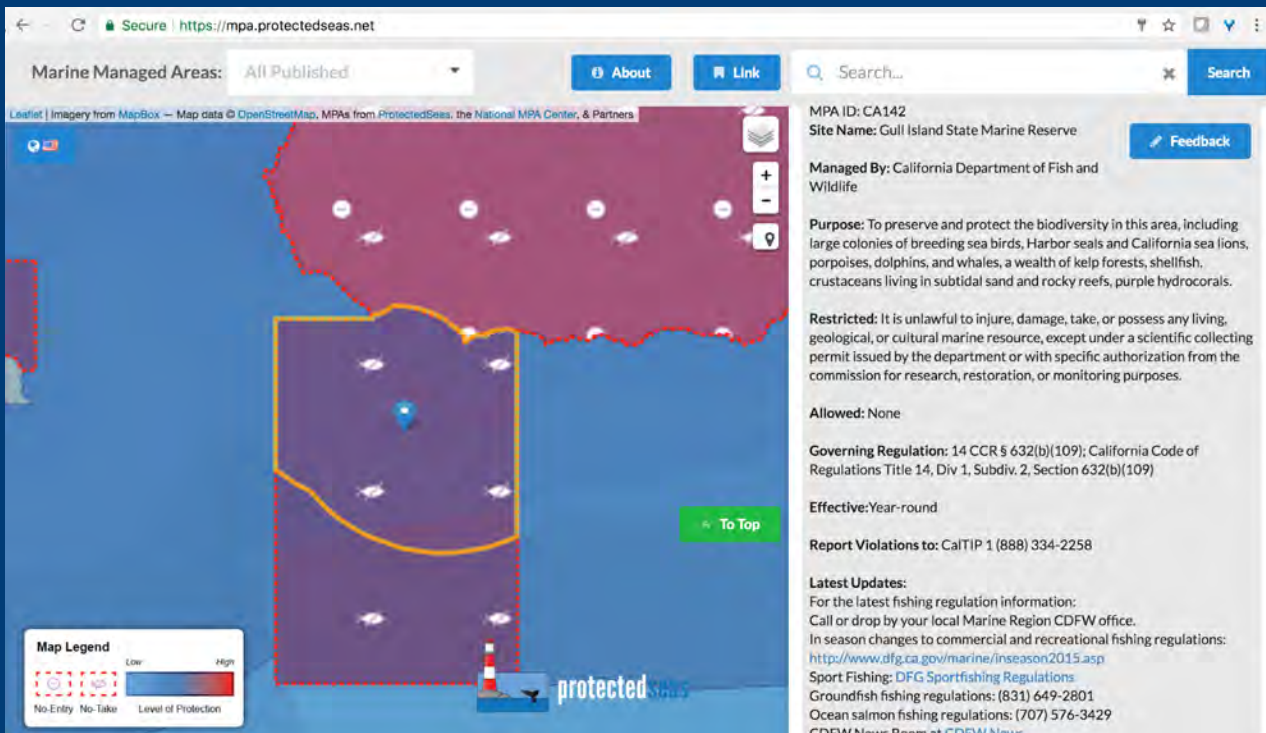
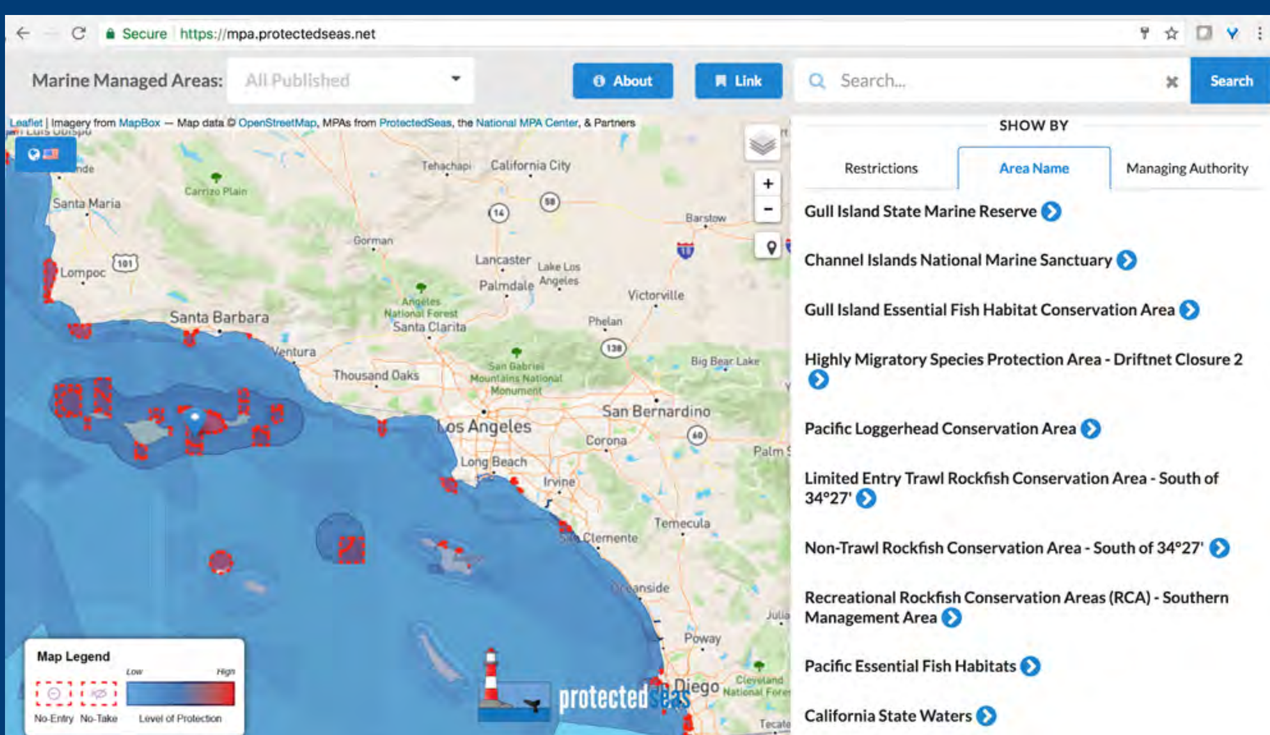


FIGURE 8-4. Each MPA includes detailed information relating to that specific MPA as well as links to related online resources beyond ProtectedSeas.



Chapter 9. Ecosystem Services

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Ecosystems provide many services that maintain planetary balances and support human and environmental well-being. Forests regulate the global climate; provide habitat for over 80% of terrestrial animal, plant, and insect species; and directly support the livelihoods of over 1.6 billion people (United Nations, 2016). Researchers and environmental managers have also increasingly begun to recognize the benefits of other ecosystem types. Grasslands and wetlands, for example, provide vital services like carbon sequestration and storage, biodiversity habitat, nutrient cycling, and coastal protection. The 2020 EPI introduces two pilot indicators, *grassland loss* and *wetland loss*, to join *tree cover loss* in an expanded Ecosystem Services issue category, formerly called Forests.

1.2 INDICATORS

1.2.1 Tree cover loss

[90% of issue category]

The percent reduction in a country's tree cover in forested areas, defined as areas with greater than 30% tree canopy cover, from the reference year 2000 using a five-year moving average.

1.2.2 Grassland loss

[5% of issue category]

The percent reduction in a country's grassland area from the reference year 1992 using a five-year moving average.

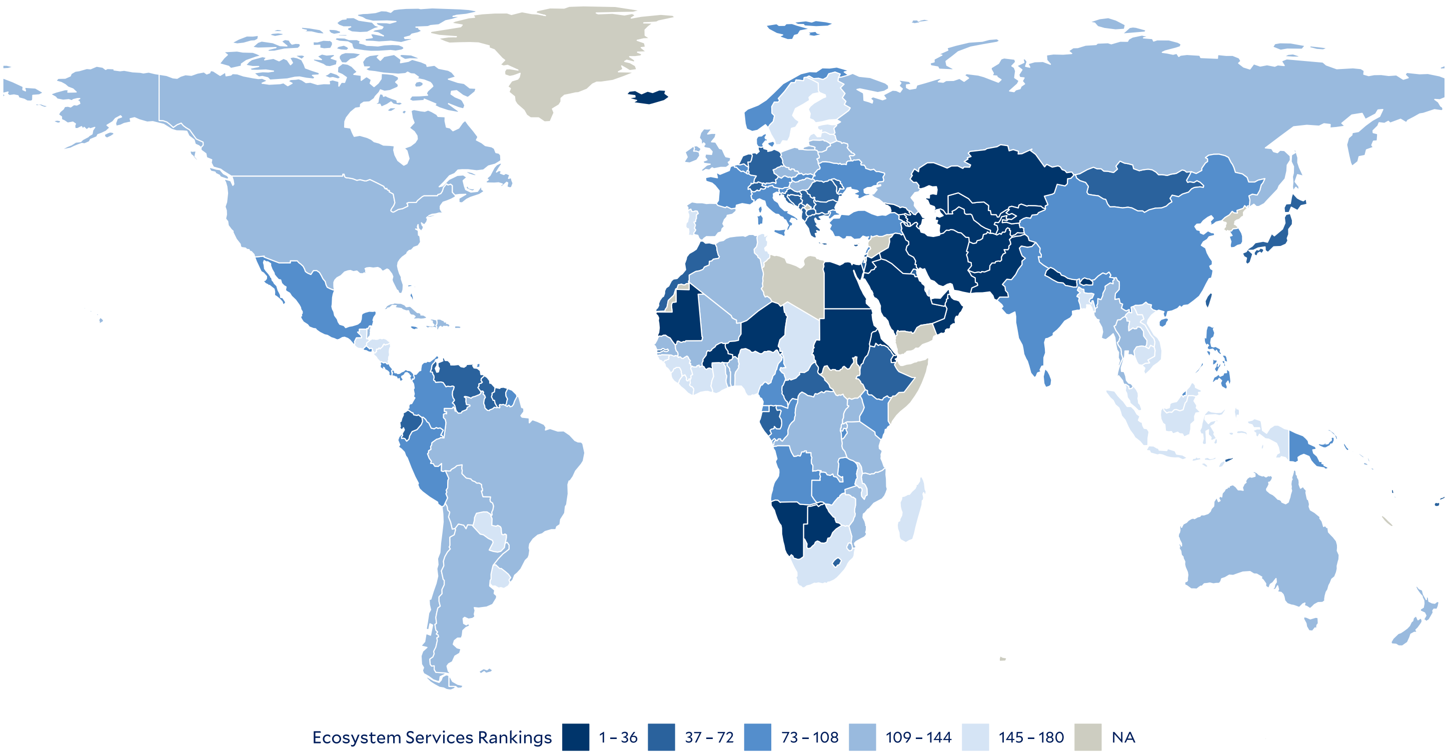
1.2.2 Wetland loss

[5% of issue category]

The percent reduction in a country's wetland area from the reference year 1992 using a five-year moving average.

9.

MAP 9-1. Rankings on Ecosystem Services.



9.

TABLE 9-1. Global rankings, scores, and regional rankings (REG) on Ecosystem Services

RANK	COUNTRY	SCORE	REG
1	Bahrain	100.0	1
	Iceland	100.0	1
	Malta	100.0	1
	Micronesia	100.0	5
	São Tomé and Príncipe	100.0	1
	United Arab Emirates	100.0	1
7	Niger	97.7	2
8	Tajikistan	97.6	1
9	Mauritania	97.2	3
10	Eritrea	97.1	4
11	Saudi Arabia	96.9	3
12	Turkmenistan	96.2	2
13	Burkina Faso	95.5	5
14	Cabo Verde	93.7	6
15	Afghanistan	93.6	1
16	Iraq	91.8	4
17	Kyrgyzstan	91.1	3
18	Iran	88.8	5
19	Seychelles	84.3	7
20	Armenia	81.5	4
21	Pakistan	80.9	2
22	Azerbaijan	80.5	5
23	Jordan	78.9	6
24	Maldives	78.2	3
25	Georgia	78.0	6
26	Djibouti	73.9	8
27	Uzbekistan	70.4	7
28	Kazakhstan	68.4	8
29	Nepal	67.8	4
30	Oman	67.0	7
31	Botswana	66.1	9
32	Egypt	62.5	8
33	Bhutan	60.2	5
34	Sudan	59.9	9
35	St. Vincent and Grenadines	56.5	1
36	Namibia	55.1	10
37	Bosnia and Herzegovina	53.4	1
38	Guyana	52.3	2
39	Suriname	51.3	3
40	Central African Republic	50.7	11
	Saint Lucia	50.7	4
42	Vanuatu	49.7	6
43	Mauritius	49.5	12
44	Taiwan	49.2	7
45	Kuwait	48.4	10
46	Lesotho	47.3	13
47	Switzerland	46.4	3
48	Moldova	45.8	9
	Serbia	45.8	2
50	Gabon	44.7	14
51	Montenegro	44.3	3
52	Greece	43.9	4
53	Timor-Leste	43.8	8
54	Grenada	43.6	5
55	Albania	43.2	5
56	Netherlands	42.8	4
57	North Macedonia	42.3	6
58	Ethiopia	42.2	15
59	Japan	41.7	9
	Mongolia	41.7	9
61	Bulgaria	41.4	7
62	Gambia	41.1	16
63	Romania	40.9	8
64	Morocco	40.8	11
65	Israel	40.6	12
	Venezuela	40.6	6
67	Croatia	40.3	9
68	Germany	39.7	5
69	Antigua and Barbuda	38.8	7
70	Cyprus	38.6	10
71	Ecuador	38.3	8
72	Fiji	38.1	11
73	Italy	37.9	6
74	Sri Lanka	37.8	6
75	Barbados	37.1	9
	Slovenia	37.1	11
	Turkey	37.1	11
78	Peru	37.0	10
79	Lebanon	36.6	13
80	Colombia	36.4	11
81	France	36.1	7
82	Trinidad and Tobago	35.9	12
83	Republic of Congo	35.8	17
84	Comoros	35.7	18
85	Austria	35.6	8
86	Costa Rica	35.4	13
87	Jamaica	35.2	14
88	Burundi	34.7	19
89	Brunei Darussalam	34.4	12
90	China	34.3	13
	Luxembourg	34.3	9
92	Papua New Guinea	34.2	14
93	India	33.8	7
94	Angola	33.7	20
	Equatorial Guinea	33.7	20
96	El Salvador	33.5	15
97	Panama	33.1	16
98	Belgium	32.5	10
	Mexico	32.5	17
100	South Korea	32.2	15
101	Norway	32.1	11
	Slovakia	32.1	13
103	Philippines	31.9	16
104	Bahamas	31.6	18
105	Cameroon	31.5	22
106	Kenya	31.1	23
	Zambia	31.1	23
108	Denmark	30.2	12
	Ukraine	30.2	10
110	Canada	30.1	13
111	Bolivia	30.0	19
112	Argentina	29.4	20
113	Russia	28.6	11
114	Rwanda	28.4	25
115	Tanzania	28.3	26
	United Kingdom	28.3	14
117	Hungary	28.2	14
	New Zealand	28.2	15
119	Togo	28.1	27
120	Australia	27.9	16
120	Belarus	27.9	12
	Brazil	27.9	21
123	Dem. Rep. Congo	27.7	28
124	Chile	27.5	22
125	Ireland	27.4	17
126	Poland	27.1	15
127	United States of America	26.8	18
128	Czech Republic	26.7	16
129	Dominican Republic	26.6	23
130	Haiti	26.2	24
131	Myanmar	25.9	17
132	Senegal	25.8	29
133	Solomon Islands	25.5	18
134	Cuba	25.2	25
135	Lithuania	24.6	17
136	Mozambique	24.5	30
137	Benin	24.4	31
	Spain	24.4	19
	Uganda	24.4	31
140	Thailand	24.3	19
141	Algeria	24.0	14
	Eswatini	24.0	33
143	Belize	23.5	26
144	Mali	23.4	34
	Nigeria	23.4	34
146	Zimbabwe	23.1	36
147	Bangladesh	22.8	8
	Malawi	22.8	37
149	Tunisia	22.5	15
150	Estonia	22.4	18
	Sweden	22.4	20
152	Chad	22.2	38
153	Guinea-Bissau	22.1	39
154	Latvia	21.4	19
155	Honduras	21.2	27
156	Uruguay	21.0	28
157	Finland	20.8	21
158	South Africa	20.6	40
159	Indonesia	20.3	20
160	Paraguay	20.2	29
161	Nicaragua	20.1	
162	Guatemala	19.5	
163	Cambodia	19.0	
164	Singapore	18.4	
165	Laos	16.6	
166	Viet Nam	16.4	
167	Côte d'Ivoire	15.7	
168	Ghana	15.4	
169	Liberia	14.6	
	Madagascar	14.6	
171	Malaysia	12.8	
172	Guinea	11.5	
173	Sierra Leone	9.6	
174	Portugal	7.4	
175	Dominica	5.3	
176	Qatar	0.0	
NA	Kiribati	NA	
	Marshall Islands	NA	
	Samoa	NA	
	Tonga	NA	

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 9-2. Regional rankings, scores, and global rankings on Ecosystem Services.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	St. Vincent and Grenadines	56.5	35
2	Guyana	52.3	38
3	Suriname	51.3	39
4	Saint Lucia	50.7	40
5	Grenada	43.6	54
6	Venezuela	40.6	65
7	Antigua and Barbuda	38.8	69
8	Ecuador	38.3	71
9	Barbados	37.1	75
10	Peru	37.0	78
11	Colombia	36.4	80
12	Trinidad and Tobago	35.9	82
13	Costa Rica	35.4	86
14	Jamaica	35.2	87
15	El Salvador	33.5	96
16	Panama	33.1	97
17	Mexico	32.5	98
18	Bahamas	31.6	104
19	Bolivia	30.0	111
20	Argentina	29.4	112
21	Brazil	27.9	120
22	Chile	27.5	124
23	Dominican Republic	26.6	129
24	Haiti	26.2	130
25	Cuba	25.2	134
26	Belize	23.5	143
27	Honduras	21.2	155
28	Uruguay	21.0	156
29	Paraguay	20.2	160
30	Nicaragua	20.1	161
31	Guatemala	19.5	162
32	Dominica	5.3	175

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Bosnia and Herzegovina	53.4	37
2	Serbia	45.8	48
3	Montenegro	44.3	51
4	Greece	43.9	52
5	Albania	43.2	55
6	North Macedonia	42.3	57
7	Bulgaria	41.4	61
8	Romania	40.9	63
9	Croatia	40.3	67
10	Cyprus	38.6	70
11	Slovenia	37.1	75
	Turkey	37.1	75
13	Slovakia	32.1	101
14	Hungary	28.2	117
15	Poland	27.1	126
16	Czech Republic	26.7	128
17	Lithuania	24.6	135
18	Estonia	22.4	150
19	Latvia	21.4	154

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Afghanistan	93.6	15
2	Pakistan	80.9	21
3	Maldives	78.2	24
4	Nepal	67.8	29
5	Bhutan	60.2	33
6	Sri Lanka	37.8	74
7	India	33.8	93
8	Bangladesh	22.8	147

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Iceland	100.0	1
	Malta	100.0	1
3	Switzerland	46.4	47
4	Netherlands	42.8	56
5	Germany	39.7	68
6	Italy	37.9	73
7	France	36.1	81
8	Austria	35.6	85
9	Luxembourg	34.3	90
10	Belgium	32.5	98
11	Norway	32.1	101
12	Denmark	30.2	108
13	Canada	30.1	110
14	United Kingdom	28.3	115
15	New Zealand	28.2	117
16	Australia	27.9	120
17	Ireland	27.4	125
18	United States of America	26.8	127
19	Spain	24.4	137
20	Sweden	22.4	150
21	Finland	20.8	157
22	Portugal	7.4	174

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Tajikistan	97.6	8
2	Turkmenistan	96.2	12
3	Kyrgyzstan	91.1	17
4	Armenia	81.5	20
5	Azerbaijan	80.5	22
6	Georgia	78.0	25
7	Uzbekistan	70.4	27
8	Kazakhstan	68.4	28
9	Moldova	45.8	48
10	Ukraine	30.2	108
11	Russia	28.6	113
12	Belarus	27.9	120

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Micronesia	100.0	1
2	Vanuatu	49.7	42
3	Taiwan	49.2	44
4	Timor-Leste	43.8	53
5	Japan	41.7	59
	Mongolia	41.7	59
7	Fiji	38.1	72
8	Brunei Darussalam	34.4	89
9	China	34.3	90
10	Papua New Guinea	34.2	92
11	South Korea	32.2	100
12	Philippines	31.9	103
13	Myanmar	25.9	131
14	Solomon Islands	25.5	133
15	Thailand	24.3	140
16	Indonesia	20.3	159
17	Cambodia	19.0	163
18	Singapore	18.4	164
19	Laos	16.6	165
20	Viet Nam	16.4	166
21	Malaysia	12.8	171
NA	Kiribati	NA	
	Marshall Islands	NA	
	Samoa	NA	
	Tonga	NA	

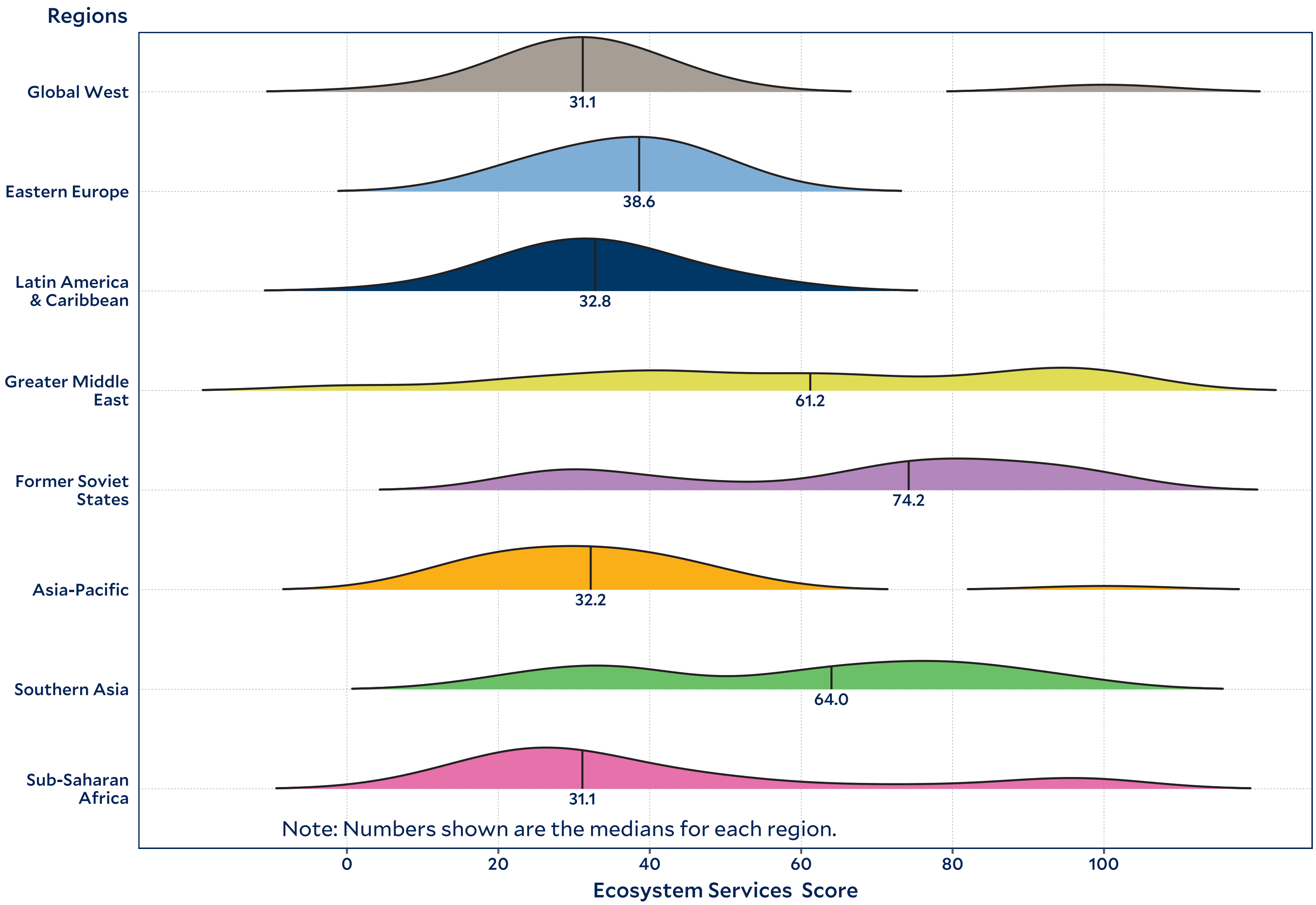
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	São Tomé and Príncipe	100.0	1
2	Niger	97.7	7
3	Mauritania	97.2	9
4	Eritrea	97.1	10
5	Burkina Faso	95.5	13
6	Cabo Verde	93.7	14
7	Seychelles	84.3	19
8	Djibouti	73.9	26
9	Botswana	66.1	31
10	Namibia	55.1	36
11	Central African Republic	50.7	40
12	Mauritius	49.5	43
13	Lesotho	47.3	46
14	Gabon	44.7	50
15	Ethiopia	42.2	58
16	Gambia	41.1	62
17	Republic of Congo	35.8	83
18	Comoros	35.7	84
19	Burundi	34.7	88
20	Angola	33.7	94
	Equatorial Guinea	33.7	94
22	Cameroon	31.5	105
23	Kenya	31.1	106
	Zambia	31.1	106
25	Rwanda	28.4	114
26	Tanzania	28.3	115
27	Togo	28.1	119
28	Dem. Rep. Congo	27.7	123
29	Senegal	25.8	132
30	Mozambique	24.5	136
31	Benin	24.4	137
	Uganda	24.4	137
33	Eswatini	24.0	141
34	Mali	23.4	144
	Nigeria	23.4	144
36	Zimbabwe	23.1	146
37	Malawi	22.8	147
38	Chad	22.2	152
39	Guinea-Bissau	22.1	153
40	South Africa	20.6	158
41	Côte d'Ivoire	15.7	167
42	Ghana	15.4	168
43	Liberia	14.6	169
	Madagascar	14.6	169
45	Guinea	11.5	172
46	Sierra Leone	9.6	173

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Bahrain	100.0	1
	United Arab Emirates	100.0	1
3	Saudi Arabia	96.9	11
4	Iraq	91.8	16
5	Iran	88.8	18
6	Jordan	78.9	23
7	Oman	67.0	30
8	Egypt	62.5	32
9	Sudan	59.9	34
10	Kuwait	48.4	45
11	Morocco	40.8	64
12	Israel	40.6	65
13	Lebanon	36.6	79
14	Algeria	24.0	141
15	Tunisia	22.5	149
16	Qatar	0.0	176

FIGURE 9-1. Regional performance on Ecosystem Services.



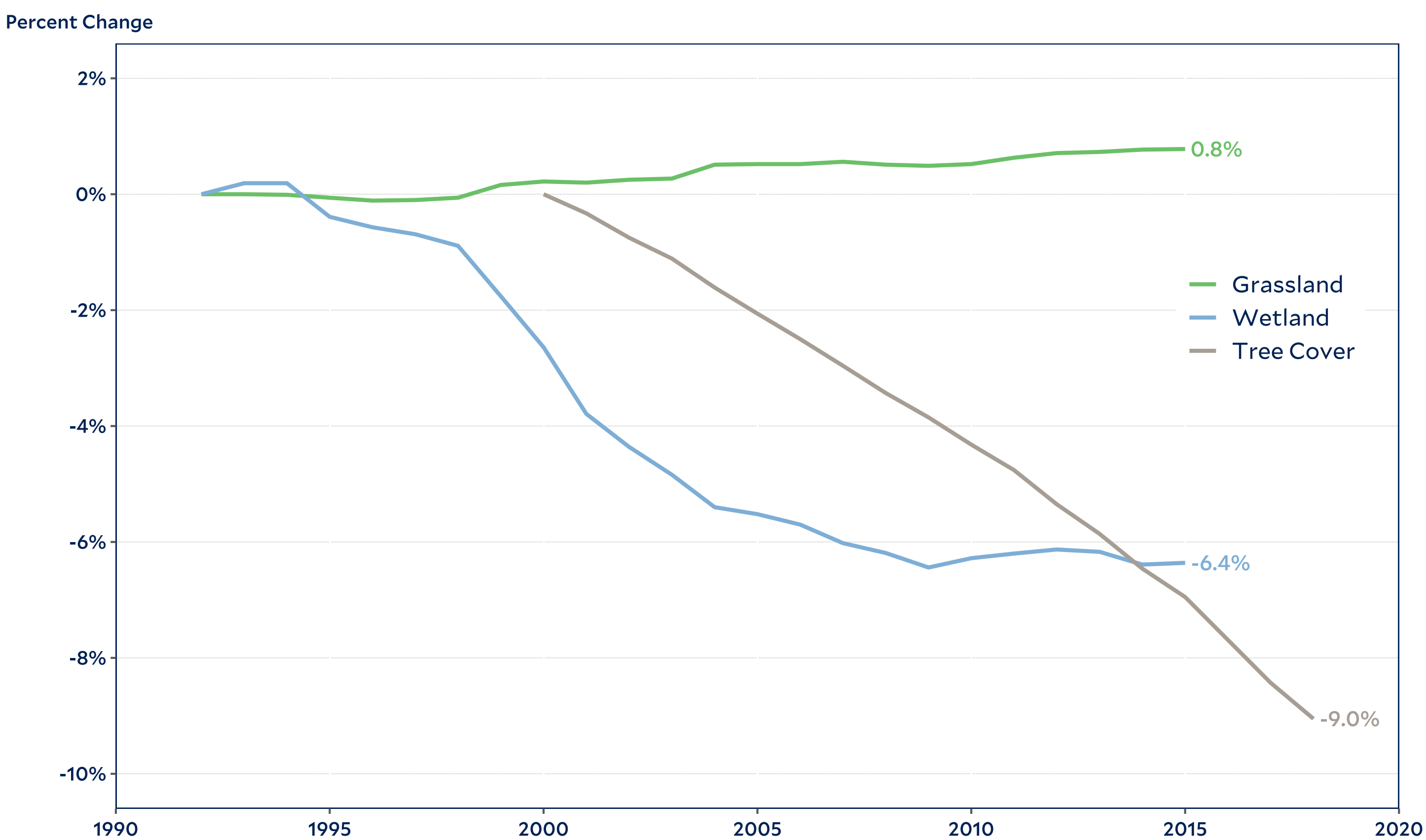
2. RESULTS

2.1 GLOBAL TRENDS

Global data on ecosystem services reveal troubling trends. The past few years have shown alarming increases in forest loss throughout the world. The years 2016–2018 exhibited the three highest levels of annual tree cover loss ever recorded, with losses of 29.7, 29.4, and 24.8 million hectares respectively (Global Forest Watch, 2020b). Total global tree cover fell by 9% from 2000 to 2018, as shown in Figure 9-2. The massive fires in the Amazon in 2019 and the Australian bushfires of early 2020, though not included in the current EPI data or country scores, represent continuations of this destructive trend with dangerous global consequences for climate change, biodiversity, and overall ecosystem vitality.

Recent analyses have begun using satellite imagery to identify global patterns in the causes of tree cover loss. Between 2001 and 2018, tree cover loss was driven mainly by timber cutting and wildfire in the Global North and by shifting agriculture and commodity production in the Global South (Curtis et al., 2018; N. Harris et al., 2020). Commodity-driven deforestation caused 20% of global tree cover loss in 2018, primarily in Southeast Asia and Latin America (N. Harris et al., 2020). Unlike forestry, wildfire, and shifting agriculture, which are typically followed by some degree of regrowth and recovery, commodity-driven deforestation results in long-term or permanent land conversion to row crop agriculture, cattle grazing, oil palm plantations, mining, and other types of commodity production (Curtis et al., 2018). Commodity-driven deforestation contributed to the loss of 3.6 million hectares of primary tropical rainforest in 2018 (Weisse & Goldman, 2019). Further developments in data collection on the drivers of tree cover loss may allow for greater refinement in future iterations of the EPI and enable countries' adoption of more effective forest management policies.

FIGURE 9-2. Percent changes in land cover by ecosystem, normalized from reference year.
Sources: European Space Agency, Global Forest Watch



2.2 LEADERS & LAGGARDS

Countries with relatively small forest areas tend to exhibit low rates of tree cover loss, thus achieving high performance scores on the *tree cover loss* metric. Arid and relatively unforested countries in the Middle East, such as Iraq and Saudi Arabia, and in Sub-Saharan Africa, including Mauritania, Niger, Eritrea, and Burkina Faso, appear to be successfully maintaining their remaining (often limited) forest resources. In some countries, high performance is the direct result of sustainable land management policies and programs. In Burkina Faso, community-led management of integrated forest, woodland, pasture, and agroforestry systems, supported by national programs, has helped slow deforestation and degradation of the country's forests and wooded savannah (FAO, 2018a; Ouedraogo, 2014). In other cases, however, countries may rank higher in the scoring simply because performance in other countries is declining.

Countries in Latin America and the Caribbean exhibited the lowest average regional scores on *tree cover loss*. Colombia experienced a dramatic increase in deforestation between 2015 and 2018, as the expulsion of the Revolutionary Armed Forces of Colombia (FARC) exposed vast areas of the Amazon to uncontrolled exploitation, such as land grabbing and clearing for pasture, cocoa, mining, and logging (Weisse & Goldman, 2018, 2019). Brazil has experienced an upward trend in deforestation since 2012, with record losses of primary rainforest to widespread fires in 2016 and 2017 and an increase in clear-cutting in the Amazon in 2018 (Weisse & Goldman, 2018, 2017, 2019). Brazil's continued backsliding in *tree cover loss* performance reflects a troubling phenomenon, especially considering that the 2020 EPI does not even capture the forest loss sustained from the devastating 2019 Amazon forest fires. Forest fires and deforestation in the Amazon form a self-reinforcing feedback loop, in which tree removal alters precipitation regimes and increases the chance of drought; forest fragmentation causes edge vegetation to dry out, increasing the likelihood and intensity of fires; and fires open additional avenues for further deforestation (Armenteras et al., 2013; Laurance & Williamson, 2001). As climate change and deforestation increase the frequency and severity of droughts – and as President Bolsanaro's administration rolls back environmental protections – fires like those seen in 2017 and 2019 may become all the more pervasive and devastating (Escobar, 2019; Ferrante & Fearnside, 2019).

Some African countries are among the worst performers on the *tree cover loss* indicator. Madagascar lost 2% of its primary rainforest in 2018 alone due to slash-and-burn agriculture and illegal sapphire mining (Weisse & Goldman, 2019). Countries in Western Africa such as Ghana, Côte d'Ivoire, Liberia, Guinea, and Sierra Leone continue to experience increasing levels of tree cover loss to shifting agriculture, illegal mining, and expansions of palm oil and cocoa production (Vijay et al., 2016; Weisse & Goldman, 2019). Deforestation in the hills north of Freetown, the capital of Sierra Leone, likely caused the mudslide that devastated the city in 2017 (Gibbens, 2017).

It is important to note that the 2020 EPI scores do not differentiate between natural and anthropogenic tree cover loss. For example, Dominica showed the lowest performance on *tree cover loss* due to Hurricanes Irma and Maria, which in 2017 destroyed 23.3 thousand hectares, equivalent to 32% of its total tree cover (GFW, 2020a; Weisse & Goldman, 2018). In Portugal, where most tree cover loss in the past two decades has been due to forestry, wildfires collectively burned almost 50,000 hectares in 2017 and 2018 (GFW, 2020d). These fires occurred mainly on eucalyptus plantations, where flammable sap and bark fueled the spread of wildfires in ways that were difficult to control (Frayer, 2017; San-Miguel-Ayanz et al., 2019). As Europe's top producer of this water-intensive tree species, which if left unchecked can suck water from the soil and dry out native ecosystems, Portugal risks becoming increasingly disaster-prone and vulnerable to deadly wildfires.

2.3 GRASSLANDS

We introduce a new pilot indicator on *grassland loss* to the 2020 EPI. Grasslands directly support the livelihoods of 800 million people worldwide (Blair et al., 2014). They provide a wide range of ecosystem services, including fodder and space for livestock production, water flow and erosion regulation, biodiversity habitat, pollinator promotion, and cultural services (Bengtsson et al., 2019; Zhao et al., 2020). Grasslands regulate the global climate through their high surface albedo and collectively account for about one-third of terrestrial carbon storage (Zhao et al., 2020). Despite their high value, native grasslands remain one of the world's most threatened ecosystems, with only 4.6% conserved within protected areas (Carbutt et al., 2017). Historically, they have suffered from overgrazing and conversion to cropland, invasive species incursion, altered fire regimes, and fragmentation (Blair et al., 2014). New threats to grasslands include climate change, hydraulic fracturing and mineral extraction, biofuel production, and even tree planting for carbon offset projects (Bond, 2016; Carbutt et al., 2017). Contrary to the popular conception that more trees are always better for the climate, new studies suggest that replacing ancient primary grasslands with tree plantations may decrease surface albedo and threaten carbon-sequestering long-lived grass and forb species, in addition to grasslands' other unique species (Bond, 2016). By including grasslands in the 2020 EPI, we hope to draw greater attention to these vital ecosystems and to encourage policymakers to prioritize their protection.

Current grassland loss appears most prevalent in countries of the Asia-Pacific region and Sub-Saharan Africa. Outside of protected areas, grasslands in Africa are threatened by drought and climate change-induced desertification, as well as areas of rapid agricultural and urban development (Seymour & Rowen, n.d.; Spriggs, n.d.; Suttie et al., 2005). Countries of the Global West received the highest average regional scores on *grassland loss* for the most recent five-year period. However, this is most likely due to the fact that grasslands in these countries had already been largely degraded or converted before the 1992 reference year.

2.4 WETLANDS

Wetlands represent another of the world's most valuable – and most threatened – ecosystem types. Wetlands store about 35% of the world's organic carbon (Ramsar, 2018); regulate local climate and hydrogeological regimes; provide flood mitigation, coastline protection, and erosion control; filter nutrients and pollutants; serve as vital biodiversity habitat; and provide water, food, and fuel for millions of people worldwide (R.C. Gardner & Finlayson, 2018). Russi et al. (2013) estimate the total monetary value of wetland ecosystem services at almost $45,000 per hectare per year for inland wetlands and over $294,000 per hectare per year for coastal wetlands, mangrove stands, and tidal marshes.

As much as 87% of global wetland coverage has been lost since 1700, and wetland coverage has declined by 35% in the past fifty years due to drainage and dam construction, excess sedimentation and pollution, invasive species, urbanization, and climate change (R.C. Gardner & Finlayson, 2018). Wetlands are disappearing three times faster than forests (Diaz et al., 2019). The 2020 EPI data revealed high rates of *wetland loss* in Asia-Pacific and Latin American countries. Asia contains the largest inland wetland area of any continent at 4.1 million km^2, but has the lowest proportion of its wetlands under formal protection – only 8% (Reis et al., 2017). Central and South America have higher rates of wetlands protected under the international Ramsar Convention on Wetlands (Reis et al., 2017; Wittmann et al., 2015), with Bolivia containing 148,000 km^2 of designated Ramsar Sites, the most of any country (Ramsar, 2014). However, many of these sites are still under threat from agriculture, poaching, and logging, and a lack of cohesive monitoring and national strategy for conservation limits the effectiveness of these protections (Wittmann et al., 2015).

Recent initiatives in wetland protection have mostly consisted of "blue carbon" projects centered on mangroves, which are known for their high rates of carbon storage and sequestration, e.g., www.thebluecarboninitiative.org. Companies and governments have made large-scale investments in mangrove restoration for carbon-offsetting schemes in countries such as Senegal (Bird, 2016) and Indonesia (Pearce, 2019). Global attention has also focused on peatlands restoration, with projects in Denmark, Russia, China, and Indonesia "re-wetting" drained peatlands to prevent greenhouse gas emissions (Joosten, 2015; Pearce, 2011, 2017; Wetlands International, n.d.). Policymakers and landscape managers would do well to direct resources toward other types of coastal and inland wetland ecosystems so that countries may continue to benefit from the myriad ecosystem services they provide.

3. METHODS

3.1 TREE COVER LOSS

3.1.1 INDICATOR BACKGROUND

We quantify *tree cover loss* by constructing a five-year moving average of the percentage of forest lost from the extent of forest cover in the reference year 2000. We define a forest as any land area with over 30% canopy cover.

3.1.2 DATA

The data on *tree cover loss* come from Global Forest Watch (GFW), an open-source initiative of the World Resources Institute in collaboration with other partner organizations. *Tree cover loss* data are available from 2001 to 2018 for 210 countries. Data are obtained through satellite imagery provided by the Global Land Analysis and Discovery laboratory, a collaboration among the University of Maryland, Google Earth, the United States Geological Survey, and the U.S. National Aeronautics and Space Administration (NASA). The data measure tree cover loss, defined as "stand level replacement of vegetation greater than 5 meters," within 30×30 meter resolution pixels (GFW, 2020e).

3.1.3 LIMITATIONS

Given the global scope and lack of information and monitoring in many countries, forest cover data collected from satellite images offer the only practical way to obtain information on the status of global forests. However, both the *tree cover loss* indicator and the GFW dataset from which it is derived have significant limitations, as outlined in Table 9-3.

Global Forest Watch data encompass only the years 2000 to 2018, and we cannot obtain historic data on forest cover before this year. Thus, we lack information about historical forest extent on longer timescales. We are also unable to include information on the 2019–2020 wildfire season in the 2020 scores. The GFW uses two different methodologies – one from 2000 to 2010 and the other from 2011 to 2018 – to compile the *tree cover loss* dataset. The methodology for the latter period incorporates data from all Landsat sensors, including Landsat 8, and includes improved quality assessment models to provide a more sensitive picture of forests globally (Potapov et al., 2015), but is currently available only for that period. Policymakers should therefore use caution when comparing results across time periods.

The GFW data do not distinguish between natural and anthropogenic forest loss, as exemplified by Dominica's tree cover loss due to hurricanes. This dataset also does not distinguish between different forest types. Tree loss in old-growth or primary forest is thus weighed equally to tree loss in a monoculture timber plantation, despite the fact that the former has significantly more harmful consequences for biodiversity and ecosystem services.

A key limitation of the GFW data is that the satellite-generated pixels representing tree cover loss only register loss of canopy cover, which makes it very difficult to detect early stages of forest regrowth. Thus, the GFW dataset cannot discern between temporary tree loss and permanent deforestation, and it does not track what happens to the land after the forest is lost, resulting in a picture of global forest loss that may be overly dire (Pearce, 2018a). New methods, however, may help researchers construct a more accurate characterization of global forest loss in the coming years. Curtis et al. (2018), for example, identified the causes of tree cover loss in GFW's satellite images to predict which losses would be temporary, while McNicol et al. (2018) detected widespread regrowth in degraded African woodlands. We note, however, that even forests which re-grow after a disturbance do not necessarily experience full ecosystem and biodiversity recovery (Watson et al., 2018), making it imperative to conserve intact forests.

TABLE 9-3. Clarification of the *tree cover loss* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
Five-year moving average of the percentage of forest cover lost in forest areas with over 30% canopy cover, compared to forest cover in the reference year 2000	• **A measure of primary forest loss** • **A measure of human-driven or permanent deforestation** • **Inclusive of historic forest losses before 2000**

3.2 GRASSLAND LOSS AND WETLAND LOSS

3.2.1 INDICATOR BACKGROUND

Grassland loss and *wetland loss* are five-year moving averages of percentage of gross losses in grassland and wetland areas compared to the 1992 reference year.

3.2.2 DATA

Data on *grassland loss* and *wetland loss* are derived from a time series of annual global land cover maps for the years 1992–2015 released by the European Space Agency's (ESA) Climate Change Initiative. The ESA's 300m resolution pixels are each classified into nine broad IPCC land cover categories, and land cover changes are calculated over five-year periods.

3.2.3 LIMITATIONS

Our pilot indicators for grassland and wetland loss represent an experimental first step toward characterizing the status of these ecosystem types on a country-by-country basis. We recognize that these indicators involve significant limitations. Table 9-4 provides clarification on the scope and limitations of the new metrics. The IPCC land cover categories used to classify the pixels are coarse. Land cover characterization using remote sensing technology may not always match realities on the ground. Remote sensing cannot distinguish between secondary grassland and old-growth primary grassland, so the *grassland loss* indicator weighs losses of these grassland types equally even though the latter is significantly more valuable in terms of biodiversity and climate benefits (Bond, 2016). In fact, the expansion of secondary grassland often harms biodiversity and the climate when it replaces other ecosystems such as rainforest. Our metric currently cannot account for these differences, nor can it reflect the problems with secondary grassland expansion because it measures gross, rather than net, grassland loss.

Measurement problems are exacerbated for wetlands, which have historically been very difficult to delineate using remote sensing technology due to their high seasonal and climatic variability. Remote sensing also cannot distinguish between natural and man-made wetlands, such as rice paddies, or between healthy wetlands and those that have been taken over by invasive species (Mahdavi et al., 2018; Reis et al., 2017). Focus 9-1 elaborates on some of these challenges and highlights new progress in wetland measurement that may benefit future iterations of the EPI. In the meantime, our indicators on wetlands and grasslands highlight the need for further research and policy attention on these vital ecosystems.

TABLE 9-4. Clarification of the *grassland loss and wetland loss* metrics.

WHAT THE METRICS ARE	WHAT THE METRICS AREN'T
Five-year moving average of the gross grassland and wetland cover lost compared to grassland and wetland cover in the reference year 1992	• **A measure of net loss in grassland or wetland cover** • **A measure of only human-driven or permanent wetland loss, as opposed to natural or temporary loss due to climatic variation** • **Able to distinguish between natural and man-made wetlands or between primary and secondary grasslands** • **Inclusive of historic grassland or wetland losses dating before 1992**

BREAKTHROUGHS IN GLOBAL WETLAND MONITORING

Wetlands provide numerous ecosystem services, from water filtration to critical habitat to flood control. Yet wetlands continue to be lost across the world in the face of land conversion to agriculture, aquaculture, infrastructure, and other uses. Wetland delineation and monitoring on the global and national scales have posed a perennial challenge for conservation managers and policymakers. Changes in wetland extent are difficult to track over time due to inadequate historical documentation, different classification systems, and high seasonal and climatic variability (Mahdavi et al., 2018). Remote sensing technologies have historically been unable to detect water in the soil or beneath dense vegetation, and often cannot identify ecosystem boundaries or distinguish between natural and man-made landscapes, such as rice paddies (Mahdavi et al., 2018; Reis et al., 2017). Researchers have attempted to track changes in wetlands based on average maximum inundation, but without nuanced ground-based data and effective interpretation, these assessments remain vulnerable to the influence of extreme events. Remotely sensed land cover data often require additional information on landforms, vegetation, and water regimes to ensure accurate wetland delineation, but these kinds of data are not available on global scales.

A number of recent initiatives contribute exciting developments to global wetland mapping and monitoring. The Global Mangrove Watch (GMW), an initiative of the Japan Aerospace Exploration Agency, Aberystwyth University (U.K.), solo Earth Observation (Japan), Wetlands International, and the World Conservation Monitoring Centre (UNEP-WCMC), is the first study to establish a map of global mangrove ecosystems. This map tracks changes in mangrove extent over time using a globally consistent, automated, and reproducible methodology (Bunting et al., 2018; UNEP-WCMC, 2019). Mangroves perform crucial ecosystem services such as coastal protection, biodiversity habitat, local food and livelihood provision, and high levels of above- and belowground carbon sequestration. Despite these benefits, they are being lost at a rate of 2% per year (Conservation International, 2019). Using ALOS PALSAR and Landsat (optical) data and Google Earth imagery, the GMW has generated a map of global mangroves for the baseline year 2010, and maps showing changes from this baseline for six years between 1996 and 2016. The two complementary datasets, which measure different properties of mangrove forests, allowed for higher accuracy in generating the baseline map (Bunting et al., 2018). GMW plans to release data for 2017 and 2018 later in 2020, and annual updates in subsequent years will facilitate continuous monitoring of global mangrove ecosystems.

In another promising initiative, the United Nations Environment Programme and the European Commission have partnered with Google Earth to launch the Freshwater Ecosystems Explorer, an open access data platform aimed at monitoring, tracking, and driving progress on Sustainable Development Goal Target 6.6, to "protect and restore water-related ecosystems." The platform recently introduced a new indicator on wetlands that uses measurements developed by the Danish satellite image and data processing company DHI GRAS. A baseline measurement of total wetlands area per country for 2016–2018 is currently available through the Freshwater Ecosystems Explorer, and annual measurements will allow for tracking of future changes in wetland extent. The platform also includes other indicators important for monitoring water management impacts and the health of wetland ecosystems. These include data on permanent and seasonal surface water dynamics from the past 36 years; data on reservoirs and modified water bodies, turbidity, and trophic state data to characterize water quality in lakes; and mangrove data produced by the Global Mangrove Watch. The EPI team hopes to incorporate these datasets into future versions of the *wetland loss* indicator and encourages policymakers to use these resources when making decisions on ecosystem conservation.

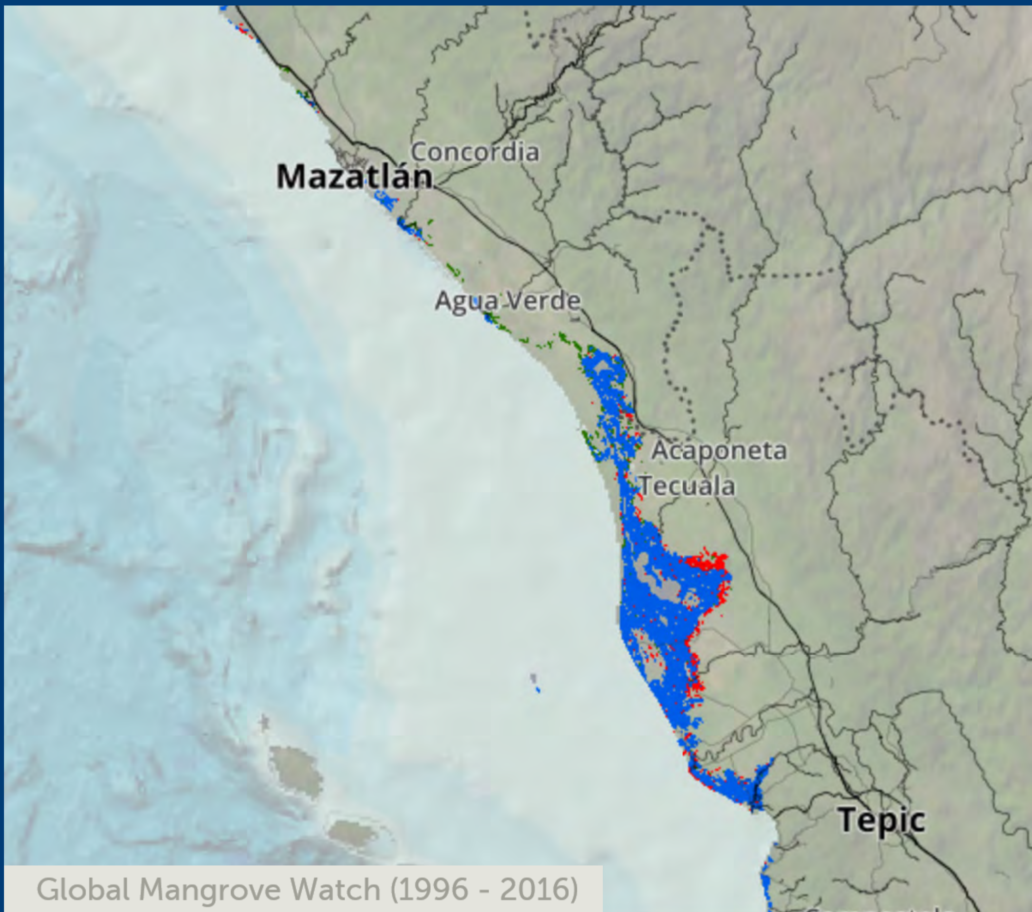
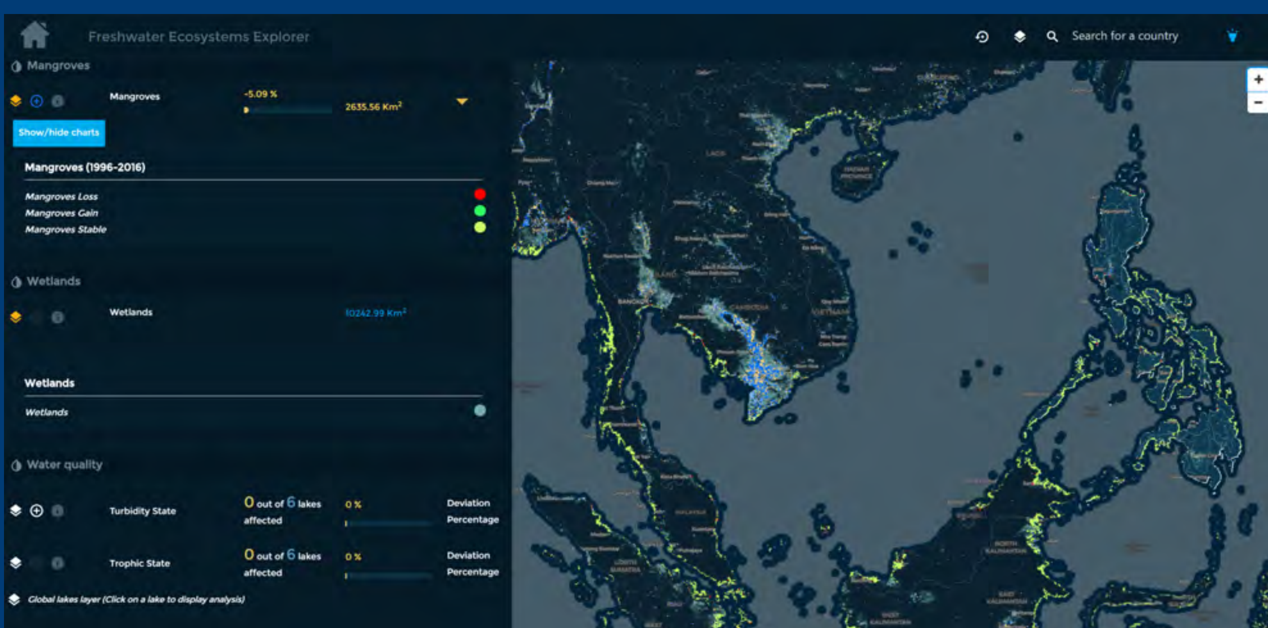


FIGURE 9-3. Global Mangrove Watch map shows mangrove coverage that has been lost (red), gained (green), and maintained (blue) off the western coast of Mexico. *Source: Global Mangrove Watch*

FIGURE 9-4. Freshwater Ecosystems Explorer interactive map shows wetlands, reservoirs, lakes, and rivers mapped alongside mangrove status data from Global Mangrove Watch. *Source: Freshwater Ecosystems Explorer*



Chapter 10. Fisheries

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Fisheries provide an important source of nutrition and economic activity to communities around the world. The Food and Agriculture Organization of the United Nations (FAO) notes in its *The State of World Fisheries and Aquaculture* (SOFIA) report that 59.6 million people participated in capture fisheries and aquaculture in 2016. Further, the report explains that fish production set a new record in 2016 of 171 million tonnes of capture and aquaculture production, with around 33% of marine fish stocks fished beyond biological sustainability (FAO, 2018). Overfishing, decreasing fish species diversity, ocean acidification, and ecosystem decline threaten the world's marine fish stocks. With increasing food demands from a growing population, the uncertain future of the world's fisheries poses a significant challenge from the standpoint of human nutrition, economic activity, and ecosystem health.

1.2 INDICATORS

1.2.1 Fish stock status [35% of issue category]

Fish stock status measures the percentage of a country's total catch that comes from overexploited or collapsed fish stocks, based on an assessment of all fish stocks caught within a country's exclusive economic zone (EEZ). Ideally, a country should reduce or eliminate catches from overexploited or collapsed fish stocks.

1.2.2 Marine Trophic Index (MTI) [35% of issue category]

Marine Trophic Index describes the health of a country's fishing stock based on expected catch and changes over time. A lower MTI score might indicate that species higher in the food web have been nearly or fully fished out, and the fishing sector has shifted to target fish at lower trophic levels – also called "fishing down the food web" (Pauly et al., 2008).

1.2.3 Fish caught by trawling [30% of issue category]

Fish caught by trawling measures the percent of a country's fish caught by bottom or pelagic trawling, where a fishing net is pulled through the water behind a boat.

10.

MAP 10-1. Rankings on Fisheries.

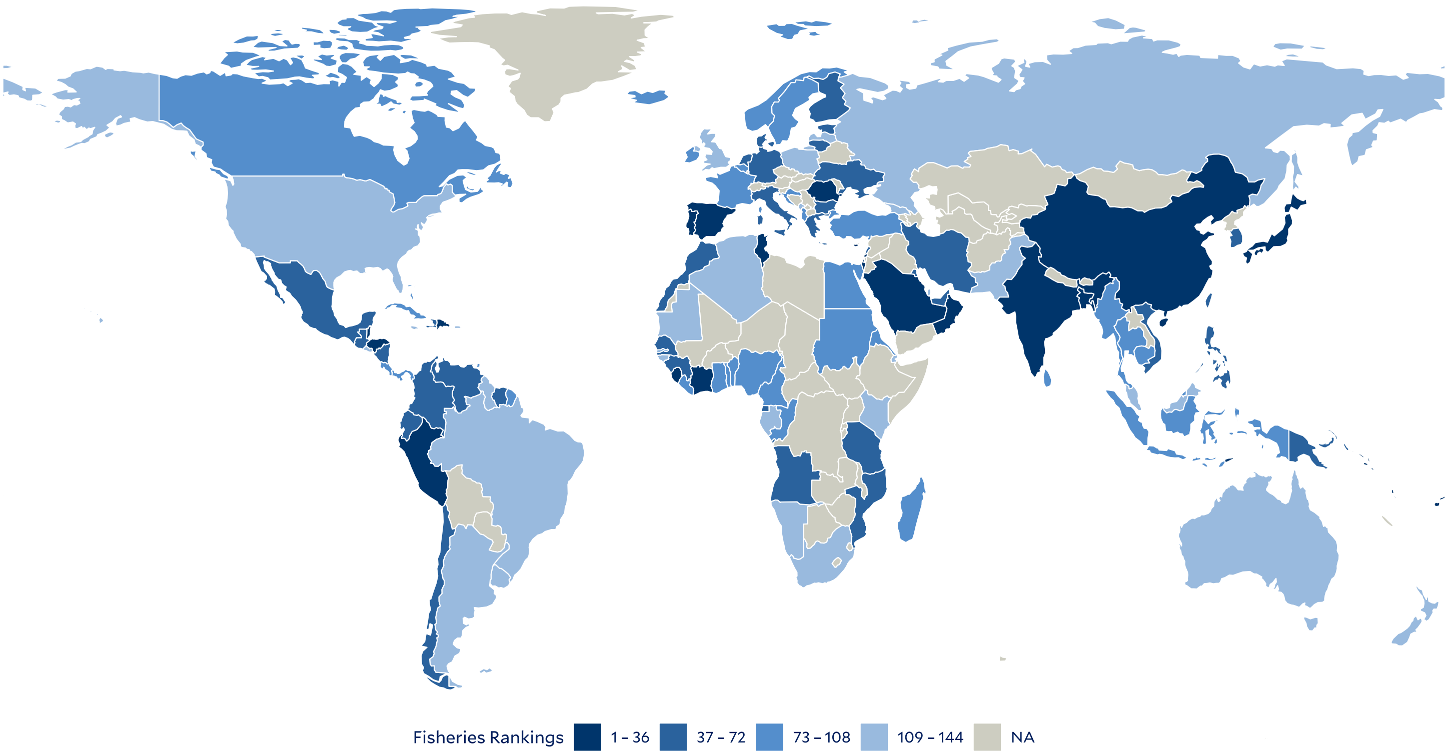


TABLE 10-1. Global rankings, scores, and regional rankings (REG) on Fisheries.

RANK	COUNTRY	SCORE	REG
1	Singapore	71.4	3
2	Fiji	59.7	4
3	Kiribati	55.4	5
4	Romania	54.5	8
5	Samoa	54.3	6
6	Marshall Islands	53.5	7
7	Timor-Leste	46.8	8
8	Maldives	46.6	4
9	Israel	45.5	3
10	Tonga	44.7	9
11	Japan	35.2	10
12	Portugal	33.1	4
13	Micronesia	32.7	11
14	Solomon Islands	31.8	12
15	Dominica	31.0	3
16	Vanuatu	26.4	13
17	Oman	24.5	4
18	Dominican Republic	21.8	4
19	Cabo Verde	20.7	17
20	Cyprus	20.2	9
21	Belize	19.8	5
22	Bangladesh	19.6	5
23	Peru	18.7	6
	Sierra Leone	18.7	18
25	Comoros	18.6	19
26	Saudi Arabia	18.5	5
	St. Vincent and Grenadines	18.5	7
28	Barbados	18.4	8
29	Tunisia	18.3	6
30	Seychelles	18.1	20
31	China	18.0	14
32	Spain	17.9	5
33	Honduras	17.6	9
34	São Tomé and Príncipe	17.2	21
35	Côte d'Ivoire	16.9	22
	India	16.9	6
37	Suriname	16.8	10
38	Haiti	16.7	11
	Morocco	16.7	7
40	Chile	16.6	12
41	Estonia	16.4	10
42	Mozambique	16.3	23
43	Saint Lucia	16.2	13
44	Colombia	15.8	14
	Grenada	15.8	14
46	Greece	15.7	11
47	Guatemala	15.4	16
48	Mauritius	15.0	24
49	Italy	14.9	6
	Kuwait	14.9	8
51	Angola	14.7	25
52	Viet Nam	14.6	15
53	Lithuania	14.5	12
	United Arab Emirates	14.5	9
55	Guinea	14.4	26
56	Equatorial Guinea	14.3	27
57	Lebanon	14.2	10
58	Germany	14.0	7
59	Iran	13.8	11
	Taiwan	13.8	16
61	Ecuador	13.5	17
62	Denmark	13.2	8
63	Netherlands	13.1	9
	Papua New Guinea	13.1	17
65	Tanzania	13.0	28
66	Bulgaria	12.9	13
67	Finland	12.8	10
	Mexico	12.8	18
	Senegal	12.8	29
70	South Korea	12.6	18
71	Ukraine	12.4	10
72	Nicaragua	12.3	19
	Philippines	12.3	19
	Venezuela	12.3	19
75	Malta	12.2	11
76	Egypt	12.1	12
	France	12.1	12
78	Indonesia	11.9	20
79	Croatia	11.8	14
	Madagascar	11.8	30
	Trinidad and Tobago	11.8	21
82	Benin	11.7	31
83	Sweden	11.6	13
84	Republic of Congo	11.4	32
85	Cambodia	11.3	21
	Sri Lanka	11.3	7
87	Thailand	11.1	22
	Togo	11.1	33
89	Canada	11.0	14
90	Nigeria	10.9	34
91	Costa Rica	10.8	22
	Turkey	10.8	15
93	Gambia	10.6	35
	Liberia	10.6	35
95	Cameroon	10.5	37
96	Iceland	10.1	15
97	Cuba	10.0	23
98	Bahamas	9.9	24
99	Norway	9.8	16
100	Myanmar	9.4	23
101	Brunei Darussalam	9.3	24
102	Ireland	9.1	17
	Panama	9.1	25
	Sudan	9.1	13
105	Belgium	9.0	18
	Eritrea	9.0	38
	Ghana	9.0	38
108	Albania	8.9	16
109	United Kingdom	8.8	19
110	Kenya	8.6	40
	Malaysia	8.6	25
	Namibia	8.6	40
113	Brazil	8.3	26
114	Algeria	8.1	14
115	Poland	8.0	17
116	Mauritania	7.8	42
	South Africa	7.8	42
118	Guyana	7.7	27
119	Pakistan	7.6	8
120	Gabon	7.3	44
120	Latvia	7.3	18
122	Montenegro	6.6	19
	United States of America	6.6	20
124	Uruguay	6.5	28
125	Qatar	6.4	15
126	Djibouti	6.2	45
127	El Salvador	5.5	29
128	New Zealand	5.4	21
129	Guinea-Bissau	5.2	46
130	Antigua and Barbuda	5.0	30
131	Jamaica	4.7	31
132	Georgia	4.4	11
133	Russia	4.3	12
134	Australia	3.4	22
135	Argentina	3.2	32
136	Bahrain	0.0	16
NA	Afghanistan	NA	
	Armenia	NA	
	Austria	NA	
	Azerbaijan	NA	
	Belarus	NA	
	Bhutan	NA	
	Bolivia	NA	
	Bosnia and Herzegovina	NA	
	Botswana	NA	
	Burkina Faso	NA	
	Burundi	NA	
	Central African Republic	NA	
	Chad	NA	
	Czech Republic	NA	
	Dem. Rep. Congo	NA	
	Eswatini	NA	
	Ethiopia	NA	
	Hungary	NA	
	Iraq	NA	
	Jordan	NA	
	Kazakhstan	NA	
	Kyrgyzstan	NA	
	Laos	NA	
	Lesotho	NA	
	Luxembourg	NA	
	Malawi	NA	
	Mali	NA	
	Moldova	NA	
	Mongolia	NA	
	Nepal	NA	
	Niger	NA	
	North Macedonia	NA	
	Paraguay	NA	
	Rwanda	NA	
	Serbia	NA	
	Slovakia	NA	
	Slovenia	NA	
	Switzerland	NA	
	Tajikistan	NA	
	Turkmenistan	NA	
	Uganda	NA	
	Uzbekistan	NA	
	Zambia	NA	
	Zimbabwe	NA	

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 10-2. Regional rankings, scores, and global rankings on Fisheries.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Dominica	31.0	15
2	Dominican Republic	21.8	18
3	Belize	19.8	21
4	Peru	18.7	23
5	St. Vincent and Grenadines	18.5	26
6	Barbados	18.4	28
7	Honduras	17.6	33
8	Suriname	16.8	37
9	Haiti	16.7	38
10	Chile	16.6	40
11	Saint Lucia	16.2	43
12	Colombia	15.8	44
	Grenada	15.8	44
14	Guatemala	15.4	47
15	Ecuador	13.5	61
16	Mexico	12.8	67
17	Nicaragua	12.3	72
	Venezuela	12.3	72
19	Trinidad and Tobago	11.8	79
20	Costa Rica	10.8	91
21	Cuba	10.0	97
22	Bahamas	9.9	98
23	Panama	9.1	102
24	Brazil	8.3	113
25	Guyana	7.7	118
26	Uruguay	6.5	124
27	El Salvador	5.5	127
28	Antigua and Barbuda	5.0	130
29	Jamaica	4.7	131
30	Argentina	3.2	135
NA	Bolivia	NA	
	Paraguay	NA	

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Romania	54.5	4
2	Cyprus	20.2	20
3	Estonia	16.4	41
4	Greece	15.7	46
5	Lithuania	14.5	53
6	Bulgaria	12.9	66
7	Croatia	11.8	79
8	Turkey	10.8	91
9	Albania	8.9	108
10	Poland	8.0	115
11	Latvia	7.3	120
12	Montenegro	6.6	122
NA	Bosnia and Herzegovina	NA	
	Czech Republic	NA	
	Hungary	NA	
	North Macedonia	NA	
	Serbia	NA	
	Slovakia	NA	
	Slovenia	NA	

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Maldives	46.6	8
2	Bangladesh	19.6	22
3	India	16.9	35
4	Sri Lanka	11.3	85
5	Pakistan	7.6	119
NA	Afghanistan	NA	
	Bhutan	NA	
	Nepal	NA	

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Portugal	33.1	12
2	Spain	17.9	32
3	Italy	14.9	49
4	Germany	14.0	58
5	Denmark	13.2	62
6	Netherlands	13.1	63
7	Finland	12.8	67
8	Malta	12.2	75
9	France	12.1	76
10	Sweden	11.6	83
11	Canada	11.0	89
12	Iceland	10.1	96
13	Norway	9.8	99
14	Ireland	9.1	102
15	Belgium	9.0	105
16	United Kingdom	8.8	109
17	United States of America	6.6	122
18	New Zealand	5.4	128
19	Australia	3.4	134
NA	Austria	NA	
	Luxembourg	NA	
	Switzerland	NA	

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Ukraine	12.40	71
2	Georgia	4.40	132
3	Russia	4.30	133
NA	Armenia	NA	
	Azerbaijan	NA	
	Belarus	NA	
	Kazakhstan	NA	
	Kyrgyzstan	NA	
	Moldova	NA	
	Tajikistan	NA	
	Turkmenistan	NA	
	Uzbekistan	NA	

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Singapore	71.4	1
2	Fiji	59.7	2
3	Kiribati	55.4	3
4	Samoa	54.3	5
5	Marshall Islands	53.5	6
6	Timor-Leste	46.8	7
7	Tonga	44.7	10
8	Japan	35.2	11
9	Micronesia	32.7	13
10	Solomon Islands	31.8	14
11	Vanuatu	26.4	16
12	China	18.0	31
13	Viet Nam	14.6	52
14	Taiwan	13.8	59
15	Papua New Guinea	13.1	63
16	South Korea	12.6	70
17	Philippines	12.3	72
18	Indonesia	11.9	78
19	Cambodia	11.3	85
20	Thailand	11.1	87
21	Myanmar	9.4	100
22	Brunei Darussalam	9.3	101
23	Malaysia	8.6	110
NA	Laos	NA	
	Mongolia	NA	

SUB-SAHARAN AFRICA

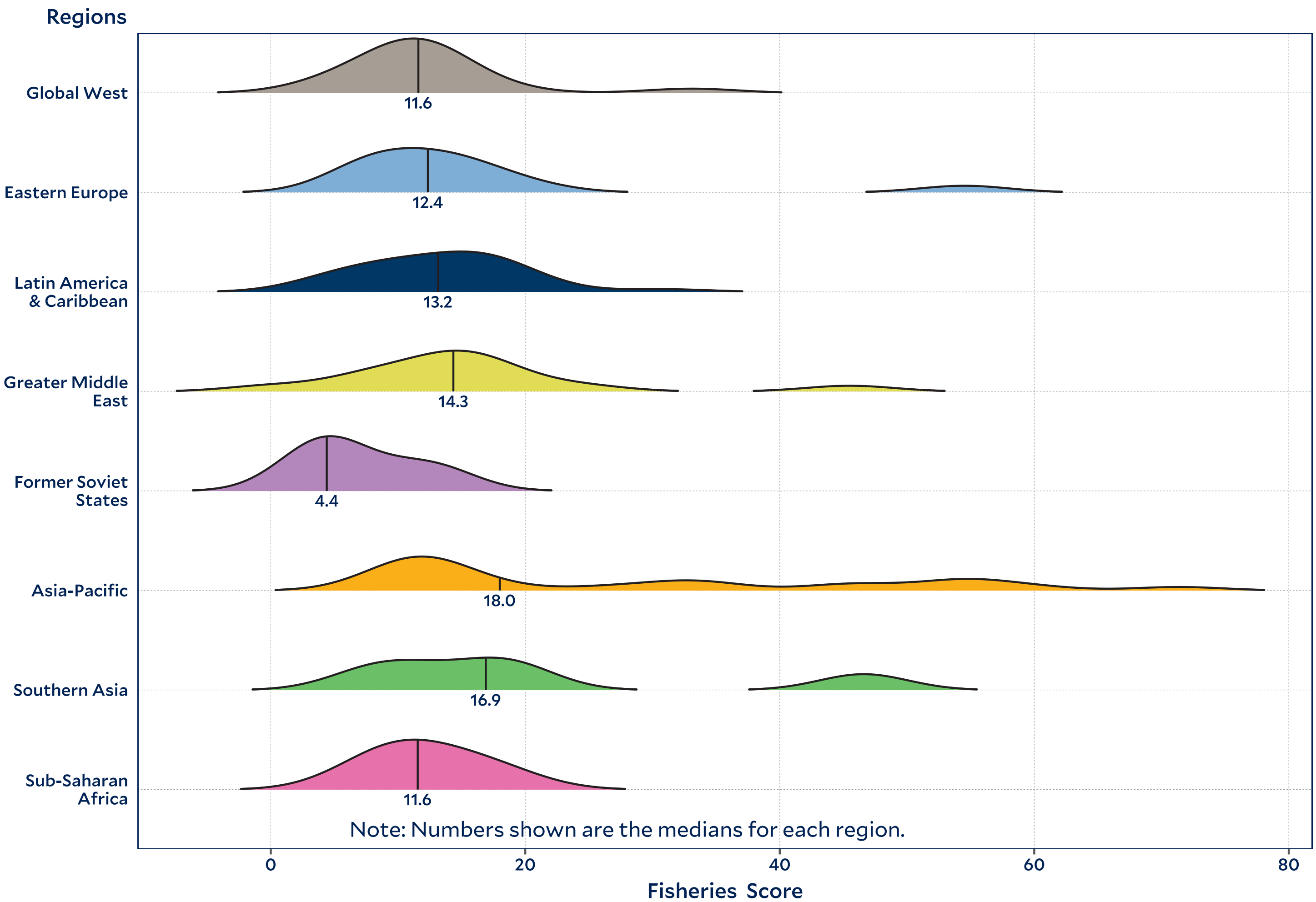
Reg Rank	Country	Score	Global Rank
1	Cabo Verde	20.7	19
2	Sierra Leone	18.7	23
3	Comoros	18.6	25
4	Seychelles	18.1	30
5	São Tomé and Príncipe	17.2	34
6	Côte d'Ivoire	16.9	35
7	Mozambique	16.3	42
8	Mauritius	15.0	48
9	Angola	14.7	51
10	Guinea	14.4	55
11	Equatorial Guinea	14.3	56
12	Tanzania	13.0	65
13	Senegal	12.8	67
14	Madagascar	11.8	79
15	Benin	11.7	82
16	Republic of Congo	11.4	84
17	Togo	11.1	87
18	Nigeria	10.9	90
19	Gambia	10.6	93
	Liberia	10.6	93
21	Cameroon	10.5	95
22	Eritrea	9.0	105
	Ghana	9.0	105
24	Kenya	8.6	110
	Namibia	8.6	110
26	Mauritania	7.8	116
	South Africa	7.8	116
28	Gabon	7.3	120
29	Djibouti	6.2	126
30	Guinea-Bissau	5.2	129
NA	Botswana	NA	
	Burkina Faso	NA	
	Burundi	NA	
	Central African Republic	NA	
	Chad	NA	
	Dem. Rep. Congo	NA	
	Eswatini	NA	
	Ethiopia	NA	
	Lesotho	NA	
	Malawi	NA	
	Mali	NA	
	Niger	NA	
	Rwanda	NA	
	Uganda	NA	
	Zambia	NA	
	Zimbabwe	NA	

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Israel	45.5	9
2	Oman	24.5	17
3	Saudi Arabia	18.5	26
4	Tunisia	18.3	29
5	Morocco	16.7	38
6	Kuwait	14.9	49
7	United Arab Emirates	14.5	53
8	Lebanon	14.2	57
9	Iran	13.8	59
10	Egypt	12.1	76
11	Sudan	9.1	102
12	Algeria	8.1	114
13	Qatar	6.4	125
14	Bahrain	0.0	136
NA	Iraq	NA	
	Jordan	NA	

10.

FIGURE 10-1. Regional performance on Fisheries.



2. RESULTS

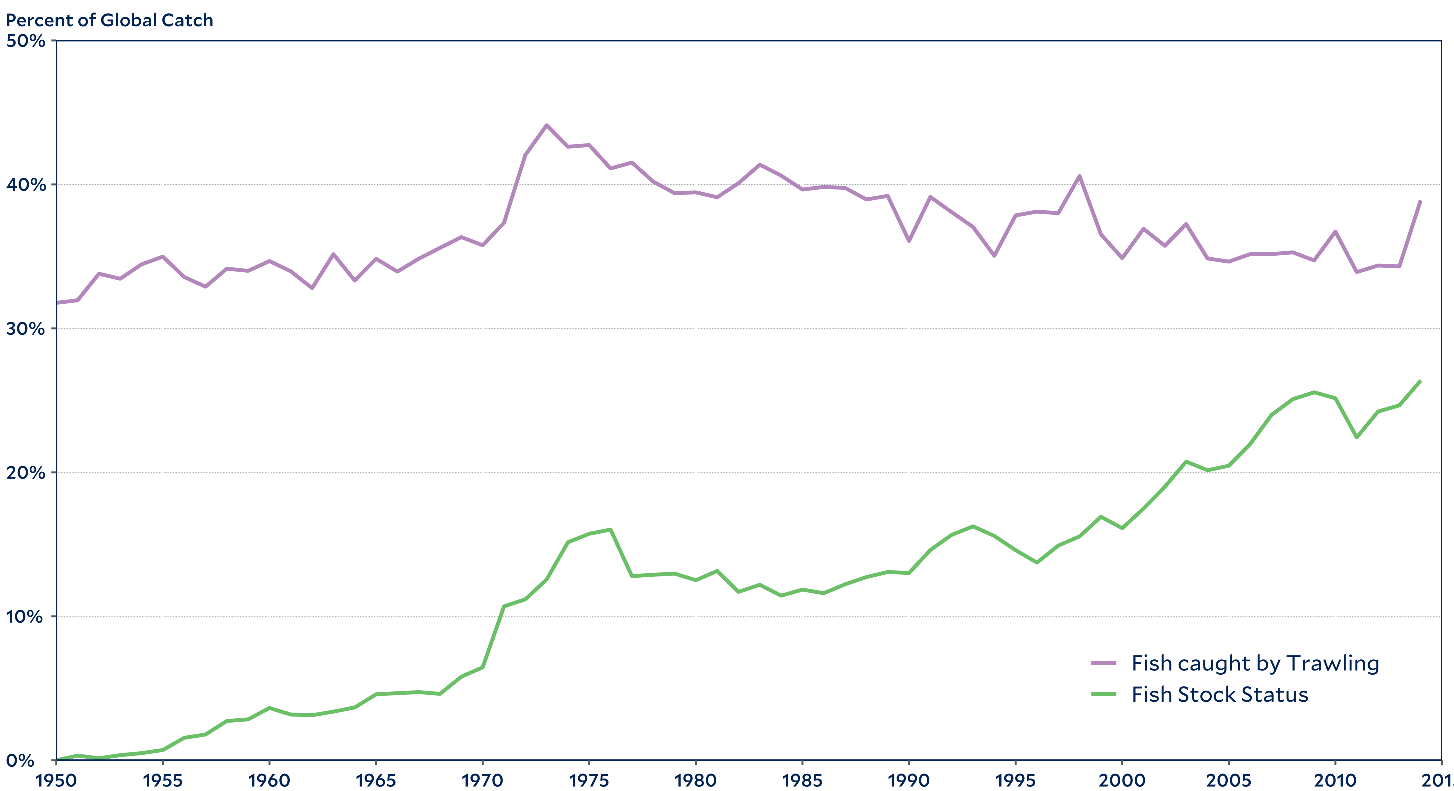
2.1 GLOBAL TRENDS

Fisheries continue to decline globally. The overall percentage of collapsed and overexploited fish stocks has increased, though at a slower rate than in previous years (FAO, 2018). The 2020 EPI finds that global performance in *fish stock status* and *fish caught by trawling* has declined, and MTI trends downward in almost every country. Since 1950, the amount of fish harvested from overexploited and collapsed stocks increased from virtually zero to approximately 30% in recent years, as the global fleet of fishing vessels rose from 1.7 to 3.7 million between 1950 and 2015 (Rousseau et al., 2019). The percent of fish caught by trawling has fluctuated between 30 and 40% since 1950, with an apparent uptick in recent years (see Figure 10-2). Trawling often causes significant ecosystem disruption, destroying corals and other habitat-forming species and leading to significant amounts of bycatch – species that are mistakenly caught and often discarded. This common fishing method is especially harmful when practiced frequently through the same areas, which prevents an ecosystem from recovering. Trawl gears remove an estimated 6–41% of marine organisms per pass, from which marine ecosystems require several years to recover (Hiddink et al., 2017).

Global fisheries suffer from several failures of governance and mismanagement. Illegal, unreported, and unregulated (IUU) fishing plague the industry: an estimated 20% of global catch comes from IUU fishing (Widjaja et al., 2019). Within the licit fisheries industry, subsidies often encourage unsustainable levels of fishing activity. Capacity-enhancing subsidies, such as for fuel or vessel construction, made up $22.2 billion of the $34.5 billion spent globally on fisheries subsidies in 2018 (Sumaila et al., 2019). The World Trade Organization is currently seeking to curb these "harmful subsidies," though the COVID-19 pandemic and country interests have disrupted conversations (Godfrey, 2020).

Declining fisheries health is not simply attributable to unsustainable fishing practices. Our indicators attempt to capture some of the complexities of the industry; however, continued efforts and improvements in data collection are needed to fully characterize the status of global fisheries.

FIGURE 10-2. Global trends in *fish caught by trawling* and *fish stock status*, 1950–2014. Source: Sea Around Us.



2.2 LEADERS & LAGGARDS

While no country excels in Fisheries, Singapore has adjusted fishing capacity by shifting attention toward farmed fish production. Strong government support for and investment in aquaculture reduces the pressure on wild fish stocks. Fish farms currently meet around 10% of the country's seafood demands, and the government has pledged to increase this percentage to 30% (Lim et al., 2020). In 2019, Singapore launched the Aquaculture Innovation Centre, aimed to spur public and private sector development in the aquaculture industry through knowledge-sharing, technology, and research and development efforts (Koh, 2019).

A notable ranking is China in 31st place – though with an overall low score of 18.0. China has a massive global presence as the world's largest producer by both catch and aquaculture (FAO, 2018). China's unsustainable fishing practices have led to declines in fish size and population, while its massive fishing fleet has been heavily involved in illegal fishing activities (Zhang et al., 2020; Hosch, 2019). At the same time, China has implemented new management and enforcement schemes that may contribute to its higher ranking. Efforts such as China's national Five-Year Plan or annual fishing moratoria strive to reduce catch and alleviate pressure on fish stocks (FAO, 2018; Godfrey, 2018). Even so, continued involvement in illegal fishing activities will pose a significant challenge to the health of global fisheries, and China should continue its efforts to rein in these activities (Godfrey, 2019).

Countries ranked at the bottom ten of this issue category are geographically diverse, many showing steep declines in their *Marine Trophic Index* performance. Bahrain's MTI score declined sharply since 2004, citing challenges of overexploitation, overcapacity of boats, harmful dredging activities, and a lack of fish stock recovery (Ali & Abahussain, 2013). Coastal development and climate also threaten Bahrain's coral reefs – and subsequently the health of its fisheries and the communities that rely on this industry for their livelihoods (Burt et al., 2013; Wabnitz et al., 2018).

Argentina, Australia, and Russia also appear at the bottom of the Fisheries ranking. In Argentina, federal law regulates fisheries and prohibits discarding bycatch. Enforcement, however, is lacking. An estimated 25–30% of trawling catches are discarded, threatening many fish and invertebrate species (Karp et al., 2019). Beyond weak enforcement, cited challenges include poor data reporting and recording (Karp et al., 2019). A lack of monitoring for the recreational fishing activities further exacerbates the problem (Venerus & Cedrola, 2017). Illegal fishing by foreign vessels also plagues Argentina's waters (Profeta, 2018).

Australian catches dropped an estimated 31% from 2005 to 2015, with fish stocks showing a decline in species abundance and large fish biomass (Edgar et al., 2018). Trawling activities caused substantial damage to Australian marine species and seabeds (Althaus et al., 2009), while illegal fishing adds to the pressures on fish stock (Lindley et al., 2019). Here, regulatory objectives and economic incentives fall short in terms of protecting Australia's fish stocks (Emery et al., 2017). Among countries in the Fisheries category – virtually all of which are laggards – a recurring theme is poor monitoring and insufficient data collection. Improved monitoring should serve as the foundation for any future improvements.

3. METHODS

Globally, data tracking has improved over the years as more fishing vessels are equipped with catch reporting systems. Improved monitoring, and subsequent reporting of previously undocumented catches, can give the perception that fish populations may be recovering (Zeller & Pauly, 2018). Also called the "presentist bias," this effect may give the impression that fish stocks may be recovering when instead improvements in data collection are driving the higher numbers (Zeller & Pauly, 2018). Additionally, many operations continue to rely on handwritten logs, and artisanal operations may not be captured in country or global statistics (Roberson et al., 2019; Rousseau et al., 2019). In these cases, efforts to reconstruct data and continued improvements in data collection can help inform missing historical and current trends.

Indeed, FAO attempts to account for such discrepancies through revisions and collaborations with national offices in its 2018 report (FAO, 2018). *The State of World Fisheries and Aquaculture* continues to provide comprehensive information about trends and changes in the global fisheries industry. The biennial assessment relies on FAO's fishery and aquaculture statistics, which are informed primarily by national reports (FAO, 2018).

The 2020 EPI Fisheries indicators and ranking rely on data from *Sea Around Us*, a research initiative at the University of British Columbia, which fills in gaps and harmonizes much of FAO's global statistics. In particular, *Sea Around Us* reconstructs missing and historical data through a process that identifies missing data, sources additional information from literature reviews and expert consultation, and interpolates data values (Zeller & Pauly, 2016).

3.1 INDICATOR BACKGROUND

3.1.1 FISH STOCK STATUS

Fish stock status evaluates the percentage of a country's total catch that comes from overexploited or collapsed stocks, considering all fish stocks within a country's EEZs. When a country has more than one EEZ, the EPI sums each EEZ catch into a single value. An overexploited fish stock describes a fish stock in which a landing, or catch, is 10–50% of the peak catch that has occurred in a prior year (Pauly et al., 2008). A collapsed fish stock describes a stock in which a landing falls below 10% of a peak catch the prior year (Kleisner & Pauly, 2015). Because continued and increased stock exploitation leads to smaller catches, this indicator sheds light on the impact of a country's fishing practices. If a country's annual catch does not consist of fish from collapsed or overexploited stocks, it will receive a higher score than a country that continues to harvest from threatened fish stocks.

3.1.2 MARINE TROPHIC INDEX

Marine Trophic Index (MTI) gives another layer of understanding to the general health of a country's fish stocks and shows the degree to which a country is "fishing down the food web." This occurs when a country's fishing activity depletes species at higher trophic levels – typically larger, predator species such as tuna – and catches begin to harvest smaller species at lower trophic levels (Pauly et al., 2008). The geographic expansion of fishing activities and development of offshore fisheries can mask the "fishing down" effect, prompting *Sea Around Us* to introduce the Regional MTI (Kleisner et al., 2014). The indicator used in the 2020 EPI considers the slope of change in MTI; that is, the rate of change from the highest MTI to the current MTI value. This change shows how rapidly fisheries are moving down the food web.

3.1.3 FISH CAUGHT BY TRAWLING

Certain fishing practices have greater environmental impact than others. Trawling contributes to around 30–40% of global fish catch even as it severely degrades marine ecosystems. Bottom and pelagic trawling methods are indiscriminate and wasteful, as the large nets capture nearly any marine species in their path. Trawling generates high discard rates and damages seabed and habitat-forming coral and other species (Victorero et al., 2018). Informed by *Sea Around Us* data, scoring for this indicator is based on the percentage of fish caught by bottom and pelagic trawling.

3.2 DATA

Scoring for these three fisheries indicators rely on data from *Sea Around Us*, a research initiative of the University of British Columbia. *Sea Around Us* builds on FAO data for the years 1950–2014 through a seven-step reconstruction process (Zeller & Pauly, 2016). This reconstruction process includes

1. collecting FAO and national data;
2. identifying missing information;
3. seeking alternative sources of information, such as national or agency fishing reports;
4. creating and expanding anchor points for missing data;
5. interpolating data for commercial and noncommercial fisheries;
6. combining reported and missing data; and
7. quantifying uncertainties.

Sea Around Us makes its data freely available on its website, www.seaaroundus.org.

3.3. LIMITATIONS

Indicators such as *fish stock status* begin to tell a story about a country's fisheries, but continued improvements in data collection and new metrics can help create a fuller picture. Current information, based on reconstructed FAO data, comes from diverse sources. While reconstruction efforts from *Sea Around Us* seek to fill in gaps, estimates may not provide the same accuracy as reliable fishing logs. Reconstruction itself is a labor-intensive and time-consuming effort, introducing substantial lags in timely reporting. Indeed, estimates used in the 2020 EPI from *Sea Around Us* are only available through 2014 – a clear sign that the world needs to modernize the data systems surrounding fishing activities, creating truly twenty-first-century tools that will enable better management. Countries that have made very recent and significant changes in fisheries policy will not be able to see the outcomes of these changes in the 2020 EPI, and our indicators reflect the legacy of fishery mismanagement.

Fisheries around the world face many threats, and our indicators do not cover all of them. Other harmful fishing practices, such as poison or dynamite fishing, may not be fully captured (Reef Resilience Network, 2020). Indicators on fish catches cannot represent detailed information on stock populations or the diversity of species in marine ecosystems. With the rise of aquaculture and its impacts on fishing of wild species, new questions arise about how this activity can be assessed from an environmental health angle – and how aquaculture will play into future rankings. Additionally, the continued challenge of illegal and unreported fishing will continue to create some inconsistencies in information.

The questions concerning production and consumption-based accounting and the presence of foreign vessels in a country's EEZ introduce complexities into data collection. Countries, such as the United States, may rely heavily on imported seafood, including both fish that have been caught by domestic fishing vessels and then exported for processing and fish that have been caught by foreign vessels (FishWatch, n.d.).

The EPI looks forward to continued progress in data collection and global metrics to carefully weigh the burden of impact for different countries and rigorously assess each country's fisheries activities.

TABLE 10-3. Clarification of the Fisheries metrics

WHAT THE METRICS ARE	WHAT THE METRICS AREN'T
Within a country's Economic Exclusion Zone: • **Percentage of a country's fish catch that comes from stocks that are overexploited or collapsed** • **Slope of a country's Regional Marine Trophic Index between its peak and current values** • **Percentage of a country's fish catch that was caught using bottom or pelagic trawling**	• **A measure of fish populations** • **A measure of species diversity** • **Adjusted for country of final consumption, or for the flags of fishing vessels** • **A measure of fishing on the high seas** • **A measure of the sustainability of aquaculture practices**

Chapter 11. Climate Change

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Global climate change imperils human health and safety, as well as the natural ecosystems and resources on which all people depend. Climate change is driven by the emissions of greenhouse gases from fossil fuel combustion, land use change, and other sources. Greenhouse gases (GHGs) trap heat in the atmosphere, increasing global temperatures and causing critical global shifts such as melting ice, rising sea levels, and more frequent extreme weather events. Climate change exacerbates all other environmental threats described in this report and, if left unchecked, could threaten the ability of human society to continue to exist as we know it. Current efforts to reduce GHG emissions are insufficient for what is needed to attain global emission reduction commitments, with average global temperatures on a trajectory to increase 3°C above pre-industrial levels by the end of the 21st century (Rogelj et al., 2016). Results in the EPI can help identify which countries are on track to decarbonize and which countries must accelerate progress toward a sustainable future

1.2 INDICATORS

1.2.1 Adjusted emission growth rates for four greenhouse gases and one other pollutant linked to climate change

Five *adjusted emission growth rate* indicators track trends in countries' emissions of four greenhouse gases and one other pollutant linked to climate change. Together these critical five factors account for 90% of the weight the climate change category:

- carbon dioxide (CO_2) [55% of issue category],
- methane (CH_4) [15% of issue category],
- fluorinated gases (F-gases) [10% of issue category],
- nitrous oxide (N_2O) [5% of issue category], and
- black carbon [5% of issue category].

We calculate the average annual rate of increase or decrease in emissions based on ten years of data, 2008–2017, and then adjust these rates for economic trends in an attempt to isolate the change related to policy rather than simply capturing the effect of economic ups and downs.

1.2.2 Growth rate in carbon dioxide (CO_2) emissions from land cover

[2.5% of issue category]

This indicator measures average annual rates of increase or decrease in CO_2 emissions from land cover change over the years 2001–2015.

1.2.3 Greenhouse gas (GHG) intensity growth rate [5% of issue category]

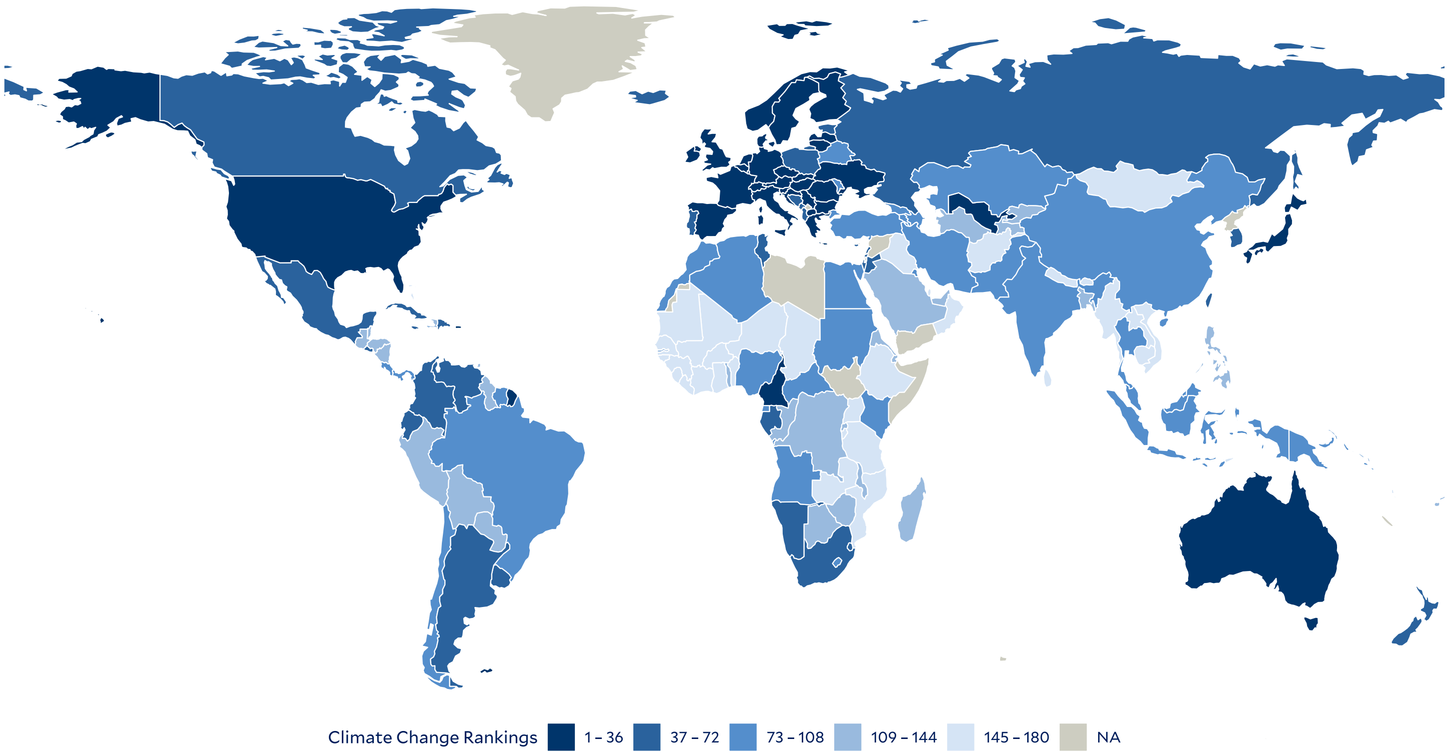
Greenhouse gas emission intensity is the ratio of tonnes of gas emitted [CO_2-equivalent] per unit of GDP. We measure average annual growth rates in GHG intensity over a ten-year period, 2008–2017.

1.2.4 Greenhouse gas emissions per capita [2.5% of issue category]

This indicator measures average greenhouse gas emissions per person in each country in the year 2017.

11.

MAP 11-1. Rankings on Climate Change.



11.

TABLE 11-1. Global rankings, scores, and regional rankings (REG) on Climate Change.

RANK	COUNTRY	SCORE	REG
1	Denmark	95.0	1
2	United Kingdom	90.0	2
3	Romania	84.6	1
4	France	81.9	3
5	Switzerland	81.6	4
6	Norway	78.9	5
7	Luxembourg	77.5	6
8	Sweden	77.2	7
9	Finland	77.0	8
10	Czech Republic	76.3	2
11	North Macedonia	75.2	3
	Slovenia	75.2	3
13	Slovakia	71.9	5
14	Germany	71.5	9
15	United States of America	71.4	10
16	Austria	71.3	11
	Hungary	71.3	6
18	Spain	71.2	12
19	Seychelles	70.7	1
20	Australia	70.4	13
21	Belgium	70.2	14
	St. Vincent and Grenadines	70.2	1
23	Croatia	70.0	7
24	Bulgaria	69.5	8
	Japan	69.5	1
26	Ukraine	69.2	1
27	Italy	68.1	15
	Serbia	68.1	9
29	Latvia	67.7	10
30	Bahrain	67.1	1
31	Ireland	66.6	16
32	Greece	66.5	11
33	Cameroon	66.4	2
34	Lithuania	65.9	12
	Uzbekistan	65.9	2
36	Netherlands	65.8	17
37	Canada	65.7	18
	Jamaica	65.7	2
39	Montenegro	65.6	13
40	Poland	65.4	14
41	Mexico	65.2	3
42	Cuba	64.2	4
43	Gabon	63.8	3
44	Portugal	63.3	19
	Venezuela	63.3	5
46	Cyprus	63.1	15
	Taiwan	63.1	2
48	El Salvador	62.8	6
	South Africa	62.8	4
50	Malta	62.6	20
	South Korea	62.6	3
52	New Zealand	61.5	21
53	Iceland	60.8	22
54	Argentina	60.2	7
	Ecuador	60.2	7
	Tunisia	60.2	2
57	Russia	59.9	3
58	Barbados	59.1	9
59	Estonia	59.0	16
	Grenada	59.0	10
61	Antigua and Barbuda	58.5	11
62	Jordan	58.4	3
63	Bosnia and Herzegovina	57.5	17
64	Eswatini	56.9	5
	Israel	56.9	4
66	Albania	56.8	18
	Lebanon	56.8	5
68	Tonga	56.6	4
69	Dominican Republic	56.1	12
70	Uruguay	55.5	13
71	Colombia	55.4	14
	Namibia	55.4	6
73	Dominica	55.1	15
74	Egypt	55.0	6
	Iran	55.0	6
76	Costa Rica	54.8	16
	Saint Lucia	54.8	16
78	Indonesia	54.4	5
79	Chile	54.3	18
80	Belarus	53.1	4
81	Malaysia	52.8	6
	Sudan	52.8	8
	Suriname	52.8	19
84	Algeria	52.5	9
	Thailand	52.5	7
86	Lesotho	52.4	7
87	Moldova	52.2	5
88	Brazil	51.7	20
89	Mauritius	51.0	8
90	Brunei Darussalam	50.9	8
91	Nigeria	50.8	9
92	Pakistan	50.6	1
93	Panama	50.3	21
94	Georgia	50.1	6
95	Kuwait	49.7	10
96	Turkey	49.3	19
97	Angola	49.0	10
	Kenya	49.0	10
99	Morocco	48.7	11
100	Azerbaijan	48.6	7
101	Papua New Guinea	47.6	9
102	Armenia	46.7	8
103	China	46.3	10
104	Equatorial Guinea	46.1	12
105	Central African Republic	45.4	13
106	India	45.0	2
	Solomon Islands	45.0	11
108	Kazakhstan	44.6	9
109	Eritrea	43.4	14
110	Honduras	43.1	22
111	Philippines	42.8	12
112	Kyrgyzstan	42.5	10
113	Trinidad and Tobago	42.1	23
114	Comoros	41.7	15
115	Peru	41.3	24
116	Paraguay	40.9	25
117	Singapore	40.2	13
118	Dem. Rep. Congo	40.1	16
	Djibouti	40.1	16
120	Bolivia	40.0	26
121	Madagascar	39.9	18
122	Marshall Islands	39.6	14
123	Cabo Verde	39.5	19
124	Micronesia	39.0	15
125	United Arab Emirates	38.9	12
126	Guyana	38.2	27
127	Nicaragua	38.0	28
128	Botswana	37.9	20
129	Belize	37.7	29
130	Saudi Arabia	37.5	13
131	Republic of Congo	37.1	21
132	Haiti	37.0	30
	Zimbabwe	37.0	22
134	Fiji	36.9	16
	Tajikistan	36.9	11
136	Guatemala	36.7	31
137	Turkmenistan	36.4	12
138	Rwanda	35.9	23
139	Gambia	35.8	24
140	Bangladesh	35.6	3
141	Samoa	35.0	17
	São Tomé and Príncipe	35.0	25
143	Togo	34.4	26
144	Malawi	34.2	27
145	Guinea-Bissau	33.6	28
146	Mauritania	32.6	29
147	Kiribati	32.2	18
148	Oman	32.0	14
	Vanuatu	32.0	19
150	Burkina Faso	31.9	30
151	Iraq	31.6	15
152	Mozambique	31.1	31
153	Sri Lanka	31.0	4
154	Cambodia	30.9	20
155	Benin	30.7	32
	Laos	30.7	21
	Viet Nam	30.7	21
158	Senegal	30.3	33
159	Ghana	29.6	34
160	Bahamas	28.7	32
161	Maldives	27.7	5
162	Uganda	27.4	35
163	Guinea	26.8	36
164	Zambia	26.5	37
165	Mali	26.3	38
166	Ethiopia	26.1	39
167	Liberia	24.9	40
	Sierra Leone	24.9	40
169	Bhutan	24.7	6
170	Nepal	23.7	7
171	Timor-Leste	23.4	23
172	Afghanistan	22.2	8
	Myanmar	22.2	24
174	Côte d'Ivoire	20.2	42
175	Tanzania	18.7	43
176	Chad	17.4	44
177	Burundi	16.8	45
178	Mongolia	16.6	25
179	Niger	12.5	46
180	Qatar	12.1	16

- Asia-Pacific
- Eastern Europe
- Former Soviet States
- Global West
- Greater Middle East
- Latin America & Caribbean
- Southern Asia
- Sub-Saharan Africa

TABLE 11-2. Regional rankings, scores, and global rankings on Climate Change

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	St. Vincent and Grenadines	70.2	21
2	Jamaica	65.7	37
3	Mexico	65.2	41
4	Cuba	64.2	42
5	Venezuela	63.3	44
6	El Salvador	62.8	48
7	Argentina	60.2	54
	Ecuador	60.2	54
9	Barbados	59.1	58
10	Grenada	59.0	59
11	Antigua and Barbuda	58.5	61
12	Dominican Republic	56.1	69
13	Uruguay	55.5	70
14	Colombia	55.4	71
15	Dominica	55.1	73
16	Costa Rica	54.8	76
	Saint Lucia	54.8	76
18	Chile	54.3	79
19	Suriname	52.8	81
20	Brazil	51.7	88
21	Panama	50.3	93
22	Honduras	43.1	110
23	Trinidad and Tobago	42.1	113
24	Peru	41.3	115
25	Paraguay	40.9	116
26	Bolivia	40.0	120
27	Guyana	38.2	126
28	Nicaragua	38.0	127
29	Belize	37.7	129
30	Haiti	37.0	132
31	Guatemala	36.7	136
32	Bahamas	28.7	160

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Romania	84.6	3
2	Czech Republic	76.3	10
3	North Macedonia	75.2	11
	Slovenia	75.2	11
5	Slovakia	71.9	13
6	Hungary	71.3	16
7	Croatia	70.0	23
8	Bulgaria	69.5	24
9	Serbia	68.1	27
10	Latvia	67.7	29
11	Greece	66.5	32
12	Lithuania	65.9	34
13	Montenegro	65.6	39
14	Poland	65.4	40
15	Cyprus	63.1	46
16	Estonia	59.0	59
17	Bosnia and Herzegovina	57.5	63
18	Albania	56.8	66
19	Turkey	49.3	96

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Pakistan	50.6	92
2	India	45.0	106
3	Bangladesh	35.6	140
4	Sri Lanka	31.0	153
5	Maldives	27.7	161
6	Bhutan	24.7	169
7	Nepal	23.7	170
8	Afghanistan	22.2	172

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Denmark	95.0	1
2	United Kingdom	90.0	2
3	France	81.9	4
4	Switzerland	81.6	5
5	Norway	78.9	6
6	Luxembourg	77.5	7
7	Sweden	77.2	8
8	Finland	77.0	9
9	Germany	71.5	14
10	United States of America	71.4	15
11	Austria	71.3	16
12	Spain	71.2	18
13	Australia	70.4	20
14	Belgium	70.2	21
15	Italy	68.1	27
16	Ireland	66.6	31
17	Netherlands	65.8	36
18	Canada	65.7	37
19	Portugal	63.3	44
20	Malta	62.6	50
21	New Zealand	61.5	52
22	Iceland	60.8	53

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Ukraine	69.2	26
2	Uzbekistan	65.9	34
3	Russia	59.9	57
4	Belarus	53.1	80
5	Moldova	52.2	87
6	Georgia	50.1	94
7	Azerbaijan	48.6	100
8	Armenia	46.7	102
9	Kazakhstan	44.6	108
10	Kyrgyzstan	42.5	112
11	Tajikistan	36.9	134
12	Turkmenistan	36.4	137

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Japan	69.5	24
2	Taiwan	63.1	46
3	South Korea	62.6	50
4	Tonga	56.6	68
5	Indonesia	54.4	78
6	Malaysia	52.8	81
7	Thailand	52.5	84
8	Brunei Darussalam	50.9	90
9	Papua New Guinea	47.6	101
10	China	46.3	103
11	Solomon Islands	45.0	106
12	Philippines	42.8	111
13	Singapore	40.2	117
14	Marshall Islands	39.6	122
15	Micronesia	39.0	124
16	Fiji	36.9	134
17	Samoa	35.0	141
18	Kiribati	32.2	147
19	Vanuatu	32.0	148
20	Cambodia	30.9	154
21	Laos	30.7	155
	Viet Nam	30.7	155
23	Timor-Leste	23.4	171
24	Myanmar	22.2	172
25	Mongolia	16.6	178

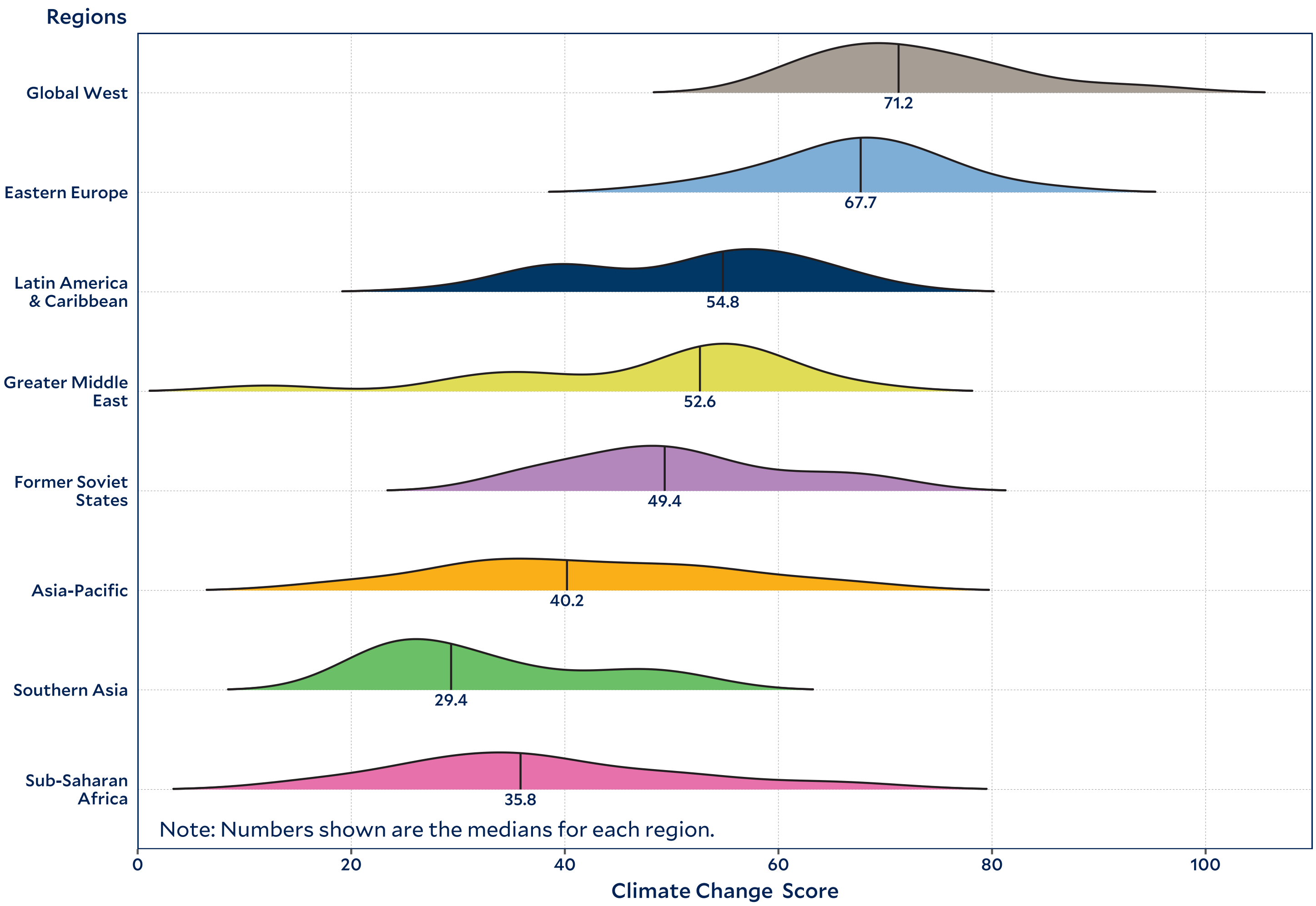
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Seychelles	70.7	19
2	Cameroon	66.4	33
3	Gabon	63.8	43
4	South Africa	62.8	48
5	Eswatini	56.9	64
6	Namibia	55.4	71
7	Lesotho	52.4	86
8	Mauritius	51.0	89
9	Nigeria	50.8	91
10	Angola	49.0	97
	Kenya	49.0	97
12	Equatorial Guinea	46.1	104
13	Central African Republic	45.4	105
14	Eritrea	43.4	109
15	Comoros	41.7	114
16	Dem. Rep. Congo	40.1	118
	Djibouti	40.1	118
18	Madagascar	39.9	121
19	Cabo Verde	39.5	123
20	Botswana	37.9	128
21	Republic of Congo	37.1	131
22	Zimbabwe	37.0	132
23	Rwanda	35.9	138
24	Gambia	35.8	139
25	São Tomé and Príncipe	35.0	141
26	Togo	34.4	143
27	Malawi	34.2	144
28	Guinea-Bissau	33.6	145
29	Mauritania	32.6	146
30	Burkina Faso	31.9	150
31	Mozambique	31.1	152
32	Benin	30.7	155
33	Senegal	30.3	158
34	Ghana	29.6	159
35	Uganda	27.4	162
36	Guinea	26.8	163
37	Zambia	26.5	164
38	Mali	26.3	165
39	Ethiopia	26.1	166
40	Liberia	24.9	167
	Sierra Leone	24.9	167
42	Côte d'Ivoire	20.2	174
43	Tanzania	18.7	175
44	Chad	17.4	176
45	Burundi	16.8	177
46	Niger	12.5	179

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Bahrain	67.1	30
2	Tunisia	60.2	54
3	Jordan	58.4	62
4	Israel	56.9	64
5	Lebanon	56.8	66
6	Egypt	55.0	74
	Iran	55.0	74
8	Sudan	52.8	81
9	Algeria	52.5	84
10	Kuwait	49.7	95
11	Morocco	48.7	99
12	United Arab Emirates	38.9	125
13	Saudi Arabia	37.5	130
14	Oman	32.0	148
15	Iraq	31.6	151
16	Qatar	12.1	180

FIGURE 11-1. Regional performance on Climate Change.



2. RESULTS

2.1 GLOBAL TRENDS

Climate change mitigation is uneven across the world, and the collective effort is insufficient to meet global targets. The IPCC estimates that the planet has already experienced approximately 1.0°C of warming above pre-industrial levels as a result of human activity (Masson-Delmotte et al., 2018). The year 2019 was the second hottest year on record, behind only 2016, which was exceptionally high in part due to El Niño conditions (WMO, 2020). Massive wildfires in Australia in 2019 and early 2020 and destructive hurricane seasons in 2017 and 2018 offer examples of phenomena that may become more common in a warming world. Though nearly all countries committed under the 2015 Paris Climate Change Agreement to limiting global warming to well below 2°C – and to strive for no more than 1.5°C – mitigation actions to date remain inadequate. Even if all countries meet their stated Nationally Determined Contributions (NDCs) under the Paris Agreement, average global temperature increases will likely reach 3°C by 2100 (Rogelj et al., 2016). Calls for countries to raise their climate change ambitions at the September 2019 UN Climate Action Summit and the 25th Conference of the Parties of the UNFCCC in Madrid were inconclusive, with major players like the United States, Brazil, Australia, and Saudi Arabia prolonging negotiations and hindering progress (Green & Spring, 2019; Mountford et al., 2019). Emissions of CO_2 and other, more powerful greenhouse gases such as methane continue to increase across the majority of countries, as shown in Figure 11-2. While some countries are reducing emissions, their mitigation efforts are outweighed by the growing emissions among the world's largest emitters.

11.

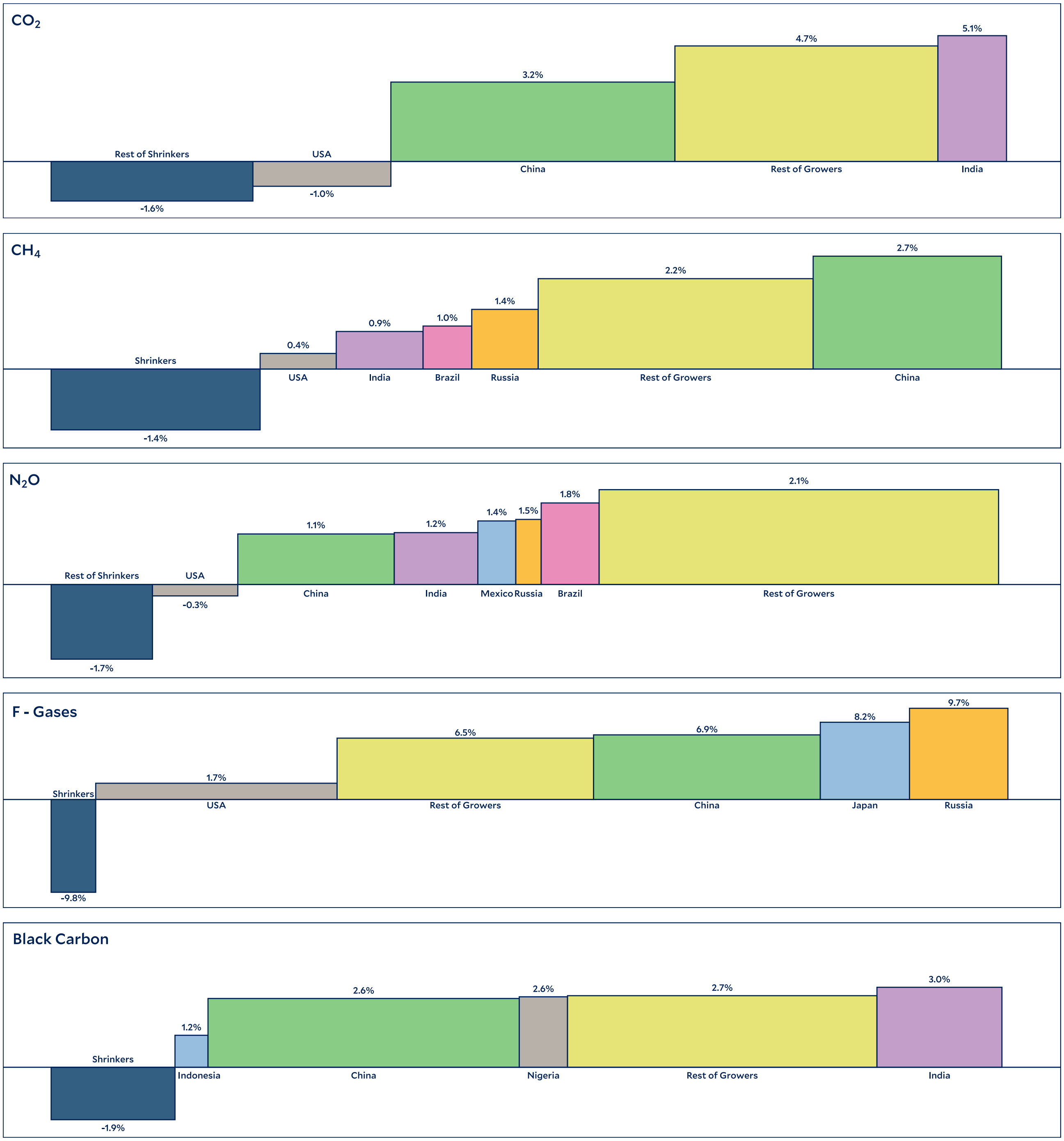


FIGURE 11-2. International comparisons of emissions and average annual growth rates for four greenhouse gases and one climate pollutant. The width of the columns is proportional to the share of global emissions in the most recent year of data, and the height of the bar shows the average annual growth rate in emissions over the past decade.

Sources: Greenhouse gas emissions from PIK, Black carbon emissions from CEDS.

Climate change policy can also be shaped by how GHG emissions are measured because, as we show in Figure 11-3, different standardizations tell different stories. GHG intensity, measured by tonnes of CO_2-eq. per unit of GDP, appears to tell a positive story, declining 30% from 1997 to 2017 as the world slowly decouples emissions from economic activity. Climate change, however, is driven not by intensity, but by the concentrations of GHGs accumulated over decades in the atmosphere. The primary driver of those concentrations is raw emissions, which have increased over the past two decades. GHG efficiency, measured by tonnes of CO_2-eq. per unit of total final consumption of energy, has remained flat, showing no overall increase in how cleanly the world meets its needs for energy services. GHG emissions have also outstripped population growth over the past 20 years.

In examining trends on GHG emissions, perhaps the only positive signal is a slight decrease in the rate of emission growth after 2012. The rate of increase of average GHG emissions per capita has also declined since 2012, despite rising consumption in some of the world's most populous countries.

While GHG emission intensity is falling globally over time, emissions at the national level are still highly correlated with GDP, as shown in Figure 11-4.

FIGURE 11-3. Percent changes in global greenhouse gas emissions under different standardizations, 1997–2017.
Sources: GHG emissions from Potsdam Institute for Climate, population and GDP from the World Bank Databank, and total final consumption from the International Energy Agency.

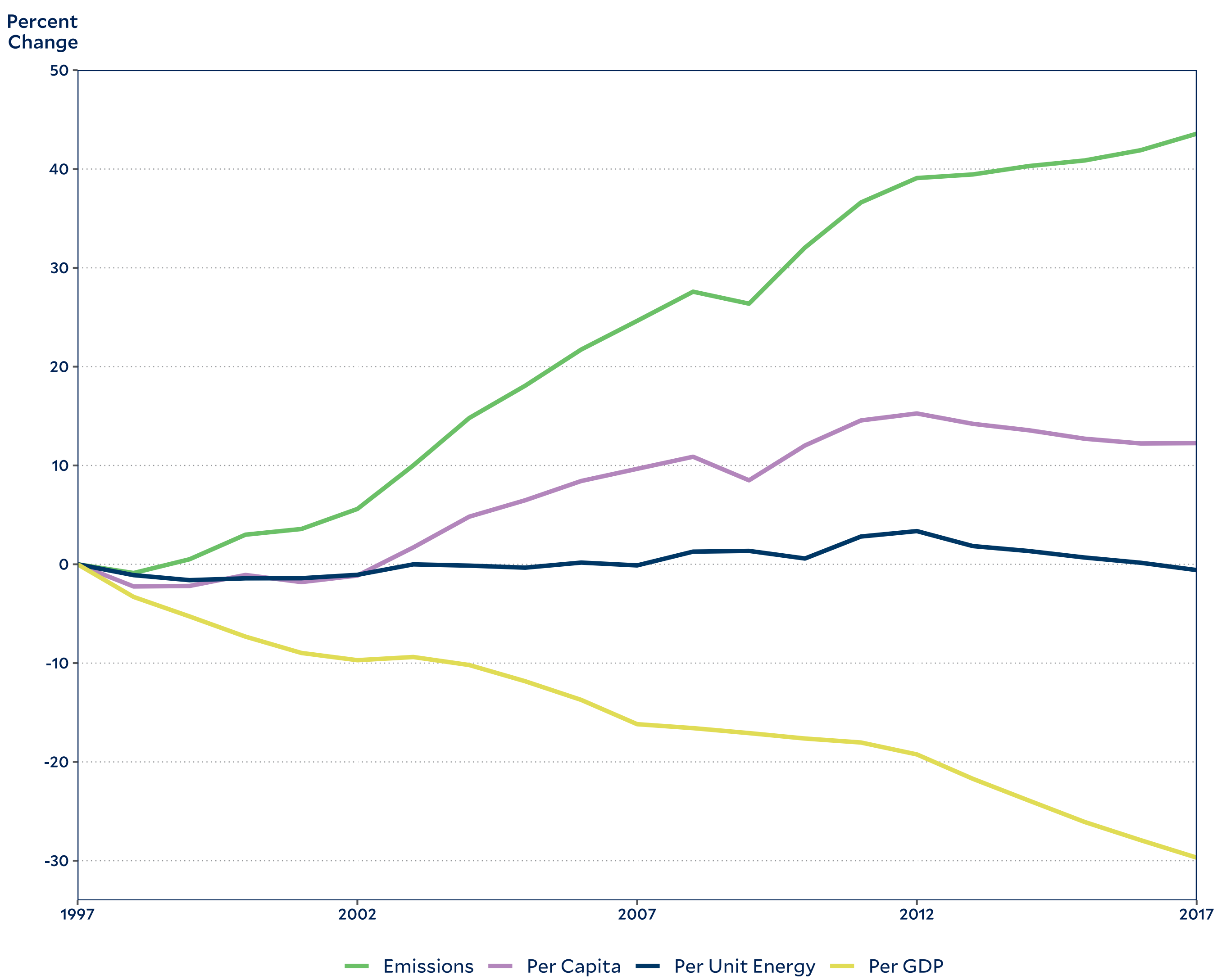
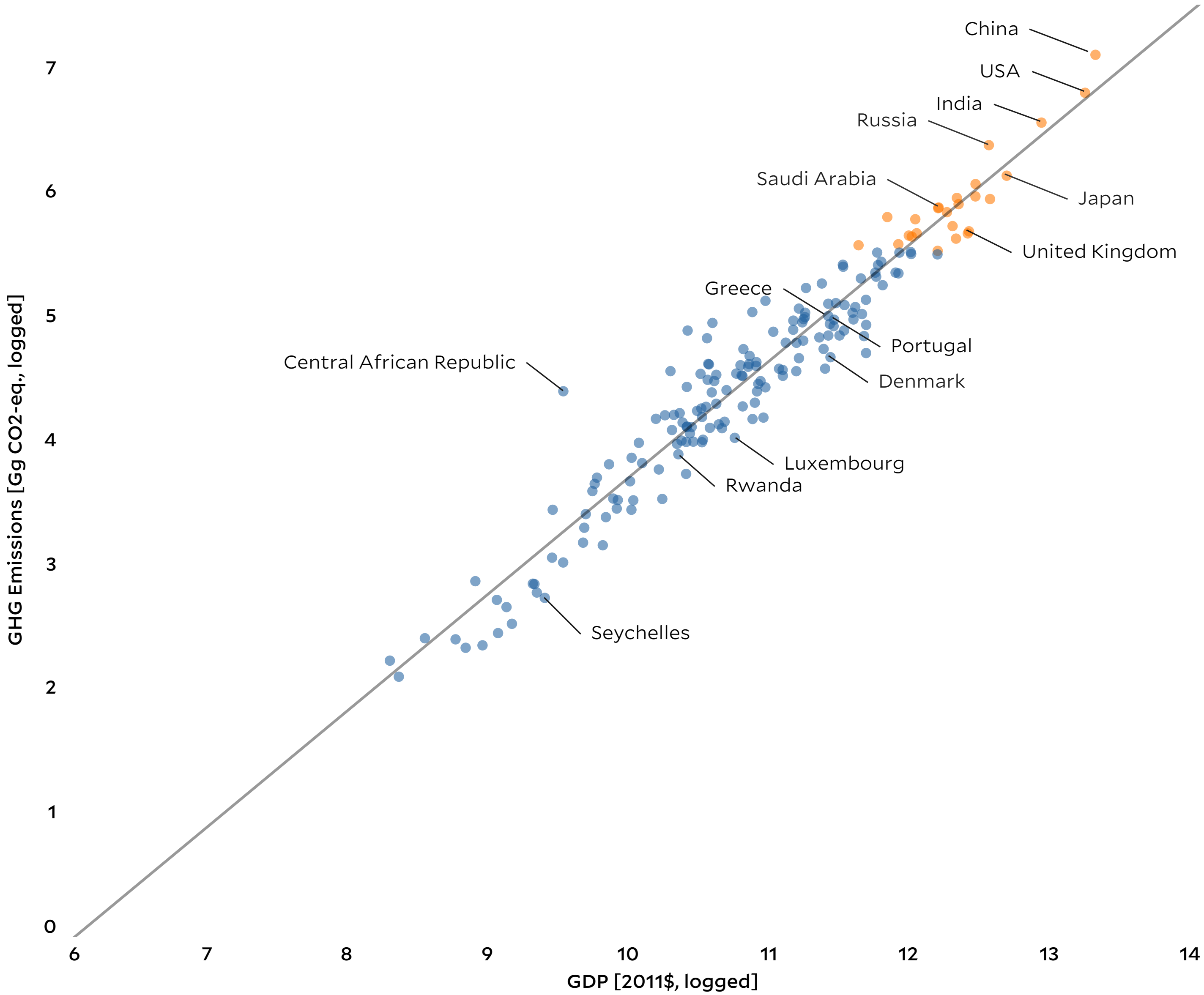
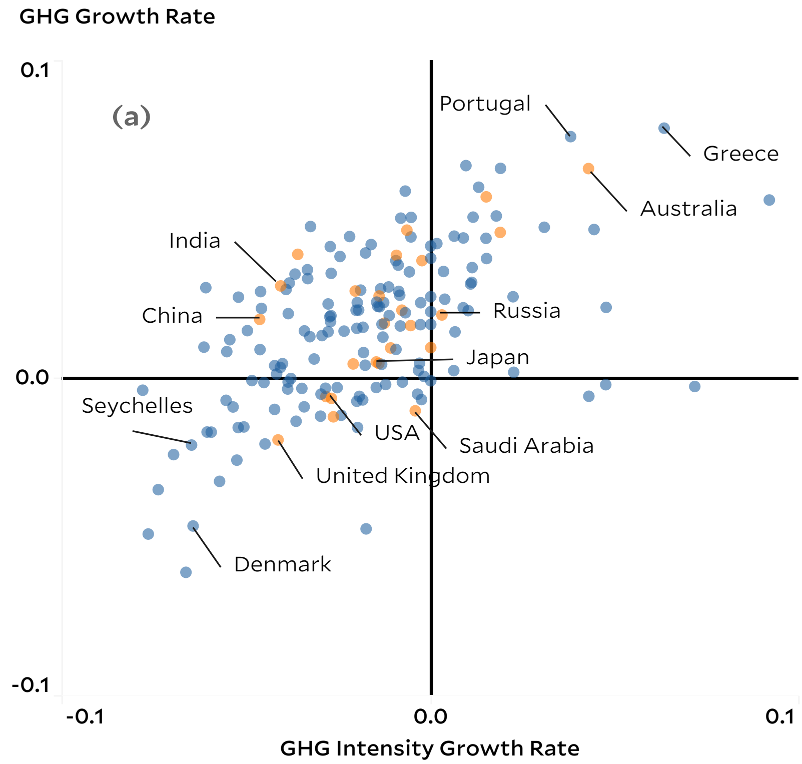


FIGURE 11-4. Relationship between countries' greenhouse gas emissions and GDP, 2017. The 25 largest emitters are highlighted in orange. *Sources: Greenhouse gas emissions from PIK, GDP from World Bank Databank and IMF.*

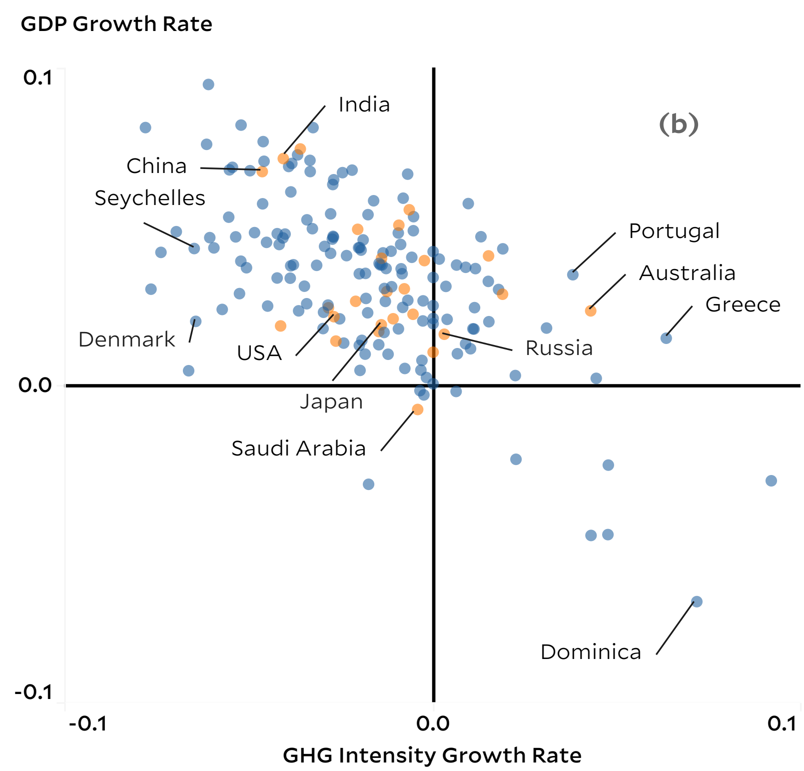


Decoupling emissions from economic growth serves as an important first step toward achieving a low-carbon society, especially for developing countries whose emissions may still increase as they work to meet other Sustainable Development Goals, including SDG 1 (No Poverty), 2 (Zero Hunger), 3 (Good Health & Well-Being), and 8 (Decent Work & Economic Growth). Figure 11-5 shows that the majority of countries exhibit negative GHG emission intensity growth rates, meaning that they may be decoupling. We would emphasize, however, the distinction between those countries that reduce GHG emission intensity while decreasing emissions in absolute terms and those that reduce intensity simply because economic growth outstrips growth in emissions. Again, achieving climate change targets depends on the success of the former rather than of the latter. To arrest global warming at 1.5°C, the world will need to reduce global GHG emissions to net zero by mid-century (Masson-Delmotte et al., 2018), requiring an absolute decline in total emissions as well as emission intensity.

FIGURE 11-5. Greenhouse gas emission intensity growth rates compared with (a) absolute GHG growth rate and (b) GDP growth rate. Calculations based on GHG emissions and GDP over the period 2008–2017.
Sources: Greenhouse gas emissions from PIK, GDP from World Bank Databank and IMF.

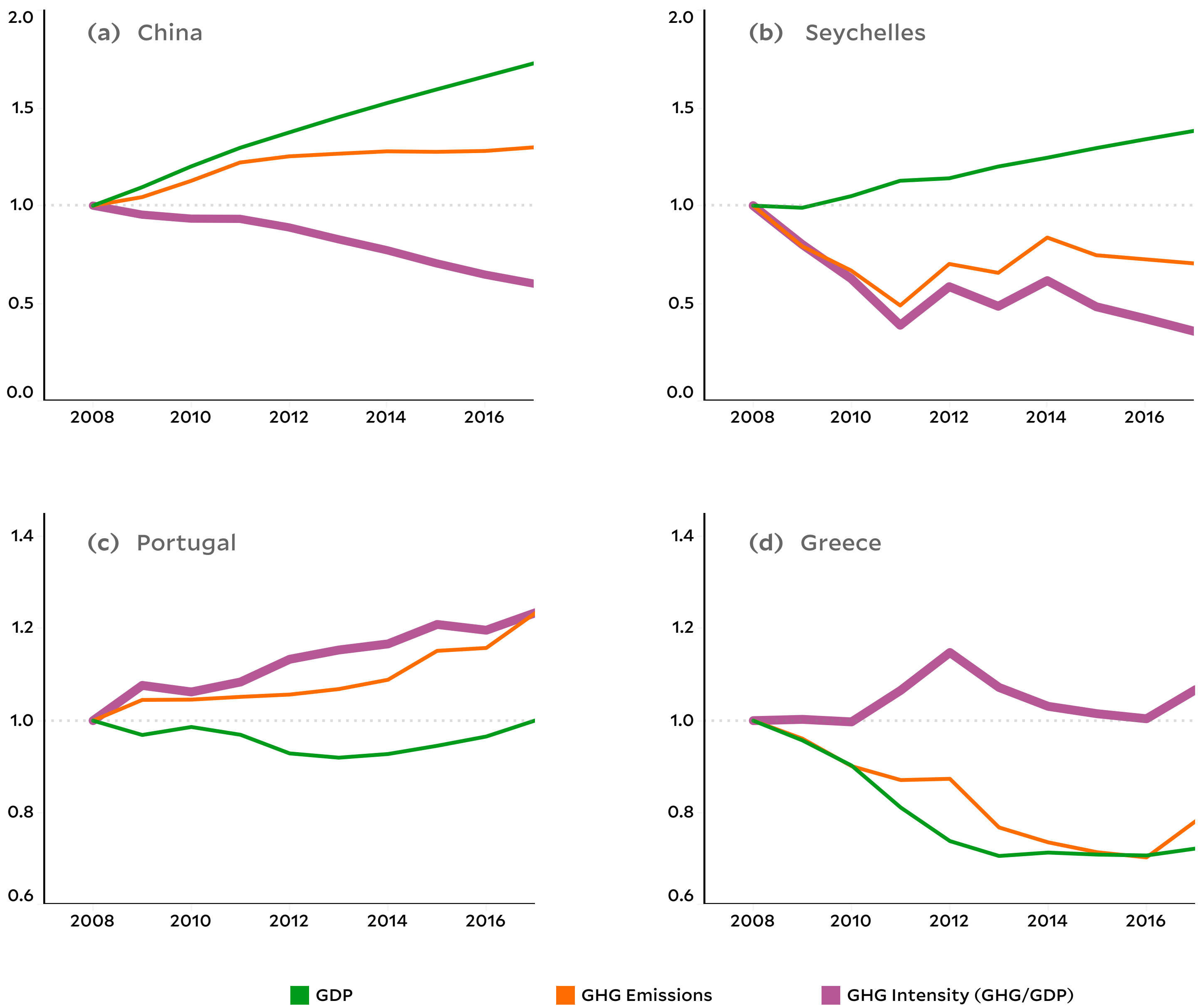


Note: The 25 largest GHG emitters are colored in orange.



We illustrate this effect in Figure 11-6 with four countries. Many countries follow a path exhibited by China in panel (a), where GHG emission intensity steadily declines, despite growing GHG emissions, due to robust economic growth. By contrast, Seychelles, shown in panel (b), has achieved impressive decoupling along with actual declines in GHG emissions – a model of growth for other countries. Portugal and Greece, in panels (c) and (d), show the dangers of economic stagnation or collapse for emission intensity.

FIGURE 11-6. Four representative countries showing trends in GDP, GHG emissions, and GHG emission intensity, 2008–2017, indexed to the first year of the period.
Sources: Greenhouse gas emissions from PIK, GDP from World Bank Databank and IMF.



Recent months have brought a spate of announcements signaling future action on climate change. Seventy-seven countries, ten regions, and over 100 cities committed in September 2019 to reach net zero emissions by 2050 (Kosolapova, 2019). In December, the EU unveiled its $110 billion European Green Deal, which mobilizes climate change action across all sectors of the economy, targets vulnerable countries and regions through a "Just Transition Mechanism," and aims for 50%–55% emissions reductions by 2030 and net zero emissions by 2050 (European Commission, 2019b; Simon, 2019). Meanwhile, a burgeoning youth climate change movement continues to pressure policymakers, promising to hold them accountable for the impact of their decisions on future generations. Lessons on the importance of global coördination and scientific leadership that are beginning to emerge from the COVID-19 crisis may offer opportunities and pathways to a low-carbon future post-pandemic, as discussed in Focus 11-1.

2.2 LEADERS & LAGGARDS

Denmark leads the world on climate change action, having reduced its CO_2 emissions by more than half since peaking in 1996 (World Bank, 2019). Denmark's capital city of Copenhagen has slashed emissions through investment in wind energy and biomass, adoption of district heating and cooling systems, and expansion of bike lanes to the point that there are now more bicycles on the streets than cars (Cathcart-Keays, 2016; L. Taylor, 2018). The city aims to become the first carbon-neutral capital by 2025. Denmark sourced 47% of its electricity from wind power in 2019 (Gronholt-Pedersen, 2020), and recently announced a plan to at least triple its offshore wind capacity by 2030 through the construction of two 2GW "energy islands" (Hook, 2020). The project could eventually expand to 12GW, exporting excess energy to neighboring countries. The "islands" represent a central part of the country's plan to implement a groundbreaking new climate law which aims for 70% emission reductions by 2030 and net zero by 2050. The legislation requires the government to set binding emission targets for each sector of the economy every five years, and could serve as a model pathway for other developed nations (de Bellefonds, 2020).

The United Kingdom stands out as another top performer, passing "net zero by 2050" legislation in June 2019 (UK Department for Business, Energy, & Industrial Strategy, 2019). The country achieved emission reductions of over 40% since 1990, driven in part by a country-wide transition away from coal and toward natural gas and renewables (Harrabin, 2019). Coal-powered generation declined to less than 3% of the country's electricity supply in 2019, and is set for a complete phase-out by October 2024 (UK Department for Business, Energy, & Industrial Strategy, 2020). This transformation was enabled in part by the introduction of a Carbon Price Floor policy in 2013, which added a tariff of £18 per tonne CO_2 to supplement the price of carbon set by the EU Emission Trading System. The policy raised the price of emissions, allowing low-carbon technologies to quickly drive coal out of the market (Hirst & Keep, 2018; Thomas et al., 2019). Declining coal extraction, along with improved landfill gas collection and a 23% reduction in food waste, allowed the United Kingdom to also reduce methane emissions by 61% between 1990 and 2017 (Flanagan et al., 2019; UK Department for Environment, Food, and Rural Affairs, 2020).

Countries across Europe demonstrate high performance in this issue category, with Western European countries receiving eight of the top ten scores. Many Eastern European countries also exhibit strong climate change performance, in part due to the prominence of nuclear energy and hydropower. They also show improvements in energy efficiency stemming from economic restructuring, as well as some targeted measures. Romania, which receives the third highest score in the Climate Change issue category, sources 38% of its electricity from renewables, including a large hydro sector and increasing investment in wind power. Romania's Fântânele-Cogealac represents the largest onshore wind farm in Europe. Though many countries in Eastern Europe remain heavily reliant on the coal industry, Slovakia and Hungary have already committed to phasing out this carbon-intensive fossil fuel by 2023 and 2030, respectively. Other countries in the region would benefit from just transition policies including job training and financial assistance for displaced coal workers (Heilmann et al., 2020).

The Republic of Seychelles maintains its status as a global climate change leader. Seychelles' "Blue Economy" policy framework has placed sustainability and climate change at the center of the country's development strategy (IMF, 2017). In its NDC under the Paris Agreement, Seychelles has committed to remain a net carbon sink through 2030 even as it continues to develop its economy, by reducing its emissions by 21.4% and 29.0% from baseline by 2025 and 2030, respectively (Republic of Seychelles, 2015). Seychelles' commitment to renewable and efficient energy use and to climate change adaptation through marine protection and a sustainable ocean economy make it a model for small island states and for developing nations around the world (IMF, 2017; Roberts & Ali, 2016).

Qatar, the largest per capita emitter of greenhouse gases, receives the lowest score in this issue category. Qatar is one of the fastest-warming areas in the world, with its annual average temperature increasing at twice the global rate. As a result of climate change and the urban heat island effect, summer temperatures have become ever more extreme, to the point that the country must deploy outdoor air conditioning to protect people from dangerous heat stress. About 60% of Qatar's electricity is used for cooling, which then produces even more greenhouse gas emissions (Mufson, 2019). Despite its wealth and climate change vulnerability, Qatar's NDC under the Paris Agreement contains no concrete emission reduction targets, and even expresses the intention to continue extracting oil and gas (Qatar Ministry of Environment, 2015). The country plans to expand liquid natural gas (LNG) production by 43% by 2024, a step in the wrong direction for the global climate and for Qatar's citizens (Mufson, 2019).

Sub-Saharan Africa and Southern Asia exhibit the lowest average regional performance, with countries from these regions receiving 16 of the bottom 20 scores. Rapid population growth, urbanization, and economic development contribute to rising emission levels in these countries. Agriculture, forestry, and land use change account for a large proportion of emissions in Sub-Saharan Africa. For instance, Niger receives the lowest score on the *growth rate in CO_2 emissions from land cover* indicator after losing 55% of its forest cover between 2001 and 2012 (Global Forest Watch, 2020c). Sustainable land management and regenerative agricultural practices offer a pathway for countries in this region to sequester carbon while boosting climate change adaptation and resilience and generating economic opportunities (Shukla et al., 2019).

3. METHODS

3.1 ADJUSTED EMISSION GROWTH RATE

Our *adjusted emission growth rate* indicators evaluate countries' progress in achieving actual emission reductions for four major greenhouse gases and one climate pollutant. The IPCC estimates that in order to limit warming to 1.5°C, the world must limit cumulative net greenhouse gas emissions after 2017 to 420–570 Gt CO_2-eq. Global emissions must reach net zero by approximately 2050 (Masson-Delmotte et al., 2018). Our *adjusted emission growth rate* indicators reflect the fact that in order to stay within this carbon budget and meet the Paris goals, global emissions should be in absolute decline as soon as possible.

While carbon dioxide accounts for approximately 78% of GHG-driven warming (Edenhofer et al., 2014) and remains the primary focus of global efforts to combat climate change, deep reductions in non-CO_2 GHGs are also necessary to meet the goals of the Paris Agreement. Table 11-3 shows that methane, fluorinated gases, nitrous oxide, and black carbon are all much more effective at trapping heat than CO_2. Some of these gases also directly harm human health and ecosystems as dangerous pollutants. Nitrous oxide depletes atmospheric ozone, exposing people, crops, and ecosystems to harmful ultraviolet radiation (Ravishankara et al., 2009). Black carbon is not a greenhouse gas but a particulate component of soot which warms the atmosphere by intercepting and absorbing sunlight in the air and as it settles on snow and ice. This effect has already exacerbated melting in the Arctic and the Himalayas (UNEP & WMO, 2011). Reducing emissions of these non-CO_2 pollutants is crucial to slowing the pace of climate change in the short term and to allowing the world to remain within its carbon budget.

TABLE 11-3. Characteristics of major non-CO2 greenhouse gases.
Note: Global Warming Potential (GWP) is defined as the ratio of the amount of energy one tonne of a gas will absorb relative to the energy one tonne of CO_2 will absorb over a given period of time (U.S. EPA, 2016). The data use GWPs from IPCC AR_4 given a 100-year time horizon.
Sources: UNEP and WMO, 2011; U.S. EPA, 2016.

GREENHOUSE GAS	GLOBAL WARMING POTENTIAL	ATMOSPHERIC LIFETIME	MAJOR SOURCES
Methane (CH_4)	25	12 years	Fossil fuel extraction and combustion, animal agriculture, rice cultivation, waste and wastewater management, melting permafrost
Nitrous oxide (N_2O)	298	114 years	Agriculture, industrial processes, wastewater treatment, fossil fuel combustion
Fluorinated gases (F-gases)	12,200–22,800	270–50,000 years	Industrial processes, use as substitutes for ozone-depleting substances in refrigerants, aerosols, and foam blowing agents
Black carbon	100–2,000	Days to weeks	Solid fuel combustion, forest fires, diesel engines, industrial processes

3.1.1 INDICATOR BACKGROUND

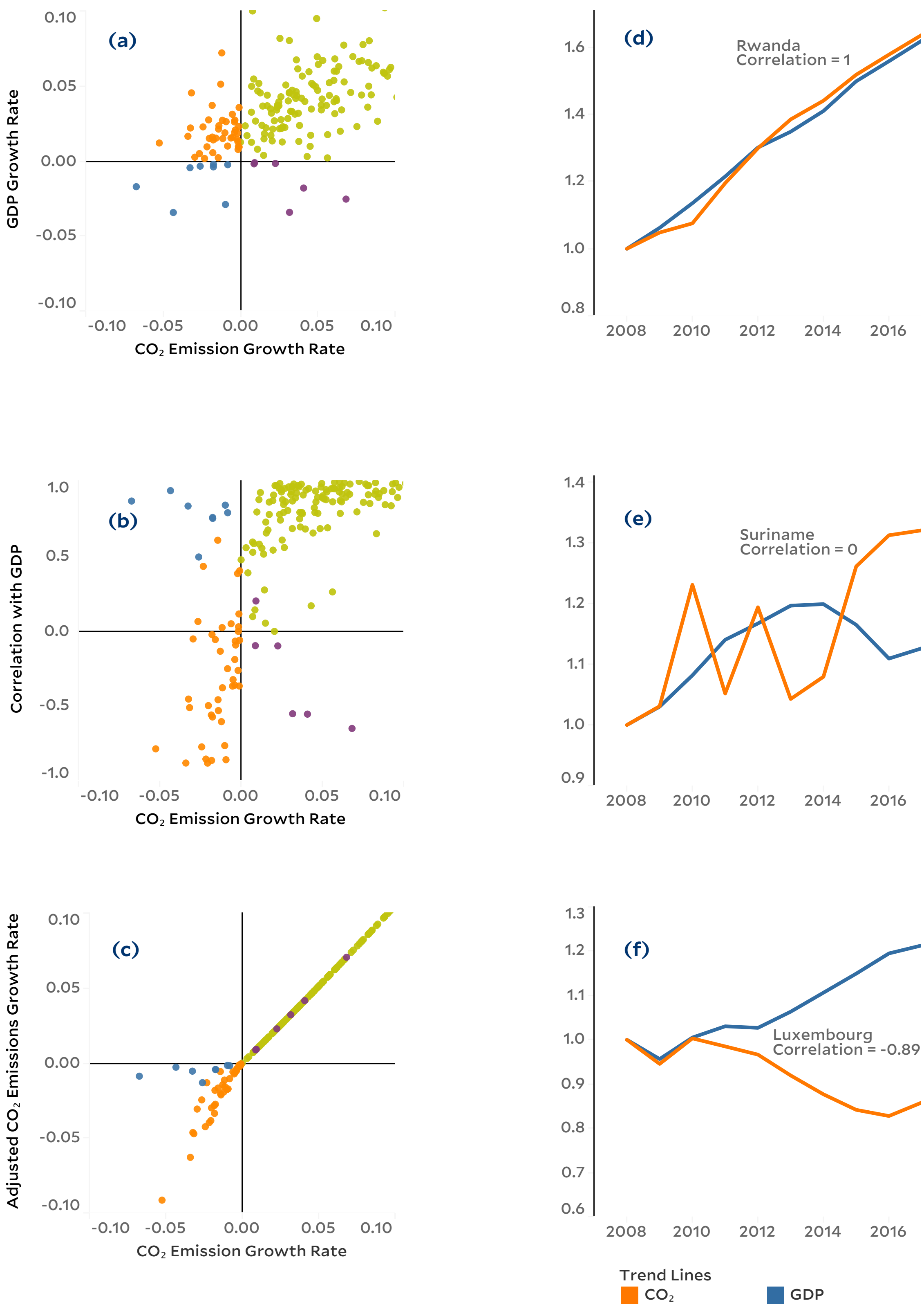
We calculate the *adjusted emission growth rate* for each greenhouse gas as the average annual rate of increase or decrease in raw emissions based on ten years of data. We then adjust these values in order to differentiate between countries whose emissions are decreasing as a result of economic decline and countries that are achieving reductions despite economic growth. Figure 11-7 illustrates the logic of this adjustment for CO_2.

CO_2 emission growth rates over the past decade have been positive for most countries, though for around 50 countries, emissions are declining. Countries with negative emission growth rates can be split between those whose economies are declining, shown as blue dots in panel (a) of Figure 11-7, and those whose economies are growing, shown in orange. Declining emissions may be due to either policy efforts or economic recession, among other factors, and to estimate which major cause explains negative growth rates, we calculate the correlation between ten years of annual CO_2 emissions and GDP. Three countries in panels (d)–(f) illustrate different levels of correlations between these two variables. Rwanda (d) typifies an industrializing country whose emissions increase with GDP. Suriname (e) emitted CO_2 without respect to economic activity. Luxembourg (f) decoupled emissions from GDP after 2010, after which emissions decreased even as GDP continued to rise. In panel (b), we show that most countries with both negative emission growth rates and negative economic growth rates, in blue, had high correlations between these variables, strongly suggestive that policy effort played a small role. Countries that had negative emission growth rates despite economic growth, shown in orange, have a much broader range of correlations. To distinguish between policy effort and economic recession, we adjust the growth rates for countries with declining emissions according to the following formula,

$$\textit{Adjusted growth rate} = \textit{Raw growth rate} \times (1 - r),$$

where r is Spearman's correlation coefficient. Countries where r is close to 1 will have their negative growth rate adjusted toward zero, and countries where r is close to −1 will have their negative growth rates adjusted to be even more negative. The difference between raw and adjusted emission growth rates is shown in panel (c). We intend this adjustment to reward countries that are successfully decoupling emission growth rates from economic performance while we give less credit to countries that have only achieved negative emission growth rates through economic collapse – a means of decarbonization we cannot endorse.

FIGURE 11-7. Adjusting declining CO_2 emission growth rates based on correlation with economic growth rates, 2008–2017. CO_2 emissions and GDP are indexed to 2008 = 1 in panels (d)–(f).
Sources: CO_2 emissions from PIK, GDP from World Bank Databank and IMF.



3.1.2 DATA

Emission data for the *adjusted emission growth rate* indicators come from the Potsdam Institute for Climate Impact Research (PIK) and the Community Emissions Data System (CEDS). Data for CO_2, CH_4, N_2O, and F-gases cover the years 2008–2017, while data for black carbon cover the years 2005–2014.

We source emission data for CO_2, CH_4, N_2O, and F-gases from PIK's "Potsdam Realtime Integrated Model for probabilistic Assessment of emission Paths" (PRIMAP-hist) dataset, which synthesizes multiple published datasets for every country and Kyoto greenhouse gas over the period 1850–2017. Gütschow et al. (2016) outline the methodology for the PRIMAP-hist dataset, which is publicly available at http://dataservices.gfz-potsdam.de/pik/showshort.php?id=escidoc:4736895.

CEDS is a collaborative research effort of the Joint Global Change Research Institute and Pacific Northwest National Laboratory, funded by the U.S. Department of Energy Office of Science. Our *adjusted emission growth rate* indicator for black carbon is based on CEDS data covering the years 2005–2014. Historical emission estimates are produced by matching default estimates to reliable, existing emission inventories and extending those values over historical years based on emission factors and driver data. This method captures trends in fuel use, technology, and emission controls over time, and it provides a sectoral and gridded historical inventory of emissions across the globe (Hoesly et al., 2018). Combustion emission data related to the energy sector are based on energy balance statistics from the International Energy Agency. Non-combustion emission data are drawn from EDGAR, a collaborative research effort of the European Commission Joint Research Centre and the Netherlands Environmental Assessment Agency. The full CEDS dataset is publicly available for download from the CEDS public GitHub repository: https://github.com/JGCRI/CEDS/.

3.1.3 LIMITATIONS

Many of our underlying data are subject to the limitations of existing GHG inventories. These inventories estimate emissions by multiplying "activity" data – e.g., the amount of a certain type of fuel consumed using a given technology – by a corresponding emission factor, or the amount of GHG released per unit of activity. Standardized emission factors mask variations across individual sites both within and between countries. Uncertainties are often higher for non-CO_2 GHGs.

Many countries lack the technology, internal capacity, and resources to monitor GHG sources and sinks effectively. Improper data collection and assessment methods can produce discrepancies between reported and actual emissions. Many countries also have missing data for certain sectors or indicators, which must then be extrapolated using regional data or data from other sectors, which introduces additional uncertainty. Since calculation of the ten-year trend only includes data up to 2017, *adjusted emission growth rate* scores do not reflect recent emission reductions arising from the COVID-19 pandemic.

Lastly, we caution policymakers not to compare scores between the 2018 and 2020 EPI reports, but to look at the ten-year change reported in our latest scores in order to evaluate changes in performance. In 2018, our indicators evaluated trends in emission intensity, focusing solely on whether countries were decoupling their emissions from economic growth. By switching to *adjusted emission growth rate*, we emphasize that global GHG emissions must decline in aggregate – not merely increase at a slower rate than economic growth. However, we understand that emission trajectories will vary between countries depending on their level of development. Principles of environmental justice dictate that countries have a right to sustainably develop their economies and improve social well-being, which may require initial increases in emissions in least developed nations.

3.2 GROWTH RATE IN CARBON DIOXIDE (CO_2) EMISSIONS FROM LAND COVER

Land use change has increasingly been recognized as a fundamental driver of climate change. The IPCC estimates that land use activities, including agriculture, forestry, and land use and land cover change account for about 23% of net global anthropogenic GHG emissions (Shukla et al., 2019). However, the land sector is often excluded from analysis of GHG emissions, including past iterations of the EPI. Estimates of land-based emissions include large uncertainties due to assumptions about emission factors for different land cover types, lack of scientific research into the dynamics of vegetation life cycles, and poor data coverage of changes on the Earth's surface. Excluding land sector emissions, however, can lead to an unbalanced view of emission trends, especially between countries and regions. For example, land sector emissions often comprise a larger proportion of total emissions in developing countries compared to developed countries. Further, patterns of emissions

TABLE 11-4. Clarification of the *adjusted emission growth rate* metrics.

WHAT THE METRICS ARE	WHAT THE METRICS AREN'T
The average annual growth rate in emissions over a ten-year period, adjusted based on the correlation between emissions and GDP, for • **Carbon dioxide (CO_2),** • **Methane (CH_4),** • **Nitrous oxide (N_2O),** • **Fluorinated gases (F-gases), and** • **Black carbon.**	• **A measure of the raw amount of emissions of each greenhouse gas** • **A measure of emission intensity, i.e., emissions per unit of economic output (GDP)** • **A measure of emission growth rate per capita** • **Inclusive of COVID-19 related emission reductions** • **Inclusive of CO_2 emissions from land use / land cover change**

between and within countries can differ as tree cover loss moves between forest types over space and time. Recent breakthroughs in data availability and processing have unlocked new estimates of GHG emissions from land cover change that provide more accurate and granular information for policymakers about important threats to climate change mitigation. The 2020 EPI incorporates these estimates in a new indicator, *growth rate in CO_2 emissions from land cover*.

3.2.1 INDICATOR BACKGROUND

The land cover change indicator represents a new metric in the 2020 EPI and as a result has been given rather low weight among the cluster of elements in the Climate Change category. As this indicator gets refined and tested in the years ahead, we anticipate that it will be given greater emphasis and weight in future versions of the EPI.

Using FLINTpro, a new data integration platform based on the open source FLINT system (see www.moja.global), researchers at the Mullion Group, based in Australia, used existing global datasets to provide estimates of CO_2 from changes in aboveground and belowground biomass and dead organic matter. From these estimates, we calculate *growth rate in CO_2 emissions from land cover* as the average annual growth rate of CO_2 emissions from land cover change over the years 2001–2015.

3.2.2 DATA

The emission data used to calculate the metric *growth rate in CO_2 emissions from land cover* were developed using existing global data sets integrated in FLINTpro. The core datasets are Hansen et al.'s (2013) dataset on forest cover change, IPCC Tier 1 emission factors (Eggleston et al., 2006), and other underpinning spatial data required to allocate the emission factors including FAO maps of soil type and Global Ecological Zones (FAO, 2012). Full details of the methods and input data are available at FLINTpro.com/Global-Run.

3.2.3 LIMITATIONS

As a pilot metric using cutting-edge tools and the latest datasets on land cover change, our new metric provides insights for policymakers while also delineating the next steps for refinement. Since the basis for the calculations is the Hansen et al. (2013) dataset on forest cover change, this metric shares the same limitations as those described for *tree cover loss* in Chapter 9. The main limitation is caused by a lack of attribution, making it impossible to determine if tree cover loss is driven by natural causes, like storms and wildfires, or by humans. Furthermore, the dataset only registers loss of canopy cover annually; yet regrowth is measured as a single value covering the years 2000–2012. This measure does not account for regrowth after tree cover loss, as would typically occur in forestry operations, or positive efforts like tree planting which lead to CO_2 removal. As such, emissions estimates will likely exceed land use change emissions reported in national inventories. The accuracy of the Hansen data also varies among countries. However, by using the data as an indicator of relative performance over time, these limitations are reduced.

The IPCC Tier 1 emission factors and the spatial data used to calculate tree cover loss emissions in different geographical areas also have limitations. The Tier 1 emission factors represent broad ecological types, and while accurate on average, the carbon levels within a forest type can vary greatly. Further, the Global Ecological Zone (GEZ) data also have limitations, as the zones may not always align with the forest type on the ground.

Additional analysis by experts from the Mullion Group indicates that the confidence in the emission trends is higher in tropical countries with deforestation patterns in wet tropical forest types, and lower in countries with savanna landscapes and significant levels of natural disturbance.

Accuracy of the metric will improve over time as better input data become available. Several global efforts to better map forest biomass are already under way. There are also new land cover products being produced that not only could improve the accuracy of the forest cover change estimates, but could broaden the results to other land uses, such as cropping and grazing. For countries or organizations that already have improved input data, it is possible to simply replace the global data with country-specific maps and emission factors.

Finally, because the input data cannot distinguish between natural and anthropogenic causes of land cover change, the estimates provided here are of limited use for tracking the outcomes of land use changes, land management policies, or land-based climate change mitigation. Given these uncertainties, policymakers should use caution in comparing *growth rate in CO_2 emissions from land cover* scores to national emission inventories and should view this metric as a directional indicator of emission trends. As new data are developed, these values can be further refined. Additional limitations of the datasets are discussed in more detail at FLINtpro.com/Global-Run.

TABLE 11-5. Clarification of the *growth rate in CO_2 emissions from land cover* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
The average annual growth rate in CO2 emissions from forest cover change over 2001–2015	• **A measure of emissions from all land use activities and land use change, including agriculture** • **A measure of emissions from only human-driven or permanent deforestation** • **Inclusive of land use-related emissions of non-CO_2 GHGs**

TABLE 11-6. Clarification of the *GHG intensity growth rate* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
The average annual growth rate in greenhouse gas emissions per unit of GDP over 2008–2017	• **A measure of emission growth rate per capita** • **A measure of emissions efficiency (per unit of energy consumed)** • **Inclusive of COVID-19 related emission reductions**

3.3 GREENHOUSE GAS INTENSITY GROWTH RATE

Our *greenhouse gas (GHG) intensity growth rate* serves as a signal of countries' progress in decoupling emissions from economic growth. This indicator highlights the need for action on climate change mitigation in countries at all income levels. Wealthier countries may be well positioned to lower GHG emissions as they transition to post-industrial, service-based economies, but developing nations can also adopt creative solutions for low-carbon sustainable development.

3.3.1 INDICATOR BACKGROUND

We calculate *GHG intensity growth rate* as the average rate of increase or decrease in emissions per unit of economic output over the years 2008–2017. The calculation is inclusive of all greenhouse gases (but not black carbon) across all sectors of the economy, reported as tonnes of CO_2-equivalent per unit of GDP.

3.3.2 DATA

Emission data for the *GHG intensity growth rate* indicator come from PIK's PRIMAP-hist dataset. GDP data come from the World Bank and IMF.

3.3.3 LIMITATIONS

Like the *adjusted emission growth rate* indicators, *GHG intensity rowth rate* faces limitations related to gaps in data collection and emission reporting. Model assumptions and standardized emission factors fail to account for country- and sector-specific variations. Since the data only cover the years 2008–2017, scores do not reflect COVID-19 related emission reductions.

3.4 GREENHOUSE GAS EMISSIONS PER CAPITA

Recognizing that many countries are still industrializing and that many developing countries still struggle with energy poverty, we also include a metric on *greenhouse gas emissions per capita*. Decreasing emissions while still meeting the energy needs of a population is a challenge even for nations with mature climate change policies. As a snapshot of emissions in a country, a per capita measure also reveals whose economies are the most wasteful, particularly among wealthy countries.

3.4.1 INDICATOR BACKGROUND

We calculate average *greenhouse gas emissions per capita* for each country for the year 2017.

3.4.2 DATA

Emission data for the *GHG emissions per capita* indicator come from PIK's PRIMAP-hist dataset. Population data come from the World Bank and IMF.

3.4.3 LIMITATIONS

In addition to the limitations related to standardized emission factors, data collection, and emission reporting, this indicator has the drawback of representing a snapshot rather than a trend. *GHG emissions per capita* represents only one year of data, 2017, making it vulnerable to the influence of extraordinary conditions. Calculating a trend and scoring based on whether emissions per capita were increasing or decreasing, however, would obscure differences in optimal emission trajectories between countries, unduly punishing countries whose emissions per capita must increase to adequately provide for social well-being. Some experts have suggested that countries follow a "contraction and convergence" approach, in which GHG emissions per capita converge to a common global level and then decrease to net zero (Persson et al., 2006). Future iterations of the EPI may explore the possibility of evaluating countries based on how closely they adhere to an optimal per capita emission trajectory.

TABLE 11-7. Clarification of the *emissions per capita* metric

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
The total greenhouse gas emissions per capita for each country in the year 2017	• A measure of the growth rate in emissions per capita across multiple years • Inclusive of COVID-19 related emission reductions

COVID-19 AND CLIMATE CHANGE

In less than six months, the COVID-19 pandemic has disrupted nearly all layers of society, from individual consumption and behavior to global trade. As a result of sweeping shifts in economic output and personal mobility, daily global greenhouse gas (GHG) emissions in early April 2020 were 17% lower than those of the previous year (Le Quéré et al., 2020). Experts estimate that total emissions for the year will represent an 8% decline from 2019 levels, the largest one-year drop since World War II (IEA, 2020b). However, these reductions are unlikely to have a substantial effect on the trajectory of climate change because warming depends on cumulative emissions. Thus, a drop in one year's GHG flow into the atmosphere cannot undo decades of pollution.

More importantly, the UN Environment Programme (UNEP) estimates that to limit warming to 1.5°C global GHG, emissions will need to fall by 7.6% every year for the next decade (2019c). Therefore the 2020 emissions reduction would need to be replicated every year out to 2030, which clearly will not happen absent much more assiduous policy intervention. But in highlighting this fact, the pandemic reveals the true scale of the climate change challenge. Simply put, even drastic alterations to individuals' behaviors and huge declines in transportation-related emissions achieve less than 10% of the decarbonization necessary to limit warming to 1.5°C above pre-industrial levels (The Economist, 2020b). The 2020 emissions reduction, moreover, must be understood as unsustainable given the stark human public health and economic costs that occurred in parallel with particular burdens concentrated among poor and vulnerable populations.

In addition, the pandemic raises new uncertainties around the future of climate change mitigation and the public's willingness to pursue the changes required to achieve deep decarbonization. Analysts have expressed concern, for example, that the 2020 economic downturn will slow the expansion of renewable energy, as over 40% of wind and solar projects scheduled for commission this year have been delayed or suspended due to supply chain disruptions and uncertainties over future energy demand (Bahar, 2020; Gardiner, 2020). People may also choose to avoid public transit, trains, and air travel out of caution against the spread of the virus, increasing the use of personal vehicles and driving up GHG emissions. Doing so may cause demand for petroleum products to rebound sharply, especially combined with low oil prices (IEA, 2020c; Pearce, 2020; The Economist, 2020a). Finally, the worldwide governmental focus on addressing the short- and medium-term public health and economic crises may push climate change farther down the global agenda. One signal of this impact is the postponement of the COP26 climate change summit meeting in Glasgow, from November 2020 to November 2021, thereby delaying the scheduled global "stocktake" and important global decisions on how best to ramp up implementation of the Paris Climate Change Agreement.

Despite these uncertainties, there is emerging cause for optimism. Demand for renewable energy grew by 1.5% in the first quarter of 2020, while demand for all other energy sources fell (The Economist, 2020a). Low oil prices have left many wells economically unviable and may reduce future investment in new oil and gas projects, freeing up financing for renewables (Pearce, 2020). Some emissions-reducing behavioral shifts may persist after the pandemic, including two important impacts from businesses. First, some analysts speculate that up to one-third of the workforce will continue working remotely at least part-time, partially reducing the 8% of total oil demand that stems from commuting. Second, aviation emissions could undergo permanent reductions from decreased business travel (Global Workplace Analytics, 2020; The Economist, 2020a).

Stimulus packages and fiscal recovery policies during and immediately after the pandemic will be decisive in shaping countries' emissions pathways. Governments have an unprecedented opportunity to set entire economies on a low-carbon trajectory through green job creation. Hepburn et al. (2020) found that stimulus policies following the financial crisis of 2008–2009 with "green" components, such as investments in renewables and clean energy infrastructure, generated more jobs in the short term due to high labor requirements for project construction and installation – without squeezing labor markets in other sectors in the long term. The Hepburn et al. study identifies six policy elements with high potential for climate change and economic benefits:

1. investment in green infrastructure like renewable energy, grid modernization, and storage;
2. building efficiency renovations and retrofits;
3. education and job training;

4. ecosystem restoration and natural capital investment;

5. research and development (R&D) on battery technology and greenhouse gas removal; and

6. rural support for climate-friendly agriculture and clean energy in low- and middle-income countries (Hepburn et al., 2020).

Policymakers may face political pressure to bail out older, polluting industries that have long served as major employers and pillars of economic performance. Instead, innovative green policies provide alternatives to doubling down on outdated sectors. Countries can make aid conditional on specified emissions reductions, such as France denying subsidies to Air France for domestic routes that compete with high-speed trains powered by zero-carbon nuclear electricity (The Economist, 2020b). Current record low energy prices also present the optimal time to place a price on GHG emissions, such as through a carbon tax, since the impact on consumers will be minimized and behaviors and technology are already shifting to new equilibria (The Economist, 2020b).

Despite the benefits of green recovery, pursuing sustainability requires overcoming a great deal of inertia. A survey of 300 economic rescue policies enacted in G20 countries since the pandemic-related financial crash, representing over $7.3 billion in spending, found that only 4% had the potential to reduce long-term emissions (Hepburn et al., 2020). For instance, China's stimulus package made no mention of the environment or climate change (Pearce, 2020). Environmental supervision of firms has been relaxed to boost industrial activity (Xu & Goh, 2020), and approvals for new coal-fired power plants have surged since the country started lifting its lockdown measures. Despite a clear relationship between air pollution levels and COVID-19 deaths in China, air pollution concentrations since reopening its economy have already risen above pre-pandemic levels (Myllyvirta, 2020; Pearce, 2020). The Trump administration in the United States is using the pandemic as an excuse to weaken environmental regulations and enforcement (Friedman & Davenport, 2020). The EU, however, has proposed a recovery package crafted specifically to strengthen the European Green Deal, including high levels of support for renewable energy and "do no harm" conditions on investment (Keating, 2020; Simon, 2020).

Climate change experts express hope that the pandemic will bring about a paradigm shift spurred by renewed appreciation for the role of scientific expertise in policymaking and a heightened understanding of the importance of coöperation and mutual care. Countries have been given an extraordinary opportunity to set a new path toward sustainability in the economy, human health, and the environment, and scientists are cautiously optimistic that the world's leaders will embrace this opportunity.

FIGURE 11-8. Potential reductions in CO_2 emissions due to COVID-19 compared to historical global crises. *Source:* *Carbon Brief (Evans, 2020)*

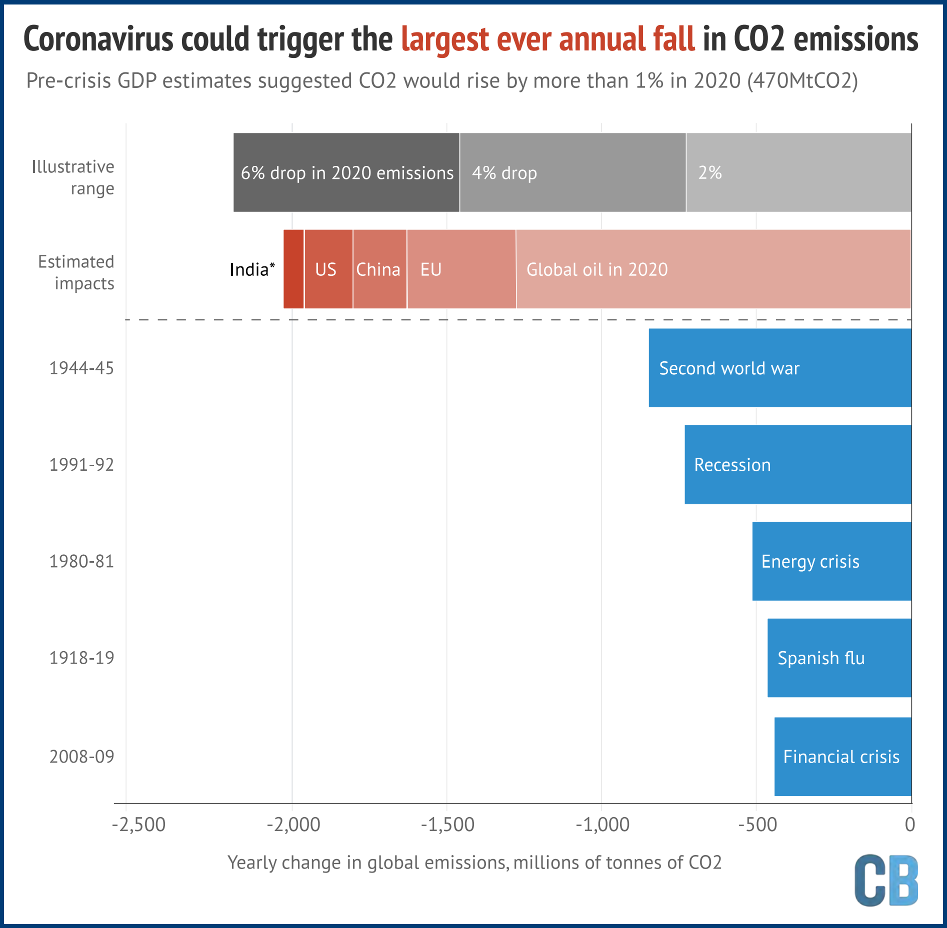
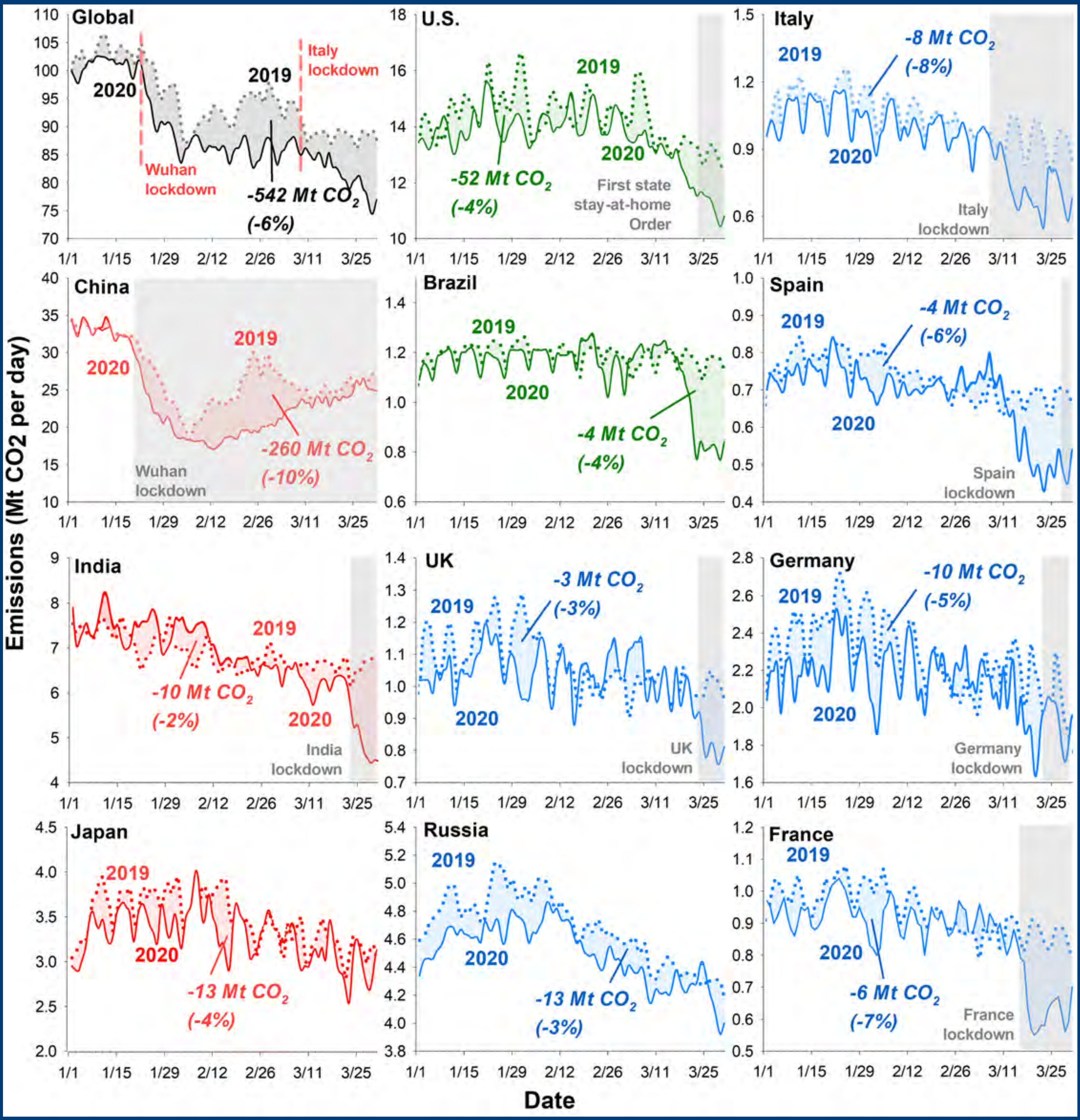


FIGURE 11-9. Daily CO_2 emissions in the first quarter of 2019 (dotted line) and 2020 (solid line) for the world, U.S., Italy, China, Brazil, Spain, India, UK, Germany, Japan, Russia, and France. *Source: Liu et al., 2020*



Chapter 12. Pollution Emissions

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

After release into the environment from human activities, many pollutants trace diverse paths through air and water, harming ecosystems in as many different ways as fate would take them. Sulfur dioxide (SO_2) and nitrogen oxides (NO_X), two primary air pollutants, degrade soil and water quality (Bouwman et al., 2002) and trigger a cascade of ecological effects that reduce biodiversity, ultimately putting human communities at risk (R.J. Payne et al., 2017). These harms can be difficult or impossible to reverse, persisting long after countries implement emission reduction policies. Policymakers require a range of data to mitigate these threats, including on the relationships between sources of air pollution and their ambient concentrations in nature – and the consequences of their presence in different ecosystems. Unfortunately, less is known about the effects of air pollutants on biodiversity than on human populations (Clark et al., 2013, p. 525). In the absence of the full picture, we focus here on emissions of these important pollutants into the atmosphere and whether countries' emissions are growing or declining.

1.2 INDICATORS

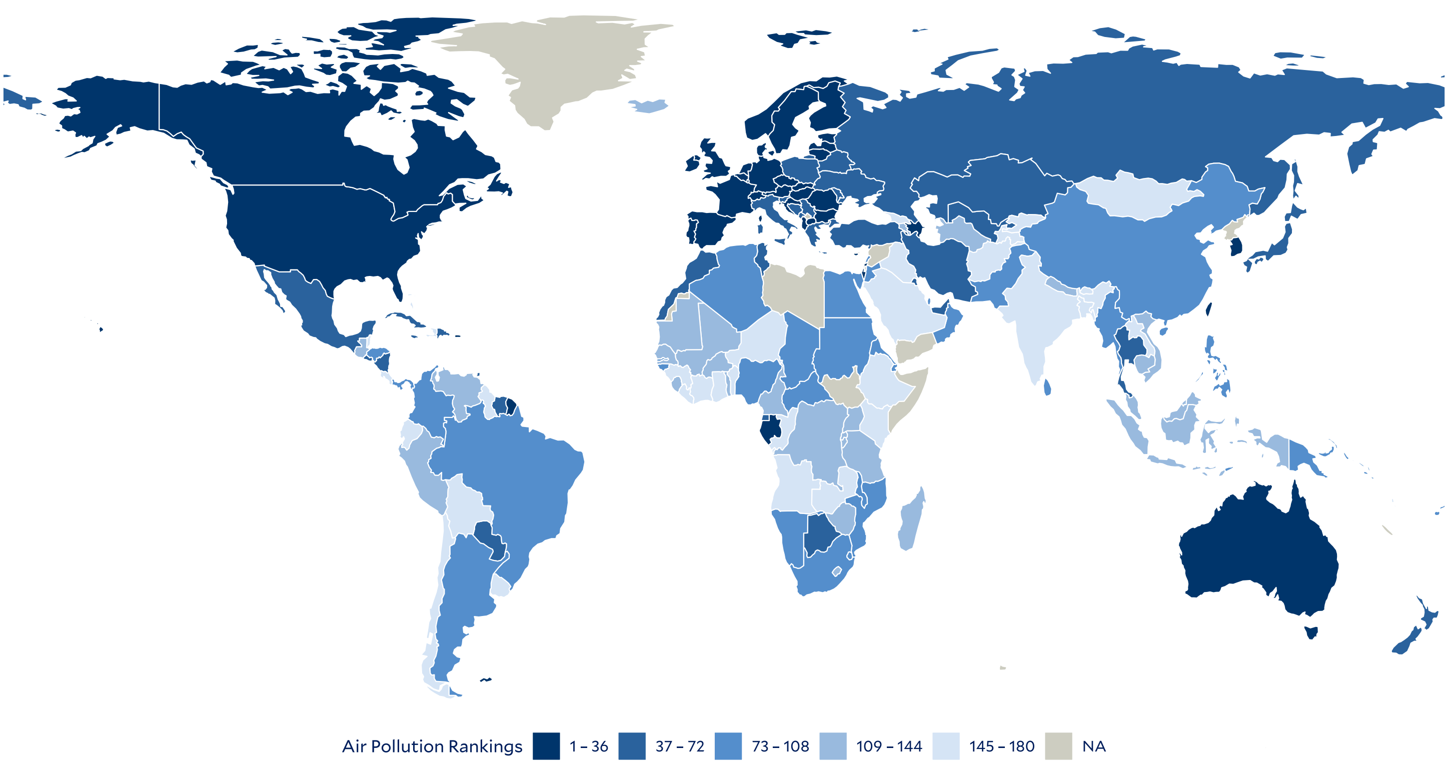
1.2.1 Adjusted emission growth rate for sulfur dioxide (SO_2) and nitrogen oxides (NO_X).

These indicators track trends in countries' emissions of two primary air pollutants:

- sulfur dioxide (SO_2) [50% of issue category] and
- nitrogen oxides (NO_X) [50% of issue category].

We calculate the average annual rate of increase or decrease in emissions based on ten years of data and then adjust these rates for economic trends.

MAP 12-1. Rankings on Pollution Emissions.



12.

TABLE 12-1. Global rankings, scores, and regional rankings (REG) on Pollution Emissions.

RANK	COUNTRY	SCORE	REG
1	Albania	100.0	1
	Austria	100.0	1
	Azerbaijan	100.0	1
	Belgium	100.0	1
	Bulgaria	100.0	1
	Canada	100.0	1
	Czech Republic	100.0	1
	Denmark	100.0	1
	France	100.0	1
	Ireland	100.0	1
	Luxembourg	100.0	1
	Netherlands	100.0	1
	North Macedonia	100.0	1
	Romania	100.0	1
	Slovakia	100.0	1
	South Korea	100.0	1
	Spain	100.0	1
	Sweden	100.0	1
	Switzerland	100.0	1
	Taiwan	100.0	1
	United Kingdom	100.0	1
	United States of America	100.0	1
23	Norway	99.2	14
24	Israel	97.8	1
25	Hungary	96.9	7
26	Estonia	96.6	8
	Lithuania	96.6	8
28	Germany	96.0	15
29	Latvia	94.8	10
30	Portugal	93.5	16
31	Bahrain	93.1	2
	Finland	93.1	17
33	Cyprus	91.5	11
34	Croatia	90.8	12
35	Australia	90.3	18
36	Gabon	90.2	1
37	Slovenia	90.0	13
38	Poland	89.6	14
39	Serbia	89.0	15
40	New Zealand	87.4	19
41	El Salvador	86.3	1
	Seychelles	86.3	2
43	Montenegro	85.2	16
44	Tunisia	84.2	3
45	Turkey	84.0	17
46	United Arab Emirates	83.4	4
47	Suriname	82.4	2
48	Kuwait	81.7	5
49	Italy	81.4	20
50	Russia	81.0	2
51	Iran	80.8	6
	Malta	80.8	21
53	Morocco	80.5	7
54	Belarus	80.4	3
55	Nicaragua	80.2	3
56	Singapore	79.5	3
57	Dominican Republic	79.3	4
58	Greece	78.9	18
59	Thailand	78.7	4
60	Jamaica	78.6	5
61	Bosnia and Herzegovina	78.1	19
62	Trinidad and Tobago	77.9	6
63	Japan	77.7	5
64	Ukraine	76.6	4
65	Equatorial Guinea	76.4	3
66	Cuba	76.1	7
	Moldova	76.1	5
68	Kazakhstan	75.2	6
69	Mexico	71.4	8
70	Uzbekistan	70.9	7
71	Paraguay	70.5	9
72	Botswana	70.0	4
73	South Africa	69.7	5
74	Jordan	69.0	8
75	Philippines	68.4	6
76	Namibia	68.2	6
77	Lebanon	67.1	9
78	Nigeria	66.3	7
79	Panama	66.1	10
80	Tonga	65.5	7
81	Sudan	64.8	10
82	Timor-Leste	64.7	8
83	Qatar	64.4	11
84	Algeria	61.7	12
85	Honduras	60.9	11
86	Eswatini	60.5	8
87	Oman	60.0	13
88	Argentina	59.3	12
89	Micronesia	58.8	9
	Pakistan	58.8	1
91	China	58.6	10
92	Papua New Guinea	58.2	11
93	Solomon Islands	57.5	12
94	Eritrea	57.1	9
95	Egypt	56.3	14
96	Guinea-Bissau	56.1	10
97	Djibouti	55.5	11
98	Chad	54.7	12
99	Mozambique	54.1	13
100	Brazil	54.0	13
101	Gambia	53.9	14
102	Barbados	53.3	14
103	Fiji	53.2	13
104	Malawi	53.1	15
	Sri Lanka	53.1	2
106	Colombia	52.5	15
107	Central African Republic	51.8	16
108	Myanmar	50.7	14
109	Marshall Islands	50.6	15
110	Rwanda	50.5	17
111	Kiribati	49.9	16
	Mali	49.9	18
	Togo	49.9	18
114	Senegal	49.5	20
115	Mauritania	49.2	21
	Mauritius	49.2	21
117	Dem. Rep. Congo	47.8	23
118	Dominica	47.3	16
119	São Tomé and Príncipe	47.1	24
120	Armenia	46.8	8
121	Burundi	45.7	25
	Viet Nam	45.7	17
123	Cambodia	45.4	18
124	Guatemala	44.8	17
	Turkmenistan	44.8	9
126	Comoros	44.5	26
127	Iceland	44.4	22
	Nepal	44.4	3
	Uganda	44.4	27
130	Lesotho	44.0	28
	Samoa	44.0	19
132	Brunei Darussalam	41.8	20
133	Venezuela	41.4	18
134	Malaysia	41.2	21
135	Peru	41.0	19
	Zimbabwe	41.0	29
137	Burkina Faso	40.6	30
138	Madagascar	40.5	31
139	Indonesia	40.4	22
140	Sierra Leone	40.1	32
	Tanzania	40.1	32
142	Grenada	40.0	20
143	Cameroon	39.8	34
144	St. Vincent and Grenadines	38.9	21
145	India	37.1	4
146	Kenya	36.8	35
147	Saint Lucia	36.7	22
148	Antigua and Barbuda	36.6	23
149	Uruguay	36.4	24
150	Cabo Verde	35.1	36
151	Mongolia	34.9	23
152	Saudi Arabia	34.7	15
153	Chile	34.6	25
154	Costa Rica	33.6	26
155	Benin	33.4	37
156	Liberia	32.7	38
157	Côte d'Ivoire	31.8	39
158	Ghana	31.5	40
159	Guinea	30.0	41
160	Tajikistan	29.8	10
161	Guyana	28.6	27
162	Ecuador	28.4	28
163	Maldives	26.7	5
164	Bolivia	26.4	29
165	Haiti	23.8	30
166	Ethiopia	23.6	42
167	Zambia	22.5	43
168	Laos	21.3	24
169	Bhutan	18.2	6
170	Kyrgyzstan	18.1	11
171	Bahamas	18.0	31
172	Vanuatu	16.4	25
173	Bangladesh	15.3	7
174	Iraq	14.1	16
175	Belize	11.4	32
176	Angola	2.6	44
177	Georgia	0.9	12
	Niger	0.9	45
179	Afghanistan	0.0	8
	Republic of Congo	0.0	46

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 12-2. Regional rankings, scores, and global rankings on Pollution Emissions.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	El Salvador	86.3	41
2	Suriname	82.4	47
3	Nicaragua	80.2	55
4	Dominican Republic	79.3	57
5	Jamaica	78.6	60
6	Trinidad and Tobago	77.9	62
7	Cuba	76.1	66
8	Mexico	71.4	69
9	Paraguay	70.5	71
10	Panama	66.1	79
11	Honduras	60.9	85
12	Argentina	59.3	88
13	Brazil	54.0	100
14	Barbados	53.3	102
15	Colombia	52.5	106
16	Dominica	47.3	118
17	Guatemala	44.8	124
18	Venezuela	41.4	133
19	Peru	41.0	135
20	Grenada	40.0	142
21	St. Vincent and Grenadines	38.9	144
22	Saint Lucia	36.7	147
23	Antigua and Barbuda	36.6	148
24	Uruguay	36.4	149
25	Chile	34.6	153
26	Costa Rica	33.6	154
27	Guyana	28.6	161
28	Ecuador	28.4	162
29	Bolivia	26.4	164
30	Haiti	23.8	165
31	Bahamas	18.0	171
32	Belize	11.4	175

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Albania	100.0	1
	Bulgaria	100.0	1
	Czech Republic	100.0	1
	North Macedonia	100.0	1
	Romania	100.0	1
	Slovakia	100.0	1
7	Hungary	96.9	25
8	Estonia	96.6	26
	Lithuania	96.6	26
10	Latvia	94.8	29
11	Cyprus	91.5	33
12	Croatia	90.8	34
13	Slovenia	90.0	37
14	Poland	89.6	38
15	Serbia	89.0	39
16	Montenegro	85.2	43
17	Turkey	84.0	45
18	Greece	78.9	58
19	Bosnia and Herzegovina	78.1	61

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Pakistan	58.8	89
2	Sri Lanka	53.1	104
3	Nepal	44.4	127
4	India	37.1	145
5	Maldives	26.7	163
6	Bhutan	18.2	169
7	Bangladesh	15.3	173
8	Afghanistan	0.0	179

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Austria	100.0	1
	Belgium	100.0	1
	Canada	100.0	1
	Denmark	100.0	1
	France	100.0	1
	Ireland	100.0	1
	Luxembourg	100.0	1
	Netherlands	100.0	1
	Spain	100.0	1
	Sweden	100.0	1
	Switzerland	100.0	1
	United Kingdom	100.0	1
	United States of America	100.0	1
14	Norway	99.2	23
15	Germany	96.0	28
16	Portugal	93.5	30
17	Finland	93.1	31
18	Australia	90.3	35
19	New Zealand	87.4	40
20	Italy	81.4	49
21	Malta	80.8	51
22	Iceland	44.4	127

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Azerbaijan	100.0	1
2	Russia	81.0	50
3	Belarus	80.4	54
4	Ukraine	76.6	64
5	Moldova	76.1	66
6	Kazakhstan	75.2	68
7	Uzbekistan	70.9	70
8	Armenia	46.8	120
9	Turkmenistan	44.8	124
10	Tajikistan	29.8	160
11	Kyrgyzstan	18.1	170
12	Georgia	0.9	177

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	South Korea	100.0	1
	Taiwan	100.0	1
3	Singapore	79.5	56
4	Thailand	78.7	59
5	Japan	77.7	63
6	Philippines	68.4	75
7	Tonga	65.5	80
8	Timor-Leste	64.7	82
9	Micronesia	58.8	89
10	China	58.6	91
11	Papua New Guinea	58.2	92
12	Solomon Islands	57.5	93
13	Fiji	53.2	103
14	Myanmar	50.7	108
15	Marshall Islands	50.6	109
16	Kiribati	49.9	111
17	Viet Nam	45.7	121
18	Cambodia	45.4	123
19	Samoa	44.0	130
20	Brunei Darussalam	41.8	132
21	Malaysia	41.2	134
22	Indonesia	40.4	139
23	Mongolia	34.9	151
24	Laos	21.3	168
25	Vanuatu	16.4	172

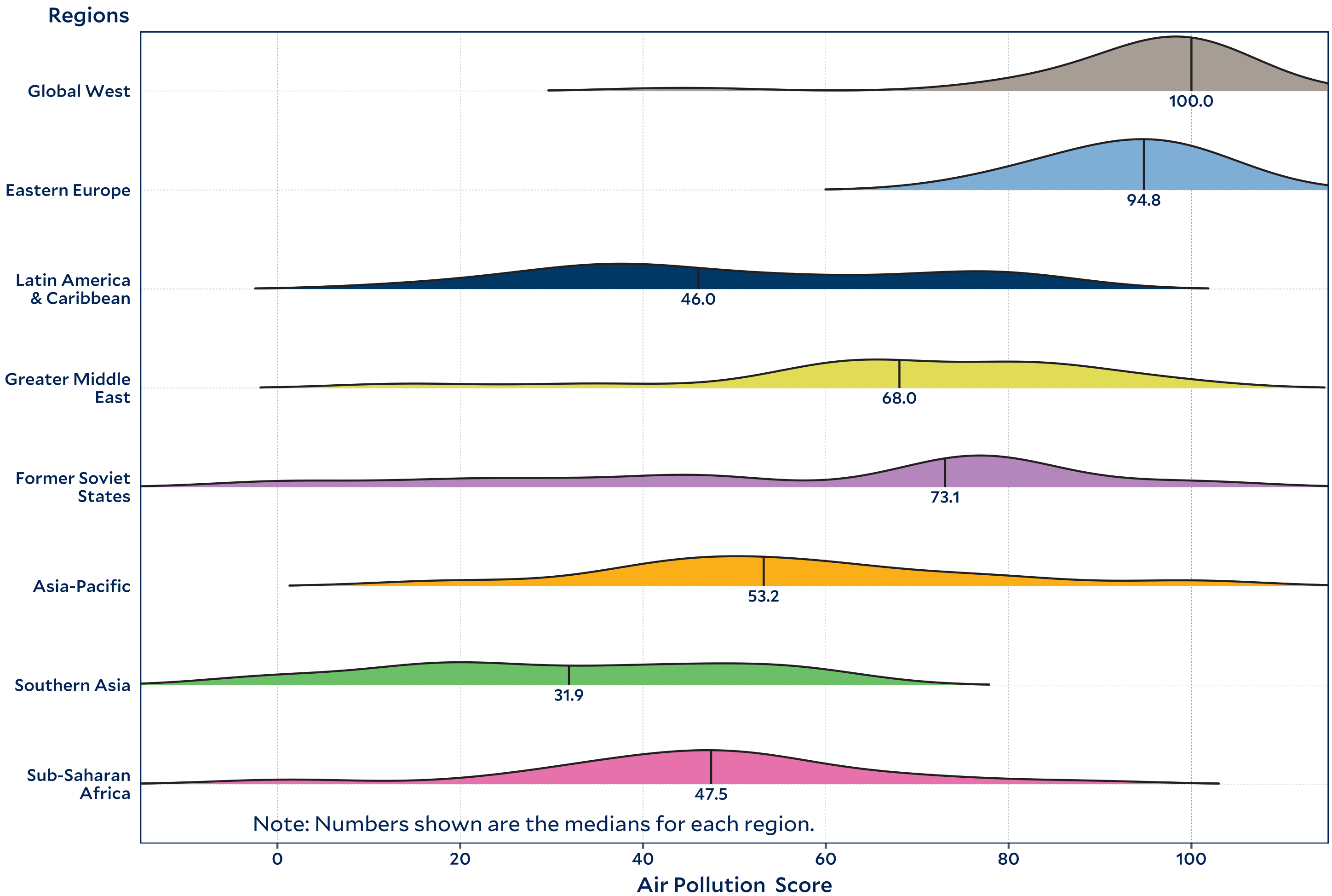
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	Gabon	90.2	36
2	Seychelles	86.3	41
3	Equatorial Guinea	76.4	65
4	Botswana	70.0	72
5	South Africa	69.7	73
6	Namibia	68.2	76
7	Nigeria	66.3	78
8	Eswatini	60.5	86
9	Eritrea	57.1	94
10	Guinea-Bissau	56.1	96
11	Djibouti	55.5	97
12	Chad	54.7	98
13	Mozambique	54.1	99
14	Gambia	53.9	101
15	Malawi	53.1	104
16	Central African Republic	51.8	107
17	Rwanda	50.5	110
18	Mali	49.9	111
	Togo	49.9	111
20	Senegal	49.5	114
21	Mauritania	49.2	115
	Mauritius	49.2	115
23	Dem. Rep. Congo	47.8	117
24	São Tomé and Príncipe	47.1	119
25	Burundi	45.7	121
26	Comoros	44.5	126
27	Uganda	44.4	127
28	Lesotho	44.0	130
29	Zimbabwe	41.0	135
30	Burkina Faso	40.6	137
31	Madagascar	40.5	138
32	Sierra Leone	40.1	140
	Tanzania	40.1	140
34	Cameroon	39.8	143
35	Kenya	36.8	146
36	Cabo Verde	35.1	150
37	Benin	33.4	155
38	Liberia	32.7	156
39	Côte d'Ivoire	31.8	157
40	Ghana	31.5	158
41	Guinea	30.0	159
42	Ethiopia	23.6	166
43	Zambia	22.5	167
44	Angola	2.6	176
45	Niger	0.9	177
46	Republic of Congo	0.0	179

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Israel	97.8	24
2	Bahrain	93.1	31
3	Tunisia	84.2	44
4	United Arab Emirates	83.4	46
5	Kuwait	81.7	48
6	Iran	80.8	51
7	Morocco	80.5	53
8	Jordan	69.0	74
9	Lebanon	67.1	77
10	Sudan	64.8	81
11	Qatar	64.4	83
12	Algeria	61.7	84
13	Oman	60.0	87
14	Egypt	56.3	95
15	Saudi Arabia	34.7	152
16	Iraq	14.1	174

FIGURE 12-1. Regional performance on Pollution Emissions.



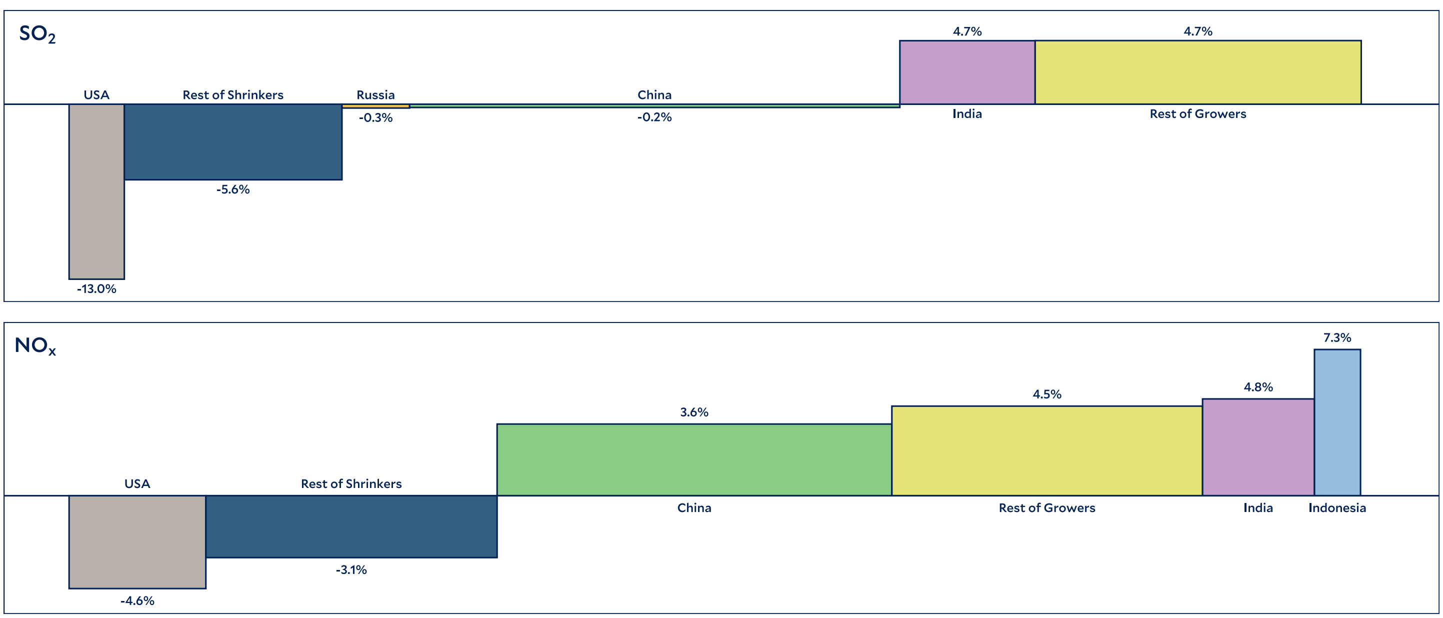
2. RESULTS

2.1 GLOBAL TRENDS

Progress in reducing pollution emissions continues to be uneven, and gains in some regions are offset by losses in others. While more than half of all countries are shrinking their SO_2 emissions, the growth rate of NO_X emissions continues to increase across much of the world. Notably, NO_X emissions are growing by 3.6% in China, 4.8% in India, and 7.3% in Indonesia each year, as shown in Figure 12-2. This upward global NO_X trend is driven, in part, by the expansion of road transport in developing countries, where increasing vehicle use is outstripping gains from technology and efficiency improvements (Elkins et al., 2019). Other human activities, including industrial processes, agricultural practices, and the use of fossil fuels in maritime shipping and energy production, continue to contribute to SO_2 and NO_X emissions.

Excess sulfur and nitrogen deposition can profoundly damage ecosystems, acidify soils and water bodies (Bouwman et al., 2002) and, in the case of nitrogen, cause eutrophication. This overabundance of nutrients can shift species composition and reduce plant diversity in natural ecosystems (R.J. Payne et al., 2017). Trends in pollution deposition vary by location, with both increases and decreases in SO_2 deposition and increases in NO_X emissions observed across Asia and Africa (Elkins et al., 2019). On the other hand, after decades of pollution control efforts, SO_2 and NO_X emissions are decreasing across Western Europe and North America (Maas & Grennfelt, 2016), and there are signs of ecosystem recovery in these regions (Elkins et al., 2019).

FIGURE 12-2. International comparisons of emissions and average annual growth rates for two primary air pollutants. The width of the columns is proportional to the share of global emissions in the most recent year of data, and the height of the bar shows the average annual growth rate in emissions over the past decade. *Source: Community Emissions Data System*



2.2 LEADERS & LAGGARDS

Europe is home to a number of countries leading the way in addressing pollution emissions. The region's approach to air quality is characterized by transboundary coördination at global and regional scales. As early as 1979, European nations signed the Convention on Long-Range Transboundary Air Pollution (CLRTAP), recognizing the need to jointly address pollution emissions. The Convention and its 2012 amendment, the Gothenburg Protocol, have driven reductions in pollution emissions across the continent (European Environment Agency, 2019a). Members of the European Union are also bound by the Ambient Air Quality Directives, enacted in 2004 and 2008, and the National Emission Ceilings Directive, enacted in 2016. The former established ambient air quality standards (European Environment Agency, 2019a), and the latter codified pollution reduction commitments for SO_2 and NO_X made by European countries under CLRTAP (European Environment Agency, 2020).

Belgium succeeded in rising from a relatively low ranking on pollution emissions in the 2016 EPI to a position of leadership, achieving a perfect score of 100 in this year's assessment. Belgium has significantly improved its air quality over the past 25 years, with NO_X and SO_X emissions dropping by 57% and 90%, respectively, between 1990 and 2017 (Flemish Environment Agency et al., 2019). The country is on track to meet or exceed its 2020 and 2030 SO_2 and NO_X commitments (European Environment Agency, 2019b). Environmental protection is largely the purview of Belgium's regional governments, which oversee air quality in Flanders, Wallonia, and the Brussels-Capital Region. The national pollution emission targets are divided across these three regions, and pollution permitting and enforcement happens at the regional or local level (Belgium Coordination Committee for International Environmental Policy, 2019).

In contrast to leaders in this category, laggards are scattered across the globe. Poor performers exist in nearly every region, from Latin America and the Pacific to the Middle East and Sub-Saharan Africa. Indonesia in particular stands out for its NO_X growth rate. Pollution from road transport represents a significant and rapidly growing problem, with vehicle use increasing by 10% annually (Shao et al., 2020). In general, the country has experienced dramatically worsening air quality over the last few decades, with particulate pollution doubling between 2013 and 2016, due in part to devastating fires, especially in 2015 (Chamorro et al., 2017; Greenstone & Fan, 2019). Despite deterioration in ecosystems and public health, Indonesia still lacks a national standard for air pollution levels (Greenstone & Fan, 2019).

3. METHODS

Pollution emissions must be accurately measured and monitored in order for policymakers to make informed decisions about how they should be managed and, ideally, eliminated. Advances in sensor technology and communication networks have the potential to revolutionize the collection of pollution emission data. In order to optimize the use of these data and allow for the evaluation of international data and benchmarking across nations, global standards for sampling and analytical methodologies must be established.

Pollution tracking and monitoring efforts face substantial gaps in scientific understanding. Uncertainty surrounds scientific understanding of atmospheric chemistry dynamics over long timescales (Pascaud et al., 2016). NO_X in particular poses a monitoring challenge, as the gas enters systems in a variety of forms, undergoing many biological and chemical transformations before returning to the atmosphere as N_2 (Fowler et al., 2015). Not all forms of NO_X are measured in existing monitoring systems, making these dynamics difficult to track (Clark et al., 2013). Due to an overall lack of data on long-term atmospheric deposition, researchers find it challenging to identify overall trends (Burns et al., 2016; Vet et al., 2014).

Ecological responses to NO_X and SO_2 depositions should also be further characterized in order to understand the full impact of these pollutants. Further research is required to establish an understanding of the effects of soils on ecosystem recovery and of the factors which affect biotic responses to varying levels of deposition (Bobbink et al., 2010). Current knowledge about ecological responses is also geographically limited. South America, remote areas of North America, Asia, Africa, Oceania, the polar regions, and the ocean have all been insufficiently studied (Vet et al., 2014). The magnitude of acidification in oceans caused by NO_X and SO_2 is also largely uncertain (Doney et al., 2007). Furthermore, gaps in knowledge regarding how SO_2 and NO_X interact with other pollutants, climate change, and the carbon cycle limit the ability of experts to identify appropriate solutions (Burns et al., 2016). Enhanced monitoring of pollutants and research into atmospheric dynamics and ecological responses are required on a global scale to comprehensively address air pollution challenges.

3.1 INDICATOR BACKGROUND

To characterize pollution emissions, we calculate the *adjusted emission growth rate* as the average annual growth rate in emissions of SO_2 and NO_X, based on ten years of data. These metrics highlight which countries benefit from decreasing emissions and which countries continue to suffer from increasing pollution emissions. In countries where pollution emissions are decreasing, we sought to understand whether the decrease was due to economic decline or the decoupling of pollution emissions from economic growth. Figure 12-3a shows a number of countries (in blue) that have both decreasing SO_2 emissions and shrinking economies, indicating that their good performance may be due to depressed economic activity rather than policy effort. Countries that have decreasing emissions and growing economies are shown in orange. Figure 12-3b shows the correlation between GDP and SO_2 emissions, while Figures 12-3d–f illustrate three correlation scenarios. GDP and SO_2 emissions are highly positively correlated in Mali, negatively correlated in Azerbaijan, and not correlated in Nigeria.

To more accurately reflect the progress countries have made in controlling their pollution emissions, we adjust the emission growth rates for countries with declining emissions according to the following formula,

Adjusted growth rate =
Raw growth rate × (1 – *r*),

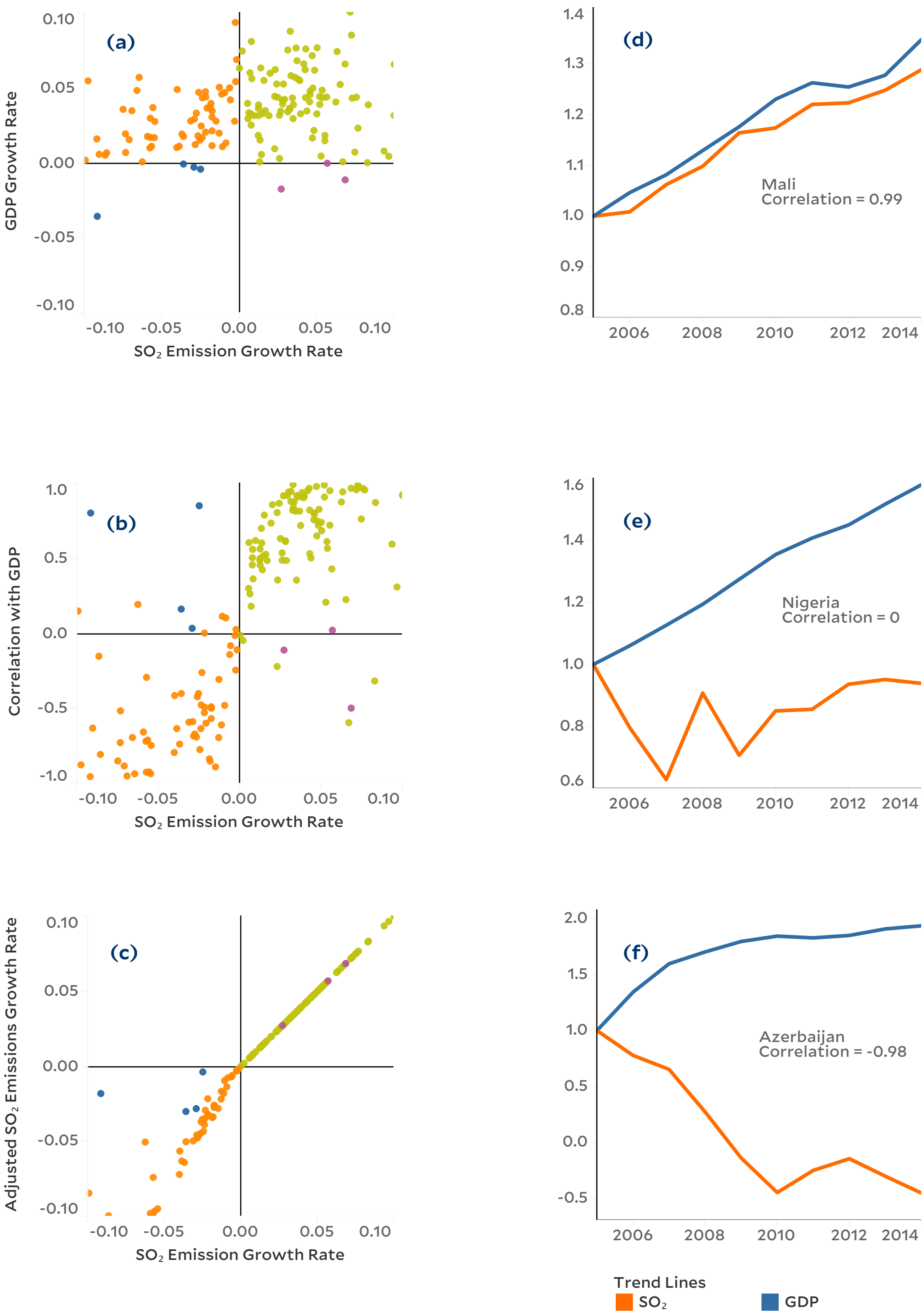
where *r* is Spearman's correlation coefficient. Countries where *r* is close to 1 will have their negative growth rate adjusted toward zero, and countries where *r* is close to -1 will have their negative growth rates adjusted to be even more negative. The adjusted growth rate, shown in Figure 12-3c, rewards countries that demonstrate true progress in decoupling emission growth rates from economic performance while giving less credit to countries that have achieved negative emission growth rates only through economic decline.

3.2 DATA

Data for these metrics are produced by the Community Emissions Data System (CEDS), a collaborative research effort of the Joint Global Change Research Institute and Pacific Northwest National Laboratory, funded by the U.S. Department of Energy Office of Science. Historical emission estimates are produced by extrapolating values from existing, reliable emission inventories to historical years based on emission factors and driver data. The method captures temporal trends in fuel use, technology, and emission controls, and provides a sectoral and gridded global inventory of emissions over time (Hoesly et al., 2018). Combustion emission data related to the energy sector are based on energy balance statistics from the International Energy Agency. Noncombustion emission data are drawn from EDGAR, a collaborative research effort of the European Commission Joint Research Centre and the Netherlands Environmental Assessment Agency. Our *adjusted emission growth rate* indicators for SO_2 and NO_X are based on CEDS data covering the years 2005–2014.

CEDS is an open-source data system that will be continually updated in subsequent years. The full dataset is publicly available for download from the CEDS public GitHub repository: https://github.com/JGCRI/CEDS/.

FIGURE 12-3. Adjusting declining SO_2 emission growth rates based on correlation with economic growth rates, 2005-2014. SO_2 emissions and GDP are indexed to 2005 = 1 in panels (d)-(f).
Sources: SO_2 emissions from CEDS; GDP from World Bank Databank and IMF.



3.3 LIMITATIONS

As with any data, CEDS data have limitations. Due to limited data availability and reliability of emission inventories, emission data in low- and middle-income regions are more uncertain than in higher-income countries (Hoesly et al., 2018). Though all SO_X compounds are pollutants, only SO_2 emissions are factored into the calculation of these indicators, because SO_2 data are most readily available and will be highly correlated with other SO_X emissions. In addition, the data cannot be used to calculate actual damages resulting from the deposition of these pollutants. Researchers for CEDS plan to continue refining and updating their emission estimates and aim to generate estimations of uncertainty for recorded emission values.

TABLE 12-3. Clarification of the *adjusted emission growth rate* metrics.

WHAT THE METRICS ARE	WHAT THE METRICS AREN'T
The average annual growth rate in emissions over the years 2005–2014, adjusted based on the correlation between emissions and GDP, for sulfur dioxide (SO_2) and nitrogen oxides (NO_X)	• A measure of the raw amount of emissions of each pollutant • A measure of emission intensity, i.e., emissions per unit of economic output (GDP) • A measure of emission growth rate per capita • A measure of effects of pollution emissions on human health

Chapter 13. Agriculture

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Agriculture provides the food that every human needs, but agricultural productivity has often come at the expense of sustainability – and resulted in soil erosion, land use transformation that damages ecosystems, water pollution, and other harms (Alexandratos & Bruinsma, 2012). Of particular note, fertilizer rich in nitrogen supports plant growth and is vital to the agricultural sector (X. Zhang et al., 2015), but when mismanaged, fertilizers can cause widespread damage through nitrogen pollution (Bodirsky et al., 2014). To move toward a future of sustainable farming and ranching will require improved pollution control and more efficient use of resources to break this pattern. Indicators that measure the agricultural sector's environmental impact provide important tools for gauging global efforts to move nations to a sustainable food future.

1.2 INDICATORS

1.2.1 Sustainable Nitrogen Management Index (SNMI) [100% of issue category]
The *Sustainable Nitrogen Management Index (SNMI)* seeks to balance efficient application of nitrogen fertilizer with maximizing crop yields as a measure of the environmental performance of agricultural production (X. Zhang & Davidson, 2019).

MAP 13-1. Performance on Agriculture.

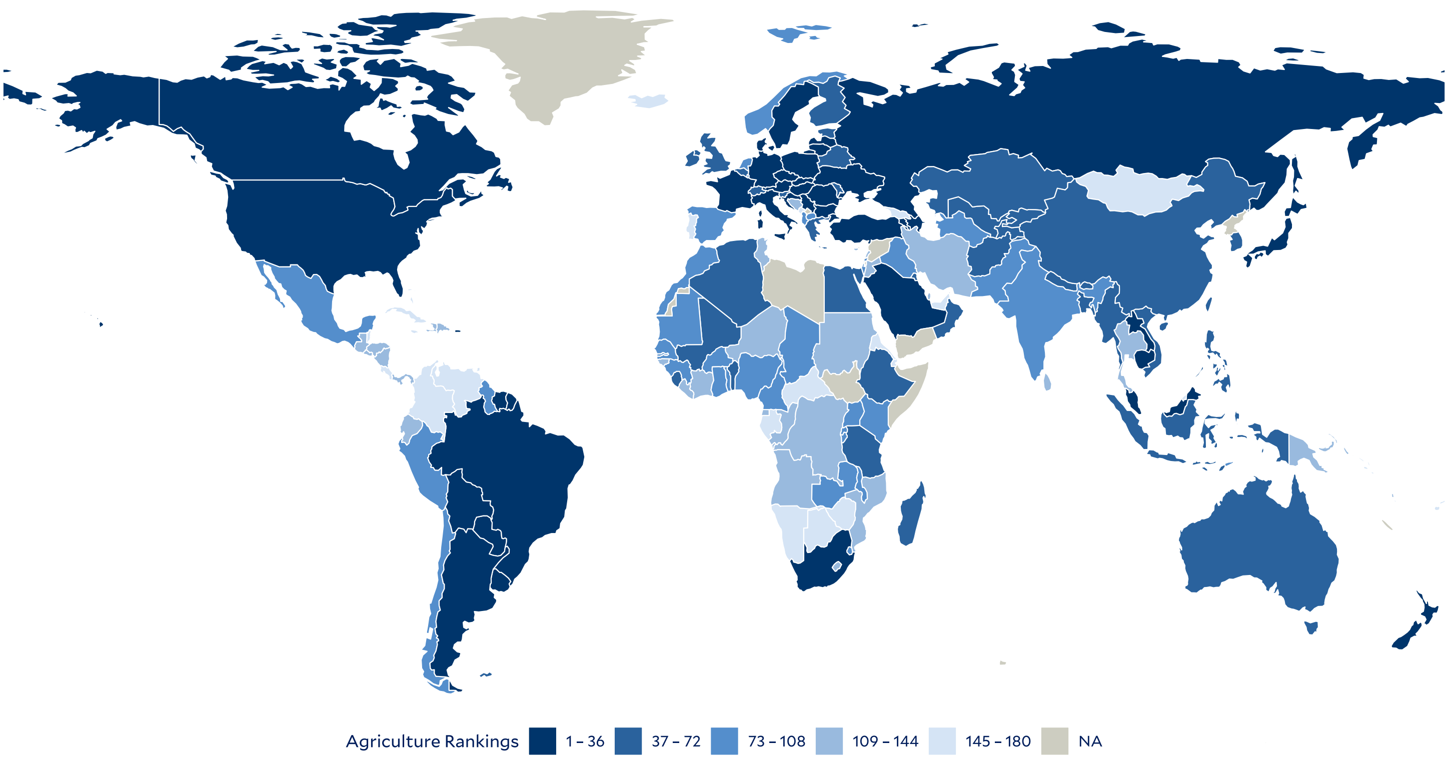


TABLE 13-1. Global scores and rankings on Agriculture.

RANK	COUNTRY	SCORE	REG
1	Ukraine	79.5	1
2	Argentina	78.4	1
3	Paraguay	77.9	2
4	Hungary	73.1	1
5	Denmark	73.0	1
6	United States of America	71.9	2
7	Uruguay	71.4	3
8	Serbia	69.9	2
9	Laos	69.2	1
10	Bolivia	68.9	4
11	Slovakia	68.8	3
12	Austria	68.0	3
13	Canada	67.3	4
14	Romania	65.7	4
15	Croatia	65.4	5
16	France	65.2	5
17	Brazil	65.0	5
18	Azerbaijan	64.3	2
	Saudi Arabia	64.3	1
20	Lithuania	64.1	6
21	Bulgaria	63.6	7
	Sweden	63.6	6
23	Malaysia	63.4	2
24	Latvia	62.8	8
25	Germany	61.9	7
26	Russia	60.5	3
27	Suriname	59.4	6
28	Cambodia	59.0	3
29	Czech Republic	58.7	9
30	Armenia	57.6	4
31	New Zealand	57.5	8
32	Poland	57.4	10
	Turkey	57.4	10
34	Italy	56.8	9
35	Japan	55.9	4
36	South Africa	54.4	1
37	United Kingdom	54.3	10
38	Myanmar	53.7	5
39	Taiwan	53.4	6
40	Ethiopia	53.3	2
41	Egypt	53.0	2
42	Greece	52.6	12
43	Finland	52.4	11
	Kyrgyzstan	52.4	5
45	Estonia	51.8	13
	Indonesia	51.8	7
47	South Korea	51.7	8
48	Afghanistan	51.0	1
49	Moldova	50.8	6
50	Oman	50.6	3
51	Madagascar	50.5	3
52	Viet Nam	50.3	9
53	Bhutan	50.2	2
54	Bangladesh	49.9	3
55	China	49.5	10
56	Australia	49.2	12
57	Switzerland	47.6	13
58	Uzbekistan	47.5	7
59	Belgium	47.3	14
	Ireland	47.3	14
61	Slovenia	47.0	14
62	Belarus	45.9	8
63	Nepal	45.8	4
64	Kazakhstan	45.6	9
65	Tajikistan	45.5	10
66	Kuwait	44.9	4
67	Algeria	44.8	5
68	Philippines	44.1	11
69	Tanzania	44.0	4
70	Mali	43.4	5
71	Benin	42.7	6
	Sierra Leone	42.7	6
73	Luxembourg	42.2	16
74	Eswatini	41.1	8
75	Ghana	41.0	9
76	North Macedonia	40.9	15
77	Cameroon	40.4	10
78	Chile	40.2	7
	Guyana	40.2	7
80	Netherlands	40.0	17
81	Turkmenistan	39.9	11
82	Togo	39.8	11
83	Burkina Faso	39.7	12
	Mauritania	39.7	12
85	Rwanda	39.4	14
86	Norway	39.3	18
87	Malawi	39.0	15
	Nigeria	39.0	15
89	Morocco	38.9	6
90	Mexico	38.8	9
91	Chad	38.7	17
	Uganda	38.7	17
93	Senegal	38.6	19
94	Albania	37.6	16
95	Iraq	37.4	7
96	Comoros	37.3	20
97	Peru	37.1	10
98	Burundi	37.0	21
99	Zambia	36.6	22
100	Spain	36.2	19
101	Gambia	36.1	23
102	Kenya	35.9	24
103	St. Vincent and Grenadines	35.4	11
104	Pakistan	35.1	5
105	Guinea	35.0	25
106	Israel	34.9	8
	Timor-Leste	34.9	12
108	India	34.7	6
109	Mozambique	34.4	26
110	Republic of Congo	34.3	27
111	Lebanon	34.1	9
	Tonga	34.1	13
113	Iran	33.8	10
114	Niger	33.6	28
115	Bahrain	33.2	11
	Sri Lanka	33.2	7
117	Thailand	33.1	14
118	Vanuatu	33.0	15
119	Côte d'Ivoire	32.0	29
120	Dem. Rep. Congo	31.7	30
121	Haiti	31.4	12
122	Papua New Guinea	31.3	16
123	Angola	29.3	31
124	Ecuador	29.2	13
125	Grenada	28.9	14
126	Guatemala	28.7	15
127	Malta	28.3	20
128	Equatorial Guinea	28.1	32
129	Cyprus	27.7	17
	Samoa	27.7	17
131	Guinea-Bissau	27.5	33
	Honduras	27.5	16
133	Lesotho	27.4	34
134	Qatar	26.6	12
135	Kiribati	26.5	18
136	Liberia	26.2	35
137	Panama	25.6	17
138	Bosnia and Herzegovina	25.1	18
139	Jordan	25.0	13
140	Sudan	24.7	14
141	Tunisia	24.3	15
142	Dominican Republic	24.2	18
143	Nicaragua	24.1	19
144	El Salvador	23.9	20
145	Zimbabwe	23.6	36
146	Venezuela	22.9	21
147	Jamaica	22.4	22
148	Colombia	22.3	23
	Eritrea	22.3	37
	Portugal	22.3	21
151	Central African Republic	21.9	38
152	Cuba	21.4	24
153	Gabon	20.6	39
154	Mauritius	20.0	40
155	Belize	19.9	25
156	Singapore	19.7	19
157	Costa Rica	19.4	26
	Micronesia	19.4	20
159	Montenegro	19.2	19
160	Iceland	18.5	22
161	São Tomé and Príncipe	18.2	41
162	Dominica	17.8	27
163	Georgia	16.9	12
164	Cabo Verde	16.7	42
165	Djibouti	15.7	43
166	Mongolia	15.4	21
167	Maldives	14.1	8
168	Bahamas	14.0	28
169	United Arab Emirates	13.7	16
170	Barbados	11.9	29
171	Namibia	11.5	44
172	Fiji	11.1	22
173	Seychelles	8.8	45
174	Solomon Islands	8.6	23
175	Saint Lucia	6.4	30
176	Trinidad and Tobago	5.2	31
177	Antigua and Barbuda	5.1	32
178	Botswana	4.8	46
179	Marshall Islands	1.7	24
180	Brunei Darussalam	0.0	25

Asia-Pacific
Eastern Europe
Former Soviet States
Global West
Greater Middle East
Latin America & Caribbean
Southern Asia
Sub-Saharan Africa

TABLE 13-2. Regional scores and rankings on Agriculture.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Argentina	78.4	2
2	Paraguay	77.9	3
3	Uruguay	71.4	7
4	Bolivia	68.9	10
5	Brazil	65.0	17
6	Suriname	59.4	27
7	Chile	40.2	78
	Guyana	40.2	78
9	Mexico	38.8	90
10	Peru	37.1	97
11	St. Vincent and Grenadines	35.4	103
12	Haiti	31.4	121
13	Ecuador	29.2	124
14	Grenada	28.9	125
15	Guatemala	28.7	126
16	Honduras	27.5	131
17	Panama	25.6	137
18	Dominican Republic	24.2	142
19	Nicaragua	24.1	143
20	El Salvador	23.9	144
21	Venezuela	22.9	146
22	Jamaica	22.4	147
23	Colombia	22.3	148
24	Cuba	21.4	152
25	Belize	19.9	155
26	Costa Rica	19.4	157
27	Dominica	17.8	162
28	Bahamas	14.0	168
29	Barbados	11.9	170
30	Saint Lucia	6.4	175
31	Trinidad and Tobago	5.2	176
32	Antigua and Barbuda	5.1	177

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Hungary	73.1	4
2	Serbia	69.9	8
3	Slovakia	68.8	11
4	Romania	65.7	14
5	Croatia	65.4	15
6	Lithuania	64.1	20
7	Bulgaria	63.6	21
8	Latvia	62.8	24
9	Czech Republic	58.7	29
10	Poland	57.4	32
	Turkey	57.4	32
12	Greece	52.6	42
13	Estonia	51.8	45
14	Slovenia	47.0	61
15	North Macedonia	40.9	76
16	Albania	37.6	94
17	Cyprus	27.7	129
18	Bosnia and Herzegovina	25.1	138
19	Montenegro	19.2	159

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Afghanistan	51.0	48
2	Bhutan	50.2	53
3	Bangladesh	49.9	54
4	Nepal	45.8	63
5	Pakistan	35.1	104
6	India	34.7	108
7	Sri Lanka	33.2	115
8	Maldives	14.1	167

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Denmark	73.0	5
2	United States of America	71.9	6
3	Austria	68.0	12
4	Canada	67.3	13
5	France	65.2	16
6	Sweden	63.6	21
7	Germany	61.9	25
8	New Zealand	57.5	31
9	Italy	56.8	34
10	United Kingdom	54.3	37
11	Finland	52.4	43
12	Australia	49.2	56
13	Switzerland	47.6	57
14	Belgium	47.3	59
	Ireland	47.3	59
16	Luxembourg	42.2	73
17	Netherlands	40.0	80
18	Norway	39.3	86
19	Spain	36.2	100
20	Malta	28.3	127
21	Portugal	22.3	148
22	Iceland	18.5	160

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Ukraine	79.5	1
2	Azerbaijan	64.3	18
3	Russia	60.5	26
4	Armenia	57.6	30
5	Kyrgyzstan	52.4	43
6	Moldova	50.8	49
7	Uzbekistan	47.5	58
8	Belarus	45.9	62
9	Kazakhstan	45.6	64
10	Tajikistan	45.5	65
11	Turkmenistan	39.9	81
12	Georgia	16.9	163

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Laos	69.2	9
2	Malaysia	63.4	23
3	Cambodia	59.0	28
4	Japan	55.9	35
5	Myanmar	53.7	38
6	Taiwan	53.4	39
7	Indonesia	51.8	45
8	South Korea	51.7	47
9	Viet Nam	50.3	52
10	China	49.5	55
11	Philippines	44.1	68
12	Timor-Leste	34.9	106
13	Tonga	34.1	111
14	Thailand	33.1	117
15	Vanuatu	33.0	118
16	Papua New Guinea	31.3	122
17	Samoa	27.7	129
18	Kiribati	26.5	135
19	Singapore	19.7	156
20	Micronesia	19.4	157
21	Mongolia	15.4	166
22	Fiji	11.1	172
23	Solomon Islands	8.6	174
24	Marshall Islands	1.7	179
25	Brunei Darussalam	0.0	180

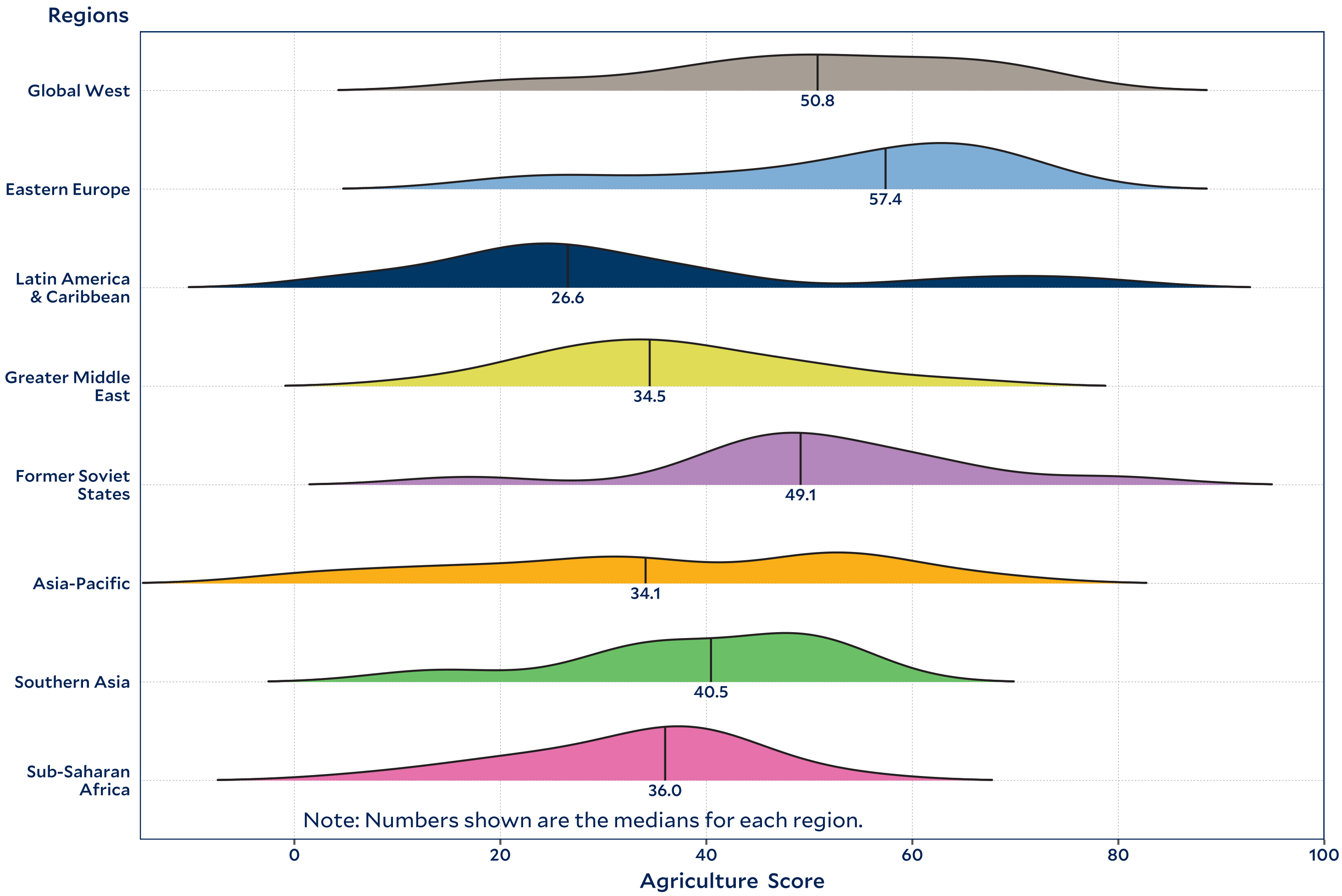
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	South Africa	54.4	36
2	Ethiopia	53.3	40
3	Madagascar	50.5	51
4	Tanzania	44.0	69
5	Mali	43.4	70
6	Benin	42.7	71
	Sierra Leone	42.7	71
8	Eswatini	41.1	74
9	Ghana	41.0	75
10	Cameroon	40.4	77
11	Togo	39.8	82
12	Burkina Faso	39.7	83
	Mauritania	39.7	83
14	Rwanda	39.4	85
15	Malawi	39.0	87
	Nigeria	39.0	87
17	Chad	38.7	91
	Uganda	38.7	91
19	Senegal	38.6	93
20	Comoros	37.3	96
21	Burundi	37.0	98
22	Zambia	36.6	99
23	Gambia	36.1	101
24	Kenya	35.9	102
25	Guinea	35.0	105
26	Mozambique	34.4	109
27	Republic of Congo	34.3	110
28	Niger	33.6	114
29	Côte d'Ivoire	32.0	119
30	Dem. Rep. Congo	31.7	120
31	Angola	29.3	123
32	Equatorial Guinea	28.1	128
33	Guinea-Bissau	27.5	131
34	Lesotho	27.4	133
35	Liberia	26.2	136
36	Zimbabwe	23.6	145
37	Eritrea	22.3	148
38	Central African Republic	21.9	151
39	Gabon	20.6	153
40	Mauritius	20.0	154
41	São Tomé and Príncipe	18.2	161
42	Cabo Verde	16.7	164
43	Djibouti	15.7	165
44	Namibia	11.5	171
45	Seychelles	8.8	173
46	Botswana	4.8	178

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Saudi Arabia	64.3	18
2	Egypt	53.0	41
3	Oman	50.6	50
4	Kuwait	44.9	66
5	Algeria	44.8	67
6	Morocco	38.9	89
7	Iraq	37.4	95
8	Israel	34.9	106
9	Lebanon	34.1	111
10	Iran	33.8	113
11	Bahrain	33.2	115
12	Qatar	26.6	134
13	Jordan	25.0	139
14	Sudan	24.7	140
15	Tunisia	24.3	141
16	United Arab Emirates	13.7	169

FIGURE 13-1. Regional performance on Agriculture



2. METHODS

The World Resources Institute's (WRI) *Indicators of Sustainable Agriculture: A Scoping Analysis* evaluated the state of research on agricultural systems in 2014. Surveying past and potential measurements, WRI identified five areas in which agricultural indicators are needed (Reytar et al., 2014, pp. 10–11):

1. *water*: indicators that reflect agricultural pressure on water resource use;

2. *climate change*: indicators that capture the impact of agriculture on greenhouse gas emissions;

3. *land conversion*: indicators that capture the conversion of natural land into agricultural land, or vice versa;

4. *soil health*: indicators that reflect the impact of agriculture on soil health and productivity; and

5. *pollution*: indicators that capture the environmental degradation caused by agricultural nutrient inputs, agricultural pesticides, and other pollutants.

Unfortunately, WRI's conclusions from six years ago still hold today. While there have been admirable efforts to address these issues in certain countries, the world still lacks the global data systems necessary to support these critical agricultural indicators. Existing studies are limited in geographical scope, infrequent or out-of-date, inconsistent in terms of methods, or otherwise unfit for measuring environmental performance according to the needs of the EPI, as explained in Chapter 15 on inclusion criteria. Given the centrality of agriculture to human well-being and its pervasive effects on ecosystem vitality, the data gaps in this issue category are among the most pressing the EPI team has identified.

2.1 INDICATOR BACKGROUND

The 2020 EPI uses the *SNMI* as a proxy for agricultural drivers of environmental damage. This metric, developed by Zhang and Davidson (2019), seeks to balance two pillars of sustainable agriculture. First, countries are assessed by their nitrogen use efficiency (NUE), the ratio of the amount of nitrogen absorbed by harvested crops during growth to the amount of nitrogen inputs, including fertilizer (X. Zhang et al., 2015). Second, countries are assessed on annual nitrogen yield, which is the amount of nitrogen bound up in harvested crops every year.

Ideally, nitrogen use efficiency should be equal to 1. When NUE is greater than 1, excess fertilizer, not used by plants as they grow, runs off from fields and pollutes waterways and other ecosystems. When NUE is less than 1, growing crops deplete nitrogen in the soil, leaving it less healthy and productive. Likewise, land should yield enough crops to feed the population, and maximizing production reduces the amount of land that must be devoted to agriculture. Zhang and Davidson (2019) set a lower threshold for sustainable yield at 90 kg N/ha/yr, based on the FAO's estimate of the "required nitrogen yield, averaged globally, to meet 2050 crop production targets without expanding the current crop land" (Alexandratos & Bruinsma, 2012).

Figure 13-2 shows the balance between NUE and yield, where the ideal point (+) represents an NUE of 1 and a yield of at least 90 kg N/ha/yr. A country can place itself on this grid given its NUE and yield in a given year, and then calculate its distance from the ideal point. At the optimum, *SNMI* is equal to zero, but *SNMI* grows as NUE deviates from 1 and yields drop below 90 kg N/ha/yr. Our indicator thus reflects the twin goals of sustainable agriculture – to maintain healthful diets while minimizing environmental impacts from our food systems.

2.2 DATA

Data on 197 countries over the period 1961–2015 are provided by Xin Zhang and colleagues at the University of Maryland Center for Environmental Science. They estimate NUE and yield using country-level data obtained from FAO's Corporate Statistical Database (FAOSTAT) (X. Zhang et al., 2015). The *SNMI* is the Euclidean distance of a country's normalized NUE and nitrogen yield from an ideal point. The methodology for *SNMI* is described in further detail in Zhang and Davidson (2019).

2.3 LIMITATIONS

The *SNMI* encompasses only part of the information necessary to capture country-specific agricultural management practices (Reytar et al., 2014). The two axes used to track the *SNMI*, nitrogen use efficiency and yield, are subject to country-specific variations and data availability limitations that hinder a more granular assessment of agriculture's environmental impacts. Regions have varying amounts of nutrients found in their soils and thus require different amounts of fertilizer to support agricultural yields. Nations can also be in nitrogen excess and deficiency at the same time (X. Zhang & Davidson, 2019). To address limitations concerning the assessment of national nitrogen yields, country-specific benchmarks are needed for normalizing findings (Reytar et al., 2014). The target for nitrogen yield in each country may differ from the FAO's general standard of 90 kg N/ha/yr used in the *SNMI*

Figure 13-2. Sustainable Nitrogen Management Index (SNMI) values are based on the Euclidean distance from an ideal point (+) defined by Nitrogen Use Efficiency (NUE) = 1, i.e., nitrogen is neither over-applied nor mined from the soil, and Yield ≥ 90 kg N/ha/yr, a universal standard for sufficient production of harvested nitrogen. The greater the distance from the ideal point, the worse the performance on SNMI. *Source: Based on X. Zhang & Davidson* [(2019, p. 2, Figure 1)](#).

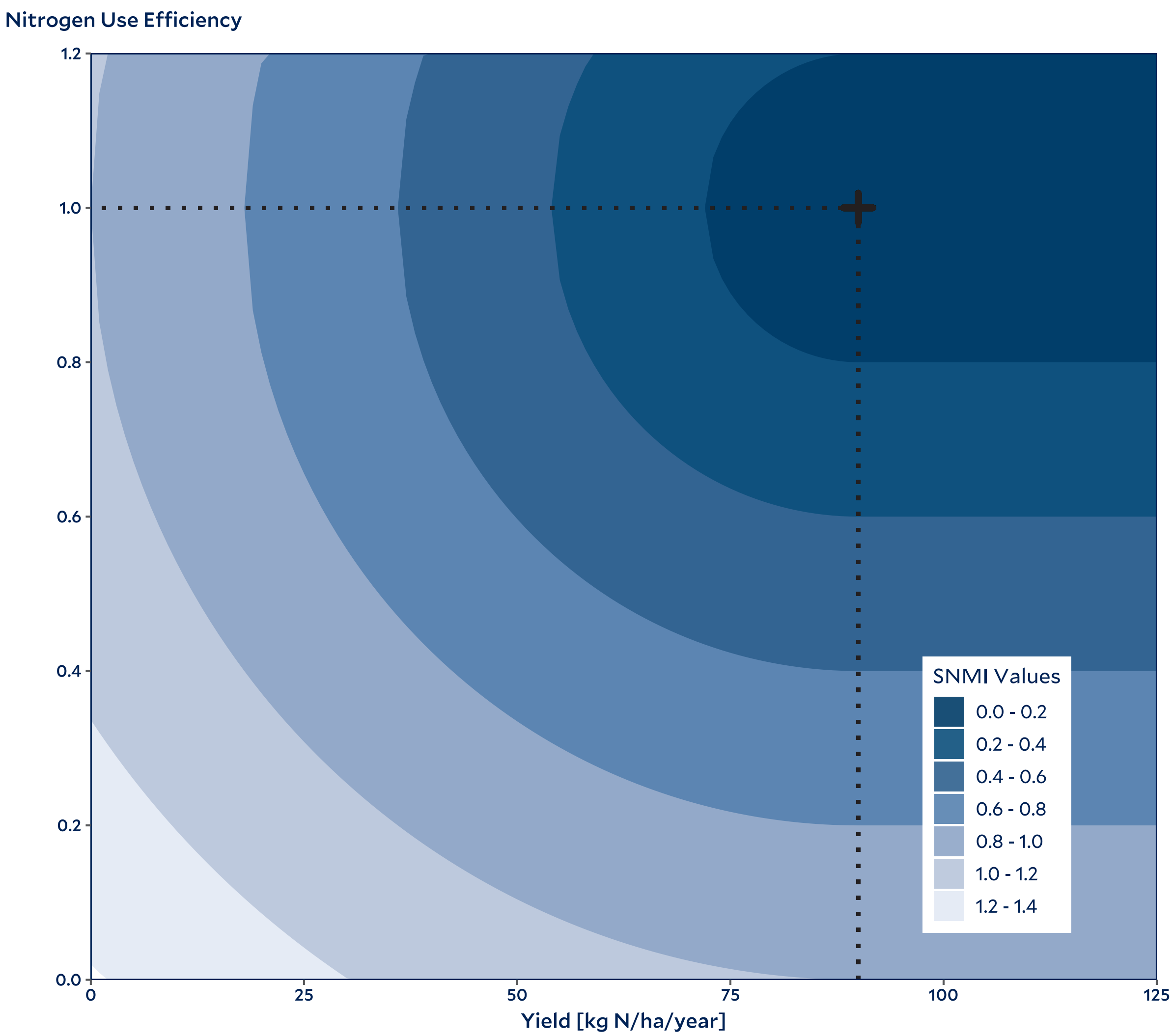


TABLE 13-3. Clarification of the *Sustainable Nitrogen Management Index.*

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
The Euclidean distance from an ideal point (+) defined by nitrogen use efficiency (NUE) = 1, i.e., nitrogen is neither over-applied nor mined from the soil, and Yield ≥ 90 kg N/ha/yr, a generic standard for sufficient production of harvested nitrogen.	**• A measure of the amount of nitrogen fertilizer applied to the soil • A measure of the amount of nitrogen pollution generated by agriculture • Differentiated by crop or soil type • A holistic measure of agricultural sustainability inclusive of water, climate change, land conversion, soil health, and pollution issues**

metric. To address these concerns, more research is needed to set country-specific targets (Alexandratos & Bruinsma, 2012; X. Zhang & Davidson, 2019).

Issues also arise from data reporting periodicity and gaps in sector-specific nitrogen uses. The most recent FAOSTAT data were taken from 2015, indicating a very long lag due to the FAOSTAT reporting process. In addition, the FAOSTAT database provides historical records of nitrogen fertilizer use but does not provide a breakdown of how the fertilizers have been used for pastures versus different crop types (X. Zhang et al., 2015). The world needs more timely and sector-specific data.

Furthermore, the indicator does not consider the impact from international trade. If international trade across croplands improves, nitrogen pollution has the potential to decrease (X. Zhang, 2017). Export- and import-oriented food production models influence the distribution of nitrogen pollution, which underscores the need to consider international trade in nitrogen emissions (Lassaletta et al., 2016). Despite these challenges, the *SNMI* represents an intermediate step toward measuring global sustainable agricultural productivity.

3. RESULTS

3.1 GLOBAL TRENDS

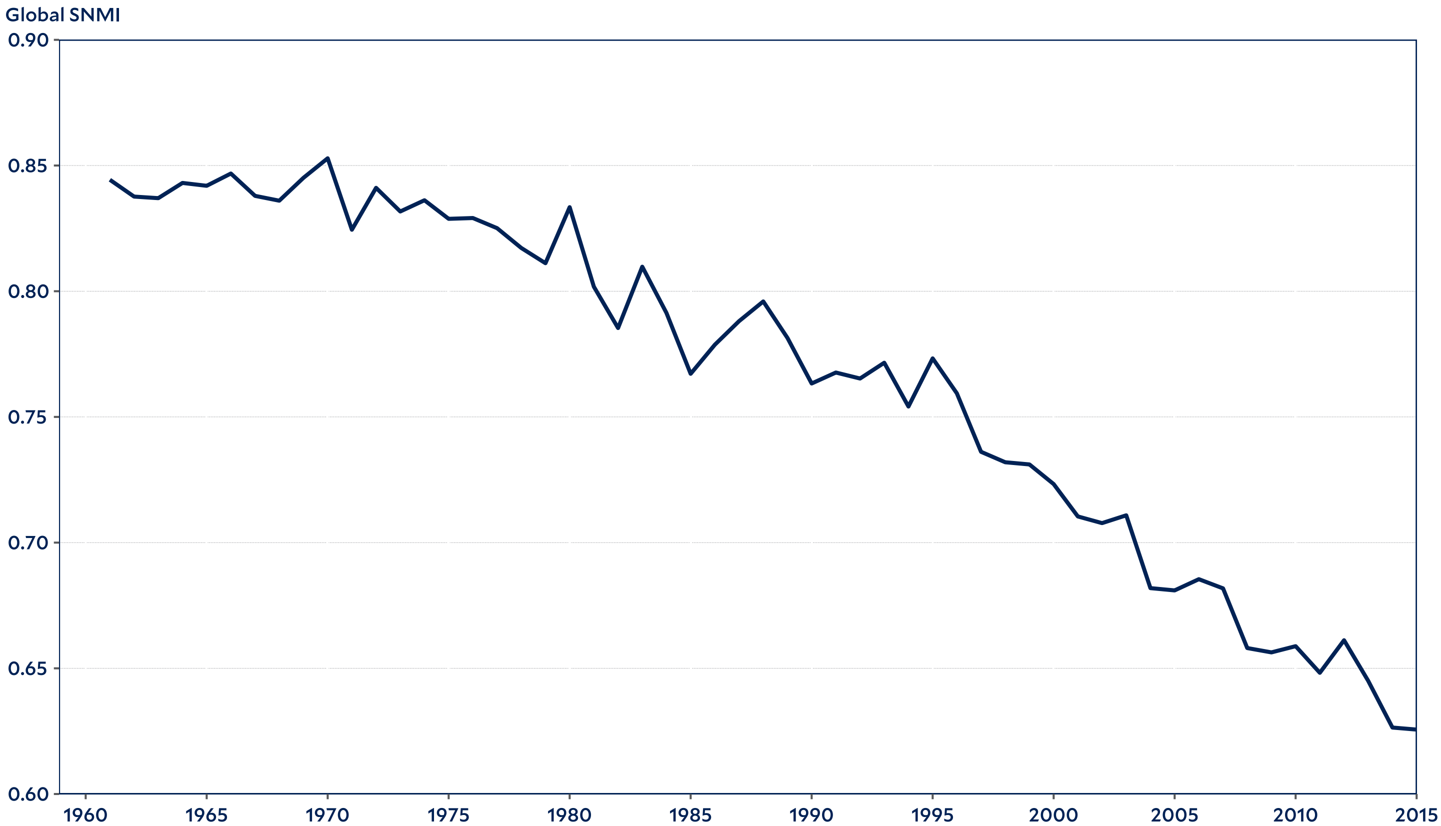
The global *SNMI* has improved gradually from 1961 to 2015, as shown in Figure 13-3. The most recent value, 0.63, is still far from the ideal of zero and would translate into a global score of 39.3, with little change in the previous decade. Internationally, 95 countries saw an improvement in performance while 81 saw a decline. Nitrogen mismanagement continues to pose several regional environmental hazards, including soil degradation and eutrophication. At the 2019 United Nations Environment Assembly 4 held in Nairobi, many nations, led by India, recognized the environmental threat of nitrogen loss and collectively resolved to establish a framework to regulate nitrogen emissions, similar to the existing structure for carbon containment policies (Sangomla, 2019).

In developed nations like the United States and EU Member States, the agriculture sector promotes efficiency by increasing yields while decreasing nitrogen inputs (X. Zhang et al., 2015). However, both the developed world and transitioning economies, including China and India – which together emit more than half of the world's nitrogen pollution – will need to make sharp increases in efficiency to reduce pollution (X. Zhang et al., 2015). Approaching a global *SNMI* of zero would require maintaining current yields while increasing NUE by approximately 30% before 2050 (X. Zhang et al., 2015).

3.2 LEADERS & LAGGARDS

The top performers demonstrate that advanced economies are generally better able to achieve high crop yields while managing nitrogen fertilizer use efficiency (X. Zhang et al., 2015, p. 53).

FIGURE 13-3. Global trend in Sustainable Nitrogen Management Index (SNMI), 1961–2015. Under ideal performance, SNMI would equal zero, and falling values indicate improved performance.*Source: Appalachian Laboratory, University of Maryland Center for Environmental Science*



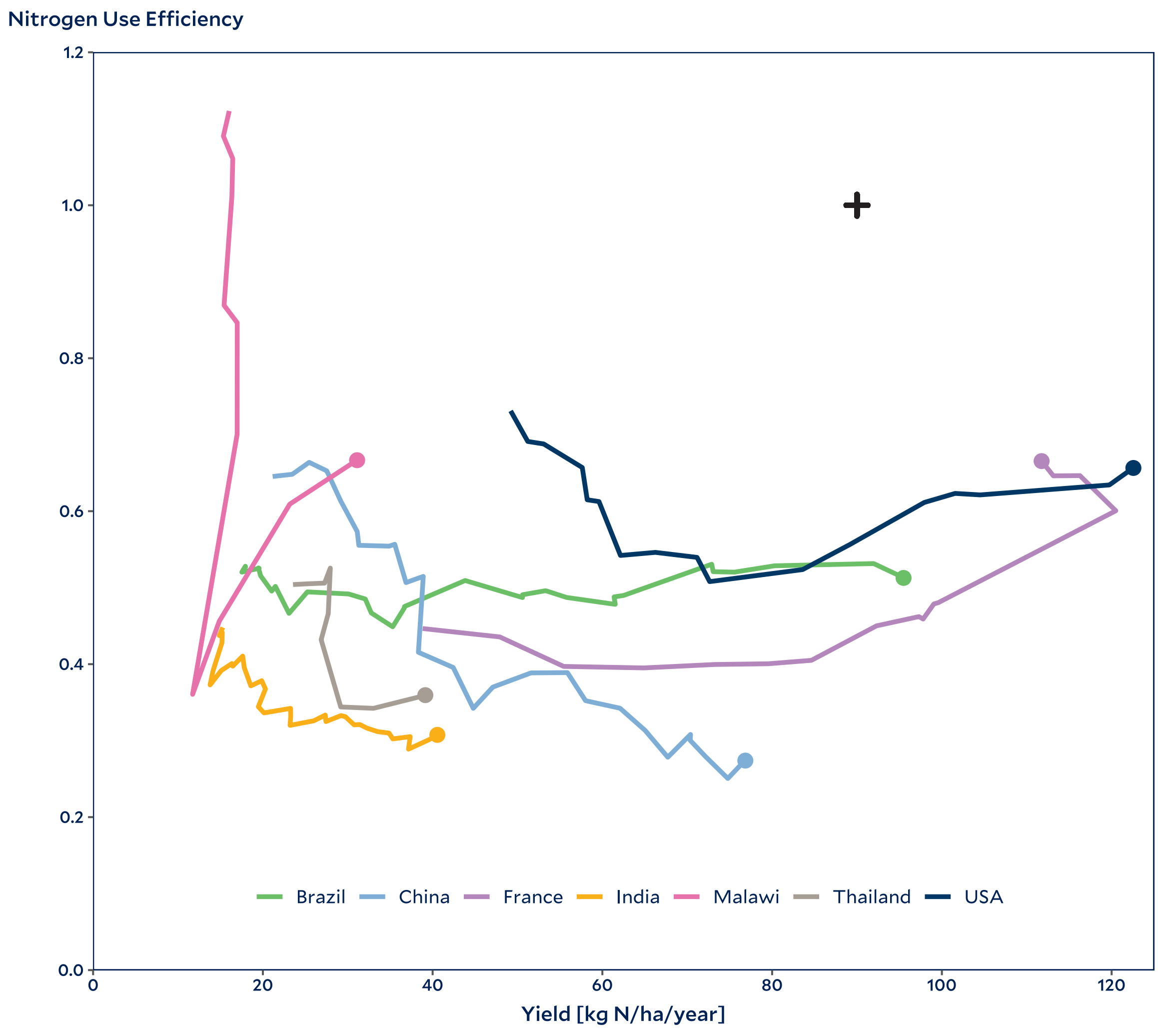
However, the global leader, Ukraine, has a GDP per capita roughly seven times lower than that of the sixth-place United States, demonstrating that factors other than economic development matter substantially as well. The presence of very wealthy countries among the laggards, including Singapore and the United Arab Emirates, further reinforces this point.

As shown in Figure 13-4, the historical performance of countries should trend toward the optimum point in the *SNMI* framework. The straight-line distance between the sets of yield and NUE equivalent scores, as represented by the iso-performance curves in Figure 13-4, illustrates the path countries should follow to improve overall performance. Top performers would achieve high yields along with efficient nitrogen use. Over four decades, Brazil and the United States have made remarkable progress in increasing yields, with the USA exceeding the FAO's generic baseline of 90 kg N/ha/yr more than two decades ago. However, there has been very little change in NUE over this period for these two breadbaskets. In contrast, France has managed to increase both yields and NUE. Aside from Brazil, the rest of the developing world, represented through the trend lines for Malawi and Thailand, shows less progress in yields and worrying declines in NUE. The challenge of sustainable agriculture is to bend these trajectories toward the ideal point.

The European Union implemented rules related to nitrogen fertilizer in 1991 under Directive 91/676/EEC, which likely contributed to improvements in NUE in Europe (van Grinsven et al., 2012, pp. 5150–5151, 5158; X. Zhang et al., 2015, p. 53). Additional efficiency gains from adapted nitrogen management practices, such as changes in fertilizer application techniques, followed the implementation of specific measures of the Common Agricultural Policy and EU Water Framework Directive (European Environment Agency, 2019c).

Europe, the United States, and Australia have championed the implementation of precision agricultural technologies (PATs) and constructive

FIGURE 13-4. Smoothed historical trends of seven countries showing yield compared to NUE over time, 1961–2015. Optimum performance indicated at (+), corresponding to Nitrogen Use Efficiency (NUE) = 1 and Yield ≥ 90 kg N/ha/yr. *Source: Appalachian Laboratory, University of Maryland Center for Environmental Science*



dietary habits as the next steps toward preserving natural capital while increasing agricultural productivity (Barnes et al., 2019). In the absence of PATs such as satellite farming or site-specific crop management, developed nations like the United States, Austria, and Sweden benefit from implementing progressive agriculture policies, but experience stagnation once these initial improvements are made. From 2000 to 2010, the EU's agricultural nitrogen balance improved, but since 2010 there has been no further improvement (European Environment Agency, 2019c). A report from Martinez et al. (2019) found that adoption of the World Health Organization's recommendations of a healthy diet, e.g., a 30% reduction in salt intake and limiting free sugars to less than 10% of total calories, can reduce the nitrogen footprint of European cities by 31% (WHO, 2018b).

Performance within South America is consistently high, with nations like Argentina, Paraguay, Uruguay, Bolivia, and Brazil in the top 20 globally. This high performance results from the smaller nitrogen footprint of South America's most common cash crops compared to those of other continents, as well as a shifting agricultural culture in the region. However, this high performance may also have deeper, concerning implications about future food production on the continent. Brazil is a major sugarcane producer, which is a highly efficient nitrogen user. However, the application of straw mulching combined with nitrogen fertilizer results in particularly high emissions of nitrous oxide, a harmful air pollutant (Bordonal et al., 2018). In Argentina, about 15% of wheat and corn and 45% of soybean are produced without any fertilizer application (Tan, 2018). While this increases Argentina's profits and NUE in the short-term, it overtaxes natural resources and cannot serve as a long-term solution for a nation with a growing population (Profeta, 2019). In Uruguay, the pilot phase of the Agricultural Transformation Pathways (ATP) initiative has defined development pathways for more sustainable agriculture (iD4D, 2016). Uruguay initiated this program in response to a report of dangerously high nitrogen levels in the nation's primary drinking water source, the Santa Lucia River basin (Barreto et al., 2017).

Consumption of fertilizer in Central America and the Caribbean is low compared to global averages, yet its performance in the *SNMI* remains poor. Nitrogen management is a serious problem throughout the region, where heavy rains can lead to excessive runoff and soil erosion. Despite these challenges, there remains an opportunity to protect the region's expansive natural forests by mitigating human impacts on the nitrogen cycle. Costa Rica, which ranked 157th in the world, is a prime example. Costa Rica is a leading producer of pineapples and coffee crops, both fertilizer-intensive agricultural products (Tye & Grinspan, 2019). However, a consortium of organizations including the University of Costa Rica's Environmental Pollution Research Centre, the Food and Agriculture Organization of the United Nations (FAO), and the International Atomic Energy Agency are exploring alternative methods of fertilization. Through the use of pineapple biochar, they hope to diminish the need for fertilizer and reduce residue, which can be a breeding ground for the dangerous stable fly (Gil, 2017).

Together, India and China represent more than half of global nitrogen pollution. Their practices and policies therefore carry a significant weight in global performance. In 2018, China managed to cut fertilizer use while improving crop yields through a comprehensive agricultural study that recommended methodological improvements to 21 million farmers. China made this important step toward restructuring its agricultural sector through workshops, on-site demonstrations, and outreach programs (B. Harris, 2018). At the same time, China has experienced a negative trend in nitrogen use efficiency, as has most of Southern Asia and the Pacific Islands. China demonstrated a regular NUE of 61% in 1961, while today it sits at just 25% (Pearce, 2018b). Across Asia, this decline in nitrogen efficiency has stemmed from low fertilizer prices and the crop selection of the "green revolution" of the 1960s (Pearce, 2018b). India has developed an increasing dependence on chemical fertilizers, which drives over 77% of the nation's nitrogen oxide emissions associated with agriculture (Jayaraman, 2018). The director of the National Rice Research Institute, Himanshu Pathak, estimates that, by 2050, the growing food demand in India will require a several-fold increase in nitrogenous fertilizer use (Jayaraman, 2018). A solution may rest in precision agricultural technologies (PATs), which are able to grow rice and wheat using a "subsurface drip fertigation system," along with other conservation agriculture approaches, such as regenerative agriculture. Together, these best practices use at least 40% less water and require 20% less nitrogen-based fertilizer (Meadu, 2019).

Chapter 14. Water Resources

1. SNAPSHOT

1.1 CATEGORY DESCRIPTION

Water is an essential element for delivering vital ecosystem services, ensuring public health, and sustaining global industries like agriculture, mining, manufacturing, and urban development. These water-intensive demands, coupled with climate change, are taxing the world's supply and quality of water. Assessing the global availability and sustainable management of water is difficult due to water's fluid and varied distribution above and below ground, as well as challenges in modeling large-scale hydrologic cycles. Ideally, countries would have reliable and consistent data collection and monitoring systems in place to track water quality and quantity at multiple geographic scales—from headwater streams to lakes, wetlands, and transboundary watersheds. Unfortunately, international data systems have not yet delivered standardized metrics appropriate for the EPI. Specifically, there are not methodologically consistent gauges of drinking water quality, aquifer depletion, and pollution levels in both groundwater and surface waters across the spectrum of countries covered by our analysis. As a result, we must rely on one proxy metric: *wastewater treatment*. We recognize that this indicator represents only a small fraction of human impacts on water resources and that policymakers urgently need a more robust framework of water quality and quantity metrics.

Water pollution and wasteful use of freshwater jeopardize the long-term welfare of our environment, economy, and public health, making effective wastewater management a fundamental necessity for nature and society. Households, industry, and agricultural processes can contaminate water with a variety of pollutants, including synthetic chemicals, organic matter, sediment, and heat, that harm life in rivers, lakes, and oceans. Treatment technologies remove these pollutants and make water safe to discharge into aquatic ecosystems – or to recycle into our built environment for further use. Reusing water has the additional benefit of reducing our need to withdraw water from natural flows in the first place, an especially important advantage in countries facing water scarcity (UN WWAP, 2017). Connecting people to adequate wastewater collection and treatment systems benefits the environment in many ways and remains an important target for sustainable development.

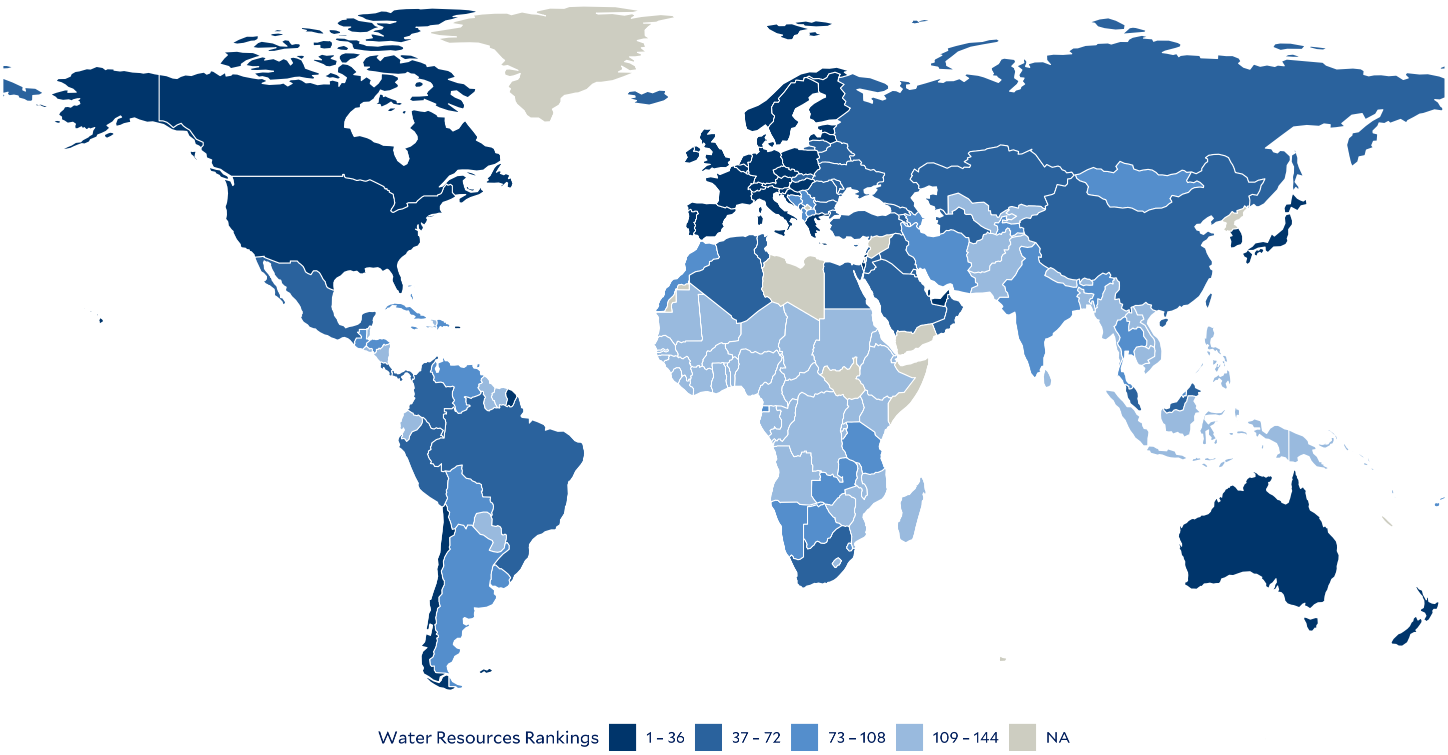
1.2 INDICATORS

1.2.1 Wastewater treatment [100% of issue category]

We measure *wastewater treatment* as the percentage of wastewater that undergoes at least primary treatment in each country, normalized by the proportion of the population connected to a municipal wastewater collection system.

14.

MAP 14-1. Rankings on Water Resources.



14.

TABLE 14-1. Global rankings, scores, and regional rankings (REG) on Water Resources.

RANK	COUNTRY	SCORE	REG
1	Denmark	100.0	1
	Finland	100.0	1
	Netherlands	100.0	1
	Singapore	100.0	1
	Sweden	100.0	1
6	Luxembourg	98.5	5
	United Kingdom	98.5	5
8	Germany	97.0	7
9	Switzerland	96.7	8
10	Austria	94.0	9
11	Australia	92.7	10
12	Spain	91.5	11
13	Latvia	90.7	1
14	Ireland	89.7	12
15	Slovenia	89.1	2
16	France	88.0	13
17	Bahrain	86.9	1
18	Greece	81.7	3
	Israel	81.7	2
20	New Zealand	79.9	14
21	South Korea	76.8	2
	United Arab Emirates	76.8	3
23	Japan	75.3	3
24	Chile	71.9	1
25	Qatar	70.0	4
26	Estonia	69.6	4
27	Belgium	67.9	15
28	Canada	67.4	16
29	Norway	64.3	17
30	Poland	60.9	5
31	Czech Republic	60.8	6
32	United States of America	58.9	18
33	Italy	58.8	19
34	Portugal	55.0	20
35	Hungary	53.8	7
36	Croatia	51.7	8
37	Lithuania	51.4	9
38	Cyprus	50.0	10
39	Brazil	49.3	2
40	Georgia	46.6	1
41	Peru	46.4	3
42	Slovakia	43.7	11
43	Kuwait	43.1	5
44	Tunisia	43.0	6
45	Egypt	42.0	7
46	Lebanon	38.2	8
47	Algeria	33.1	9
48	Mexico	31.6	4
49	Romania	30.4	12
	Turkey	30.4	12
51	Kazakhstan	28.6	2
52	Colombia	25.6	5
53	Panama	23.1	6
54	South Africa	21.7	1
55	Cabo Verde	20.9	2
56	Iraq	19.5	10
57	Jordan	18.6	11
58	Russia	18.5	3
59	Iceland	15.6	21
60	Ukraine	14.1	4
61	Bulgaria	13.9	14
62	Oman	13.4	12
63	Malaysia	12.4	4
64	Saudi Arabia	11.8	13
65	Turkmenistan	9.8	5
66	Costa Rica	9.7	7
67	China	9.4	5
68	Moldova	9.0	6
69	Armenia	8.8	7
70	Montenegro	8.4	15
71	Belarus	7.2	8
72	Taiwan	7.1	6
73	Guatemala	6.8	8
74	Venezuela	6.4	9
75	Namibia	6.2	3
76	Brunei Darussalam	6.0	7
77	Argentina	5.9	10
78	Dominican Republic	5.8	11
79	Eswatini	5.7	4
80	Morocco	5.4	14
81	Maldives	4.3	1
82	Zambia	4.2	5
83	Fiji	3.9	8
84	Azerbaijan	3.8	9
85	Iran	3.7	15
86	Cuba	3.6	12
87	Bolivia	3.5	13
88	Mongolia	3.3	9
89	Trinidad and Tobago	3.2	14
90	Honduras	3.1	15
91	Jamaica	3.0	16
92	Albania	2.7	16
93	Mauritius	2.5	6
94	India	2.2	2
	Tajikistan	2.2	10
96	Uruguay	2.1	17
97	Thailand	2.0	10
98	Serbia	1.7	17
99	Seychelles	1.6	7
100	Bahamas	1.4	18
	Tanzania	1.4	8
102	Antigua and Barbuda	1.3	19
103	Equatorial Guinea	1.2	9
104	Barbados	1.1	20
	Bosnia and Herzegovina	1.1	18
106	Botswana	1.0	10
	Dominica	1.0	21
108	Grenada	0.9	22
	North Macedonia	0.9	19
	Saint Lucia	0.9	22
111	St. Vincent and Grenadines	0.8	24
112	Paraguay	0.7	25
	Philippines	0.7	11
114	Belize	0.6	26
	Côte d'Ivoire	0.6	11
116	Kenya	0.5	12
	Senegal	0.5	12
118	Uganda	0.4	14
119	Lesotho	0.3	15
	Republic of Congo	0.3	15
119	Samoa	0.3	12
	São Tomé and Príncipe	0.3	15
	Timor-Leste	0.3	12
	Tonga	0.3	12
	Viet Nam	0.3	12
126	Kyrgyzstan	0.2	11
	Mozambique	0.2	18
	Nigeria	0.2	18
129	Comoros	0.1	20
	El Salvador	0.1	27
	Gambia	0.1	20
	Micronesia	0.1	16
	Pakistan	0.1	3
134	Afghanistan	0.0	4
	Angola	0.0	22
	Bangladesh	0.0	4
	Benin	0.0	22
	Bhutan	0.0	4
	Burkina Faso	0.0	22
	Burundi	0.0	22
	Cambodia	0.0	17
	Cameroon	0.0	22
	Central African Republic	0.0	22
	Chad	0.0	22
	Dem. Rep. Congo	0.0	22
	Djibouti	0.0	22
	Ecuador	0.0	28
	Eritrea	0.0	22
	Ethiopia	0.0	22
	Gabon	0.0	22
	Ghana	0.0	22
	Guinea	0.0	22
	Guinea-Bissau	0.0	22
	Guyana	0.0	28
	Haiti	0.0	28
	Indonesia	0.0	17
	Kiribati	0.0	17
	Laos	0.0	17
	Liberia	0.0	22
	Madagascar	0.0	22
	Malawi	0.0	22
	Mali	0.0	22
	Malta	0.0	22
	Marshall Islands	0.0	17
	Mauritania	0.0	22
	Myanmar	0.0	17
	Nepal	0.0	4
	Nicaragua	0.0	28
	Niger	0.0	22
	Papua New Guinea	0.0	17
	Rwanda	0.0	22
	Sierra Leone	0.0	22
	Solomon Islands	0.0	17
	Sri Lanka	0.0	4
	Sudan	0.0	16
	Suriname	0.0	28
	Togo	0.0	22
	Uzbekistan	0.0	12
	Vanuatu	0.0	17
	Zimbabwe	0.0	22

- Asia-Pacific
- Eastern Europe
- Former Soviet States
- Global West
- Greater Middle East
- Latin America & Caribbean
- Southern Asia
- Sub-Saharan Africa

TABLE 14-2. Regional rankings, scores, and global rankings on Water Resources.

LATIN AMERICA & CARIBBEAN

Reg Rank	Country	Score	Global Rank
1	Chile	71.9	24
2	Brazil	49.3	39
3	Peru	46.4	41
4	Mexico	31.6	48
5	Colombia	25.6	52
6	Panama	23.1	53
7	Costa Rica	9.7	66
8	Guatemala	6.8	73
9	Venezuela	6.4	74
10	Argentina	5.9	77
11	Dominican Republic	5.8	78
12	Cuba	3.6	86
13	Bolivia	3.5	87
14	Trinidad and Tobago	3.2	89
15	Honduras	3.1	90
16	Jamaica	3.0	91
17	Uruguay	2.1	96
18	Bahamas	1.4	100
19	Antigua and Barbuda	1.3	102
20	Barbados	1.1	104
21	Dominica	1.0	106
22	Grenada	0.9	108
	Saint Lucia	0.9	108
24	St. Vincent and Grenadines	0.8	111
25	Paraguay	0.7	112
26	Belize	0.6	114
27	El Salvador	0.1	129
28	Ecuador	0.0	134
	Guyana	0.0	134
	Haiti	0.0	134
	Nicaragua	0.0	134
	Suriname	0.0	134

EASTERN EUROPE

Reg Rank	Country	Score	Global Rank
1	Latvia	90.7	13
2	Slovenia	89.1	15
3	Greece	81.7	18
4	Estonia	69.6	26
5	Poland	60.9	30
6	Czech Republic	60.8	31
7	Hungary	53.8	35
8	Croatia	51.7	36
9	Lithuania	51.4	37
10	Cyprus	50.0	38
11	Slovakia	43.7	42
12	Romania	30.4	49
	Turkey	30.4	49
14	Bulgaria	13.9	61
15	Montenegro	8.4	70
16	Albania	2.7	92
17	Serbia	1.7	98
18	Bosnia and Herzegovina	1.1	104
19	North Macedonia	0.9	108

SOUTHERN ASIA

Reg Rank	Country	Score	Global Rank
1	Maldives	4.3	81
2	India	2.2	94
3	Pakistan	0.1	129
4	Afghanistan	0.0	134
	Bangladesh	0.0	134
	Bhutan	0.0	134
	Nepal	0.0	134
	Sri Lanka	0.0	134

GLOBAL WEST

Reg Rank	Country	Score	Global Rank
1	Denmark	100.0	1
	Finland	100.0	1
	Netherlands	100.0	1
	Sweden	100.0	1
5	Luxembourg	98.5	6
	United Kingdom	98.5	6
7	Germany	97.0	8
8	Switzerland	96.7	9
9	Austria	94.0	10
10	Australia	92.7	11
11	Spain	91.5	12
12	Ireland	89.7	14
13	France	88.0	16
14	New Zealand	79.9	20
15	Belgium	67.9	27
16	Canada	67.4	28
17	Norway	64.3	29
18	United States of America	58.9	32
19	Italy	58.8	33
20	Portugal	55.0	34
21	Iceland	15.6	59
22	Malta	0.0	134

FORMER SOVIET STATES

Reg Rank	Country	Score	Global Rank
1	Georgia	46.6	40
2	Kazakhstan	28.6	51
3	Russia	18.5	58
4	Ukraine	14.1	60
5	Turkmenistan	9.8	65
6	Moldova	9.0	68
7	Armenia	8.8	69
8	Belarus	7.2	71
9	Azerbaijan	3.8	84
10	Tajikistan	2.2	94
11	Kyrgyzstan	0.2	126
12	Uzbekistan	0.0	134

ASIA-PACIFIC

Reg Rank	Country	Score	Global Rank
1	Singapore	100.0	1
2	South Korea	76.8	21
3	Japan	75.3	23
4	Malaysia	12.4	63
5	China	9.4	67
6	Taiwan	7.1	72
7	Brunei Darussalam	6.0	76
8	Fiji	3.9	83
9	Mongolia	3.3	88
10	Thailand	2.0	97
11	Philippines	0.7	112
12	Samoa	0.3	119
	Timor-Leste	0.3	119
	Tonga	0.3	119
	Viet Nam	0.3	119
16	Micronesia	0.1	129
17	Cambodia	0.0	134
	Indonesia	0.0	134
	Kiribati	0.0	134
	Laos	0.0	134
	Marshall Islands	0.0	134
	Myanmar	0.0	134
	Papua New Guinea	0.0	134
	Solomon Islands	0.0	134
	Vanuatu	0.0	134

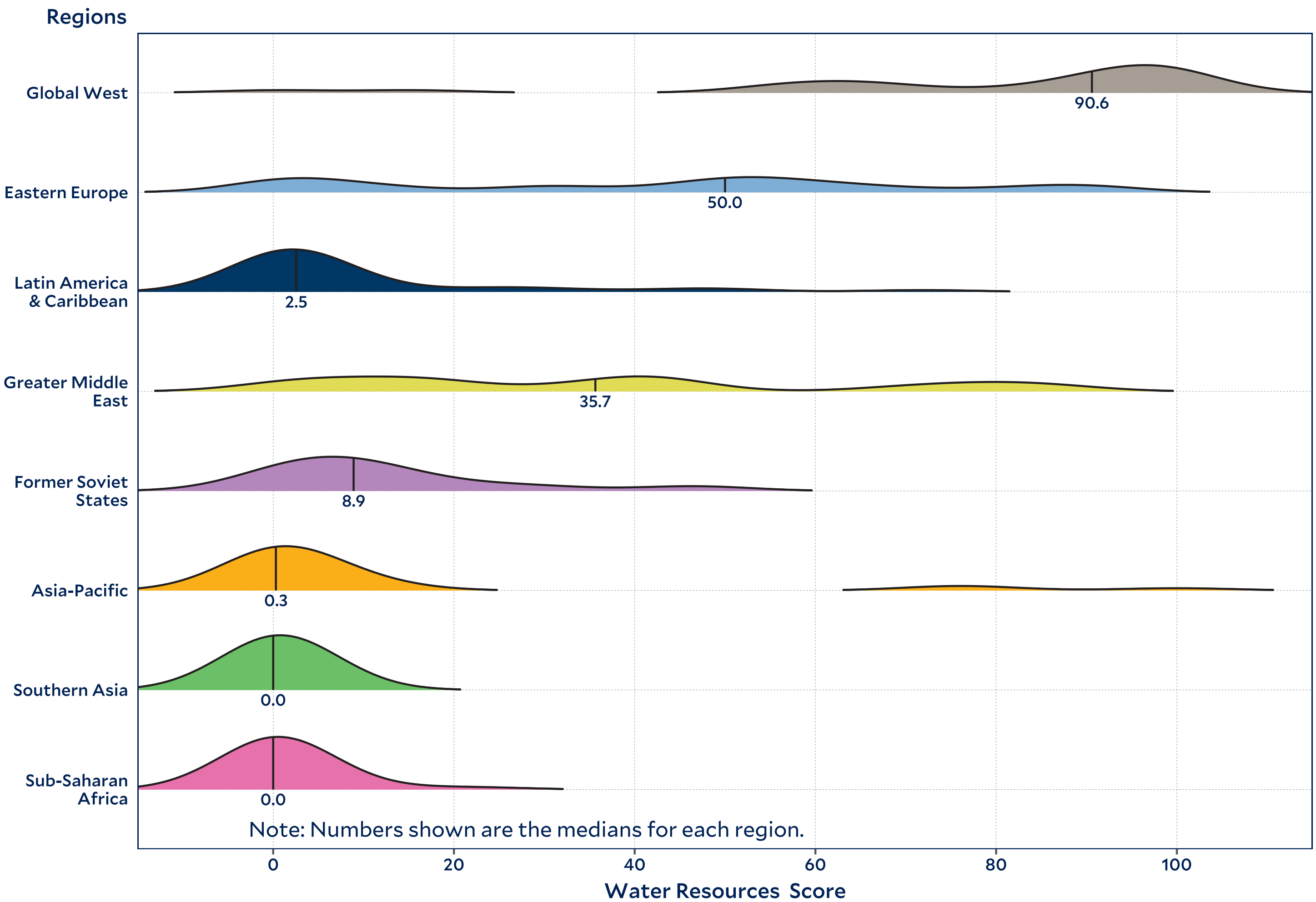
SUB-SAHARAN AFRICA

Reg Rank	Country	Score	Global Rank
1	South Africa	21.7	54
2	Cabo Verde	20.9	55
3	Namibia	6.2	75
4	Eswatini	5.7	79
5	Zambia	4.2	82
6	Mauritius	2.5	93
7	Seychelles	1.6	99
8	Tanzania	1.4	100
9	Equatorial Guinea	1.2	103
10	Botswana	1.0	106
11	Côte d'Ivoire	0.6	114
12	Kenya	0.5	116
	Senegal	0.5	116
14	Uganda	0.4	118
15	Lesotho	0.3	119
	Republic of Congo	0.3	119
	São Tomé and Príncipe	0.3	119
18	Mozambique	0.2	126
	Nigeria	0.2	126
20	Comoros	0.1	129
	Gambia	0.1	129
22	Angola	0.0	134
	Benin	0.0	134
	Burkina Faso	0.0	134
	Burundi	0.0	134
	Cameroon	0.0	134
	Central African Republic	0.0	134
	Chad	0.0	134
	Dem. Rep. Congo	0.0	134
	Djibouti	0.0	134
	Eritrea	0.0	134
	Ethiopia	0.0	134
	Gabon	0.0	134
	Ghana	0.0	134
	Guinea	0.0	134
	Guinea-Bissau	0.0	134
	Liberia	0.0	134
	Madagascar	0.0	134
	Malawi	0.0	134
	Mali	0.0	134
	Mauritania	0.0	134
	Niger	0.0	134
	Rwanda	0.0	134
	Sierra Leone	0.0	134
	Togo	0.0	134
	Zimbabwe	0.0	134

GREATER MIDDLE EAST

Reg Rank	Country	Score	Global Rank
1	Bahrain	86.9	17
2	Israel	81.7	18
3	United Arab Emirates	76.8	21
4	Qatar	70.0	25
5	Kuwait	43.1	43
6	Tunisia	43.0	44
7	Egypt	42.0	45
8	Lebanon	38.2	46
9	Algeria	33.1	47
10	Iraq	19.5	56
11	Jordan	18.6	57
12	Oman	13.4	62
13	Saudi Arabia	11.8	64
14	Morocco	5.4	80
15	Iran	3.7	85
16	Sudan	0.0	134

FIGURE 14-1. Regional performance on Water Resources.



2. RESULTS

2.1 GLOBAL TRENDS

Safeguarding clean water resources is an important measure of a country's environmental performance, given the centrality of water to all life and the severity of risks associated with water quality degradation. As demand for water increases from agriculture, industry, and households, countries must collect and treat wastewater to prevent pollution from harming human and ecosystem health. Our results reflect the preliminary assessment of global wastewater treatment conducted by Malik et al. (2015). Some countries perform well, but entire regions have serious gaps in their treatment and reporting levels. A staggering 122 countries fall below the global mean score of 18.1, while a select handful score significantly higher. Southern Asia and Sub-Saharan Africa both have median scores of 0.0, and Asia-Pacific earned a marginally higher median score of 0.3.

Proper wastewater treatment often requires substantial investments for infrastructure, especially in large cities. Such infrastructure includes pipes and lift stations to connect the population to the sewerage system and treatment plants capable of returning pollutant-free water to natural ecosystems. These infrastructural demands help to explain the low performance in developing countries, which face rapid levels of urbanization that outpace the capacity of municipal and federal governments to adequately finance and manage these infrastructure projects.

2.2 LEADERS & LAGGARDS

While most countries must improve their *wastewater treatment* performance, some countries are close to target in the Water Resources category. Strong policies in the European Union, Singapore, Bahrain, and Israel have encouraged strong performance in wastewater treatment. Wealthier countries tend to have higher wastewater treatment rates and use advanced treatment for a greater percentage of wastewater (UN WWAP, 2017).

Many countries with the best scores in this category also experience water stress. Water-stressed nations have a greater incentive to treat and recycle wastewater. According to WRI Aqueduct, the three best-performing non-European nations, Israel, Bahrain, and Singapore, experience extremely high water stress and rank in the top ten globally for this metric (WRI Aqueduct, 2015). They also possess the resources to undertake such infrastructural developments.

In the European Union, the Urban Waste Water Treatment Directive (91/271/EEC) requires Member States to report performance on wastewater collection and treatment (European Commission, 2017). This directive tracks collection rates and treatment at the secondary level and beyond. Compliance with the directive varies between Member States, but most EU countries that rank within the top ten for the 2020 EPI fully comply with the directive.

Malta is a notable exception. While Malta has wastewater treatment infrastructure in place, the country's water quality is threatened by agricultural waste discharge and high concentrations of salt in sewage (European Commission, 2017). Malta has low levels of rainfall, high temperatures, and no significant freshwater lakes or streams. These conditions strain the country's ability to provide adequate freshwater and force the country to rely on overburdened desalination plants that draw water from the Mediterranean Sea (Sapiano, 2019). A 2019 project funded by the EU seeks to improve wastewater treatment infrastructure to help Malta catch up to the imposed standards (European Commission, 2019b).

In South America, Chile outperforms its neighbors. Since 1998, Chile's regulatory regime for water and sanitation has been partially privatized, allowing water utility rates to reflect the cost of providing services. Under government supervision, state-owned regional water companies transformed into privately owned and operated urban water companies (Bitran & Valenzuela, 2003). An effective regulatory framework, paired with successful subsidies for water access among low-income communities, have contributed to Chile's strong performance.

In many Sub-Saharan African countries, overpopulated urban communities and inaccessibly remote communities both lack access to a wastewater treatment facility. Out of the 48 nations to receive a score of zero, 26 are located in sub-Saharan Africa, where urban populations are growing more rapidly than in any other region. Connecting households and businesses to wastewater treatment in growing cities and suburban outskirts is a financial and logistical challenge, but vital for maintaining human and ecosystem health.

Island nations such as Haiti, Marshall Islands, Indonesia, and Madagascar consistently performed poorly as well. Even Iceland's sewage treatment system does not meet EU standards, and the necessary infrastructure would cost 500 million USD (Iceland Review, 2017). Several islands in the Seychelles lack sanitation facilities, and despite a new treatment facility built on its third most populated island in 2018, Seychelles continues to underperform (Ernesta, 2019). Trinidad and Tobago's treatment system collects only 20% of domestic wastewater and treats only a portion of the water it collects (Charles, 2016).

3. METHODS

To provide the most useful information to decisionmakers, metrics on wastewater should contain a wide variety of data. An ideal wastewater metric would account for the various processes and sources that generate wastewater, such as household and commercial use, as well as information on how it is collected, the level of treatment it receives, and where it is discharged. As with all data used in the EPI, we advocate for adopting standardized methods of data collection and frequent reports to international bodies which could verify and disseminate the datasets. Unfortunately, the world is still far from this ideal, and even rudimentary data collection remains a challenge for many countries.

3.1 INDICATOR BACKGROUND

The EPI first introduced the *wastewater treatment* indicator in 2014, with a companion article describing its methodology, results, and limitations (Malik et al., 2015). To generate the *wastewater treatment* metric, we calculate the percentage of wastewater generated within a country that receives at least primary treatment. Primary treatment is defined as the physical removal of larger solids found in raw wastewater, usually done by coarse screening, grit removal, sedimentation, and comminution, the reduction of material into smaller fragments. Second, we multiply this treatment rate by the connection rate, or proportion of the country's population connected to a centralized sewage system.

3.2 DATA

Since the original *wastewater treatment* estimate in 2014, the EPI has made occasional updates to the data underlying the treatment and connection rates. The 2020 EPI builds on these efforts by turning to three main sources for more recent and accurate data: the United Nations Statistics Division (UNSD), the Organization for Economic Co-operation and Development (OECD), and Eurostat. The United Nations Environment Programme (UNEP) and the UNSD provide every country outside of the OECD and the EU an opportunity to report relevant data on their treatment of wastewater and connection rate in their biennial Questionnaire on Environment Statistics. The OECD and Eurostat, which cover only a fraction of the world's countries, collect data on members using their own joint questionnaire. When no recent data are available from these three sources, we resort to EPI records, drawing on the Pinsent Masons *Water Yearbooks* (2009, 2010, 2011, 2012), Global Water Intelligence data, individual country reports, and data on municipal wastewater for each country's largest cities. Even so, we still lack data on some components of our indicator in some countries. For the 2020 EPI, we impute missing data on wastewater treatment rates and connection rates – applying a 25% penalty to imputed estimates for failing to report information to UNSD, OECD, or Eurostat. Additional details about our imputation methods and data sources are available in our Technical Appendix and downloadable data files, as well as in Malik et al. (2015) and Supplementary Information.

3.3 LIMITATIONS

The 2020 EPI *wastewater treatment* indicator involves substantial data limitations, pointing to the need for future improvements in data collection and reporting to support more robust water quality and quantity metrics. Available wastewater datasets are infrequently updated, and several nations fail to report values to international data collectors. Data from multiple sources occasionally have different values for the same country, indicating differences in definitions or methods.

Unfortunately, many of the difficulties in constructing this indicator highlighted when it was first developed in 2014 still persist in the 2020 EPI. Data reporting on both components of wastewater treatment are sparse and must be assembled from a variety of data sources, including international organizations, government reports, and industry estimates. Few countries provide regular updates to reported figures, and many records are not current. Additionally, the EPI team continues to find that terms for wastewater treatment also do not share consistent definitions across data sources, complicating how disparate estimates can be reconciled and synthesized. Originally intended as a pilot to spur richer, standardized data collection, our *wastewater indicator* still remains, to our regret, an imperfect metric for gauging performance on Water Resources.

Further difficulty arises from attempts to standardize monitoring approaches for cross-country comparisons. Global data sharing is poor, and access to original data sources can get lost in data aggregation (Hering, 2017). Where national-level data are unavailable, municipal data sources may be used as proxies for national values. However, these data may not be representative of a country's overall wastewater treatment rate, as important wastewater sources such as agriculture and rural industrial plants can be overlooked (Malik et al., 2015). Even countries and cities that do collect data make infrequent updates, so tracking progress across time is difficult.

A final limitation is that most datasets do not distinguish simple filtration from more intensive wastewater treatment. Detailed information about the level of wastewater treatment is available from some developed countries, but such information is not sufficiently standardized or commonly available to create an indicator that compares the treatment level across countries. Greater international attention and discussion are needed to provide standardized, accurate, detailed, and frequent data on protection of water resources.

TABLE 14-3. *Clarification of the controlled solid waste* metric.

WHAT THE METRIC IS	WHAT THE METRIC ISN'T
The percentage of wastewater that undergoes at least primary treatment in each country, normalized by the proportion of the population connected to a municipal wastewater collection system	• A measure of total wastewater pollution or generation • A measure of wastewater treatment efficiency or quality • A measure of waste or pollution present in a nation's water supply • A measure of water resource quality, scarcity, or efficiency

Chapter 15. Methodology

As a composite index, the Environmental Performance Index distills data on many aspects of sustainability into a single number. This chapter describes the methods used in the 2020 EPI to gather data, translate metrics into scores, and aggregate indicators into the index. For a more general and authoritative explanation of approaches to the development of composite indices, we refer the reader to the OECD Handbook (Nardo et al., 2008). Our goal is to provide a composite index of environmental performance that is analytically rigorous, based on high-quality data and informed by sensible methodological choices.

We remain committed to producing the EPI under the principles of transparency, candidness, and openness. This chapter lays out some of the key decisions, assumptions, and choices we made in constructing the 2020 EPI (Papadimitriou et al., 2020). The online Technical Appendix contains further details on metadata, calculations, and other information on how we assemble the individual metrics, which is available at our website, epi.yale.edu, along with downloadable files containing the data and our results. Our goal is to provide enough information for any researcher to replicate our analysis – or make different methodological choices and calculate alternative scores. As with past reports, we have invited the European Commission Joint Research Centre to audit the 2020 EPI, also available on our website. While there is no one correct way to construct a composite index, we welcome and invite criticisms, feedback, and suggestions for future improvements.

1. DATA SELECTION

Advances in scientific investigation, sensing methods, and data reporting mean that the world's access to data on the state of the environment has never been richer. With every iteration of the EPI, we seek the best available data to produce useful and credible scores that permit us to gauge national government success in addressing urgent sustainability policy questions. This section describes our selection process and data sources.

1.1 INCLUSION CRITERIA

Data must match the purposes for which they are collected, and the EPI's purposes are to track performance on environmental outcomes and allow for comparisons between countries and over time. Not all environmental data address these goals, despite providing rich insights in other contexts. We have developed the following criteria to judge whether potential datasets enhance our understanding of environmental performance and increase the credibility of the EPI.

- **Relevance:** Data should measure something about the environment that is applicable to most countries in most circumstances.
- **Performance orientation:** Data should measure environmental issues that are amenable to policy intervention. Countries should not be penalized for environmental or resource endowments beyond their control. Indicators should also measure on-the-ground outcomes from policies rather than policy inputs. If direct measurement of outcomes is not possible, proxy measurements that are causally related to those outcomes may be acceptable substitutes. All of the EPIs indicators fall within the System or Impact categories of the Driving Force-Pressure-State-Impact-Response framework (see Bradley & Yee, 2015).
- **Established methodology:** Different governments, researchers, or stakeholders may attempt to measure the same thing in different ways, resulting in data that are not comparable across countries or time. To be included in the EPI, data should be measured using an established methodology, peer-reviewed by the scientific community or endorsed by an international organization.
- **Verification:** The most credible data are either verified by a third party or produced from a data collection process that a third party can openly access and audit to confirm results.
- **Spatial completeness:** A dataset is spatially complete if it covers a sufficient number of countries. Many studies are conducted at the regional level or for some set of countries, *e.g.*, the OECD, and so cannot provide information on the entire world. Sufficiency may be context dependent, but we generally accept datasets with at least 140 countries. Smaller datasets are acceptable if the subject matter applies only to a subset of the world's countries, *e.g.*, only those with coastlines.
- **Temporal completeness:** A dataset is temporally complete if it provides measurements across time. Some studies are one-off measurements that provide a snapshot. Such snapshots do provide information about environmental performance, but they cannot show trends. We therefore

prefer to use longitudinal data if available. It is also important that the producers of datasets demonstrate a commitment to continued production of data into the future.

- **Recency:** Newer datasets are more responsive to the needs of policymakers and other stakeholders, and we strive to find recent data collection efforts. For datasets that exist as time series, recent data are also indicative of data systems with the resources necessary to ensure ongoing collection and reporting.
- **Open source:** Data carry the greatest potential for raising awareness and driving policy when they are available without financial burden. Providers who offer data to the general public increase the reach of information and foster trust by opening themselves and their methods to greater scrutiny.

Ideally, each metric should satisfy all of these criteria. The EPI occasionally uses a dataset that falls short of these criteria for two reasons. First, an issue category may be so critically important to understanding environmental performance that it is necessary to use some metric rather than no metric. As long as an indicator provides some useful signal to policymakers and stakeholders about the state of the environment – when no better datasets are available – we may include an imperfect dataset. Second, in issue categories where global data systems are still emerging, the EPI may rely on pilot or nascent metrics to draw further attention to efforts that could benefit from greater support. In the interest of transparency, the EPI has always been candid about the limitations of the datasets used, and these are noted throughout the report.

1.2 DATA SOURCES

Data sets that satisfy the inclusion criteria typically come from international organizations, research institutions, academia, and government agencies. These sources use a variety of data collection instruments and approaches, including:

- Remote sensing data collected and analyzed by research partners;
- Observations from monitoring stations;
- Surveys and questionnaires;
- Estimates derived from both on-the-ground measurements and statistical models;
- Industry reports; and
- Government statistics, reported either individually or through nternational organizations, that may or may not be independently verified.

Complete details on the metadata for the 2020 EPI are provided in our Technical Appendix, available online at epi.yale.edu

2. COUNTRY-LEVEL DATA

For the first time, the 2020 EPI pays special attention to issues of sovereignty in our data collection and processing. Data providers have disparate purposes when they collect and report their data, with different levels of granularity. We receive or process all data in tabular form, with values given for each territory in each year. These territories usually have an official ISO 3166 designation, though occasionally other observations are available based on regions, historical unions, or subnational units. In time series data, especially, data may be available for countries that no longer exist or currently exist in smaller forms, *e.g.*, Yugoslavia or Sudan. As a practical matter, these historical data are not used in the calculation of EPI scores, but we assign the values from these historical countries to all successor states in our data cleaning process; *e.g.*, values for Sudan prior to 2011 are entered for both Sudan and South Sudan. This assignment may affect some back-casted scores but does not affect any of our trend-based indicators.

Data on territories that are formally under the control or protection of other countries pose an additional challenge. The EPI is meant to measure country-level performance, even while recognizing that environmental policy – and outcomes – may work within several levels of government, from national to local. Measuring country-level performance requires aggregating data for all territories under a sovereign government, which means making decisions about whether certain territories merit separate inclusion in our datasets. In making these decisions, we consider a number of questions, including whether territories exercise autonomy over their environmental policies, report environmental data through their own national statistical offices, or are usually aggregated into a sovereign's data reporting system. On balance, we include most territories as separate countries within the EPI database, even though many of them do not have sufficient data to calculate an EPI score. Otherwise, territories that we judge to lack sufficient distinction are typically small island possessions belonging to a handful of sovereign countries. A full list of territories and their disposition within the EPI database is in the online Technical Appendix. We recognize that such judgments are fraught with political sensitivities, and nothing about our country-level data aggregation should be interpreted as an endorsement or rejection of claims of autonomy or recognition; rather, we are forced to make decisions for the purposes of proceeding with our calculations and do so with caution.

3. INDICATOR CONSTRUCTION

One of the most important challenges to fostering data-driven policymaking is translating scientific and technical knowledge into terms that a general audience can understand. To this end, the EPI takes the data we receive from our providers and constructs indicators on a scale that identifies worst performance as a score of 0 and best performance as a score of 100. While some data sources offer metrics that are already intuitive, many other datasets require additional calculations and processing. Each issue category chapter in the 2020 EPI report describes the indicators in general terms, and the online Technical Appendix gives more details about the individual calculations. The Technical Appendix and all of our raw data are available for download at our website, epi.yale.edu.

3.1 STANDARDIZATION

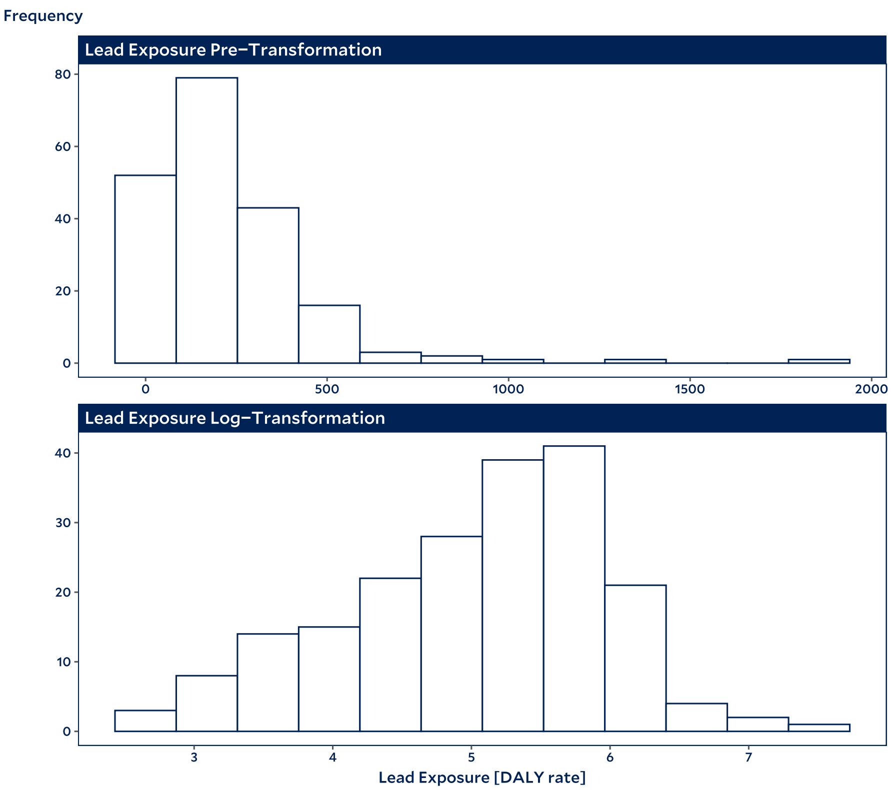
It is crucial to ensure that every metric of environmental performance allows for appropriate comparisons across countries and over time. Standardizing variables with a common denominator is common. For example, we control for the natural endowment of countries and their size in our indicator on *fish caught by trawling* by dividing the mass of fish caught by trawling by the total mass of fish caught, yielding a proportion. Similarly, our data on environmental health risks from the Institute for Health Metrics and Evaluation (IHME) are expressed as a rate per 100,000 people, but IHME also takes into account the structure of each country's population to produce age-standardized measures, meaning that metrics from countries with older populations can be compared with countries with younger populations. Several of the metrics in the 2020 EPI are based on trends, and calculating average annual growth rates in, for example, emissions of air pollutants, yields metrics that can be compared across countries regardless of the countries' sizes. While we try to control for every country characteristic that could confound comparison, perfect metrics are sometimes elusive. Just as we add and subtract data for each version of the EPI, we also refine our standardizations, trying to develop metrics that are insightful and comparable. The 2020 EPI reflects our current progress toward this goal, and we invite comments and suggestions for further improvements in how to standardize our indicators.

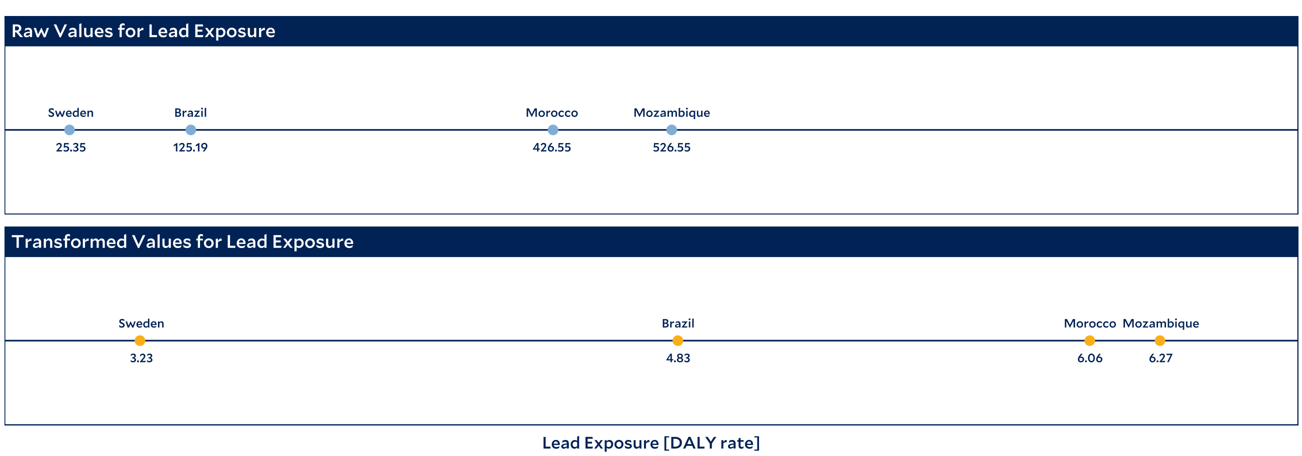
3.2 TRANSFORMATION

On theoretical and statistical grounds, even properly standardized metrics must be inspected for skewness. Skewed datasets have most countries clustered at one end of the distribution with few countries spread across the rest of the range of data values. In such cases we rely on logarithmic transformations, which improve the interpretation of results and spread out the countries crowded around one end of the range. This spread allows us to better differentiate between countries whose relative performances would otherwise be obscured. With raw data, only the countries at the extremes of the measurement spectrum can easily be compared, and making important distinctions between the leaders is difficult without a suitable transformation.

One of our metrics, *lead exposure*, illustrates the usefulness of transforming the data. In the upper panel of Figure 15-1, the histogram of raw values shows a typically skewed distribution, with most countries crowded around the low end, and the log-transformed distribution more closely approximating a normal curve. In the lower panel, four countries mark this transformation. The leaders, Sweden and Brazil, are separated by the same difference in DALY rate as the laggards, Morocco and Mozambique – about 100. Sweden is approximately 80% better than Brazil, while Morocco is only approximately 20% better than Mozambique. Improvements in performance are thus hard to compare between these pairs, as it may require different levels of effort for Mozambique to reach the DALY rate of Morocco than for Brazil to catch up with Sweden, especially if there are diminishing marginal returns for lead abatement programs. Figure 15-1 illustrates that the important differences in performance often aren't between leaders and laggards but among the leaders.

FIGURE 15-1. Transforming skewed data on lead exposure using the natural logarithm.
Note: DALY rate = age-standardized disability life-years lost per 100,000 people.





Logarithmic transformation aids in making appropriate comparisons based on percentage differences rather than absolute differences. Transforming the data also improves the interpretation of differences between countries where relative performance depends on the end of the spectrum into which they fall.

3.3 SCORING

The final step is to rescale the data into a 0–100 score. This process puts all indicators on a common scale that can be compared and aggregated into the composite index. The EPI uses the distance-to-target technique for indicator scoring, which situates each country relative to targets for best and worst performance – discussed in more detail below – corresponding to scores of 100 and 0, respectively. The generic formula for calculating the indicator is

Indicator Score =

$(X - W) / (B - W) \times 100$

Where

X is a country's value,

B is the target for best performance, and

W is the target for worst performance.

If a country's value is greater than *B*, we cap its indicator score at 100. Likewise, if a country's value is less than *W*, we set its indicator score to 0. Trimming off the tails of the underlying distribution is helpful because it prevents outliers from having undue influence on the resulting scores.

The EPI selects targets for best performance according to the following hierarchy:

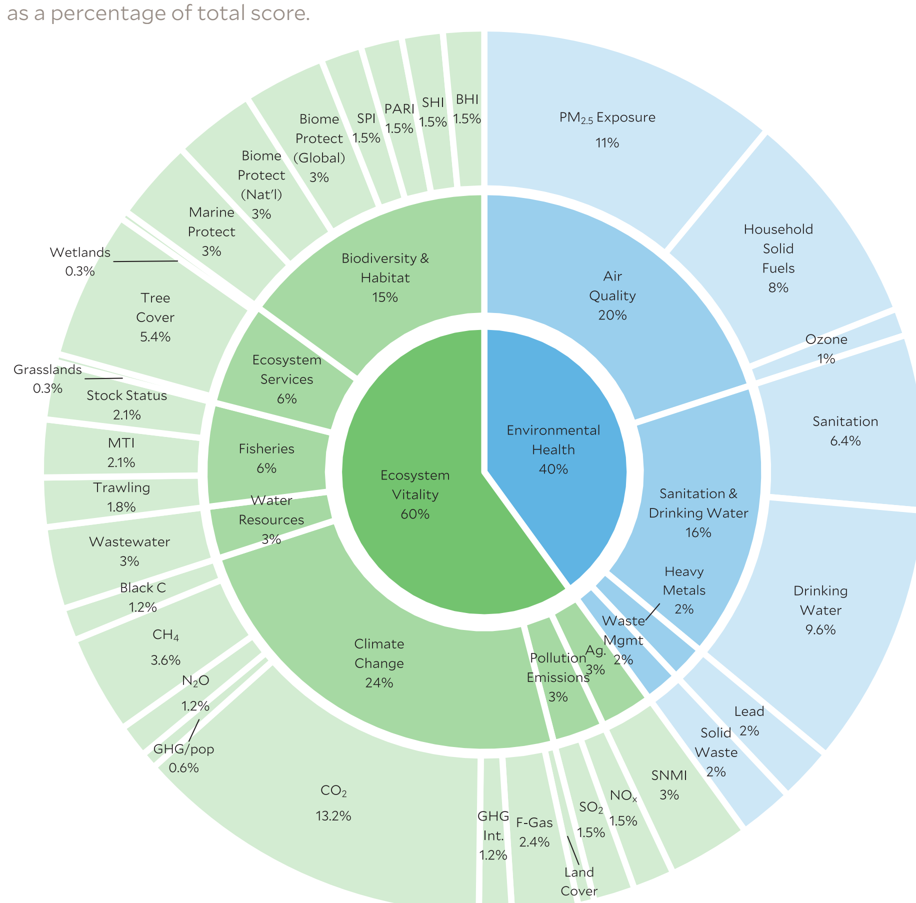
- Good performance is set forth in international agreements, treaties, or institutions. If there are no such targets,
- Good performance is based on the recommendation of expert judgment. If no such recommendations are available,
- Good performance is set at either the 95th or 99th percentile, depending on the distribution of the underlying data and the nature of the indicator.

Setting the target for worst performance follows a similar logic, though the first two criteria are rarely available. We usually set the worst performance target at the 1st or 5th percentile, depending on the distribution of the underlying data. For the 2020 EPI, we calculate percentiles using the complete panel of all available data for each indicator, not just using data from the most recent year or from the countries for which we produce EPI scores. Complete details about the targets are in the online Technical Appendix.

4. INDICATOR FRAMEWORK

Measuring a complex construct like environmental performance requires an organizing structure for the component metrics. The EPI uses a hierarchical framework that groups indicators within issue categories, issue categories within policy objectives, and policy objectives within the overall index; see Figure 15-2. The EPI has long used two policy objectives: Environmental Health,

FIGURE 15-2. The 2020 EPI Framework. The framework organizes 32 indicators into 11 issue categories and two policy objectives, with weights shown at each level as a percentage of total score.



which measures threats to human health, and Ecosystem Vitality, which measures natural resources and ecosystem services. These objectives reflect the dominant policy domains within which policymakers and their constituents generally deal with environmental problems. Many governments have departments or ministries devoted to public health and natural resources, whose portfolios correspond to the EPI policy objectives.

Likewise, the issue categories are organized along the lines most familiar to stakeholders within environmental policy. In the 2020 EPI, 32 indicators are grouped within 11 issue categories:

- Air Quality
- Sanitation & Drinking Water
- Heavy Metals
- Waste Management
- Biodiversity & Habitat
- Ecosystem Services
- Fisheries
- Climate Change
- Pollution Emissions
- Agriculture
- Water Resources

A country's EPI score is thus the starting point for further investigation, where one can drill down to inspect the scores at the levels of the policy objectives, the issue categories, or individual indicators. All scores for all countries can be viewed or downloaded at our website, epi.yale.edu.

5. WEIGHTING AND AGGREGATION

Within the framework hierarchy, the final step is to weight and aggregate each level to calculate the composite index. Indicator scores are aggregated into issue category scores, issue category scores into policy objective scores, and policy objective scores into final EPI scores. In the field of composite indices, there are various methods for weighting and aggregation (Munda, 2012; Munda & Nardo, 2009; Nardo et al., 2008, pp. 33ff). The EPI sacrifices sophistication in favor of transparency; at each level of aggregation we calculate a simple weighted arithmetic average. The weights used to calculate EPI scores (Figure 15-2) reflect a mixture of emphases determined by subjective best judgment, data quality, and analysis of global trends. These weights represent just one possible structure, and we recognize that users of the EPI may favor different weights. Our data are available for download from epi.yale.edu for those interested in trying alternative weights and aggregation methods.

5.1 POLICY OBJECTIVES

As in previous years, the relative weight given to each policy objective is informed by the variance of each. Environmental Health has a much wider spread – and more indicators – than Ecosystem Vitality (see Figure 15-2). A simple 50–50 weighting would give too much influence to the Environmental Health policy objective, masking the meaningful variation within Ecosystem Vitality. Without adjustment, countries that perform well on Environmental Health would score well on the EPI, with less input from their performance on Ecosystem Vitality. In order to help account for this potential imbalance, the 2020 EPI gives a weight of 40% to Environmental Health and 60% to Ecosystem Vitality. These weights do not reflect a prioritization of "nature" over humans, and we believe that ecosystem services are just as vital to human well-being as clean air and water. Rather, our choice of weights is guided by the data and serves to produce a more balanced and useful final score.

5.2 ENVIRONMENTAL HEALTH

Weights within the Environmental Health policy objective reflect two approaches to assigning weights. The 2020 EPI introduces a new indicator, *controlled solid waste*, within a new issue category, Waste Management. While we are hopeful that this indicator proves useful for shaping policy and inspiring greater attention in this issue category, we recognize that its novel nature also holds some degree of uncertainty in the underlying data and in the assumptions and decisions we made in its construction (see Chapter 7 for further discussion). We therefore assigned the issue category a modest weight of 5% of the policy objective. As our confidence in the metrics supporting Waste Management grows, we expect its weight may increase. The balance of indicators come from IHME and are measured in Disability Adjusted Life Year (DALY) rates (see Chapters 4–6). Aggregated to a global level, we find that the majority of DALYs lost are due to air pollution and, within that suite of risks, to ambient particulate matter ($PM_{2.5}$), which receive the greatest weights among the issue categories and indicators, respectively. All non-waste weights roughly correspond to the proportion of DALYs lost worldwide in the most recent year of available data (Blanc et al., 2008). Environmental Health is thus a combination of our regard for the data quality of a new indicator and an empirical analysis of the other metrics.

5.3 ECOSYSTEM VITALITY

Whereas the policy objective of Environmental Health has a largely data-driven basis for deriving weights, the selection of weights in Ecosystem Vitality, shown in Figure 15-2, is more subjective. We attempt to strike a balance between the relative gravity of each issue category and the quality of the underlying data. According to the Planetary Boundaries model (Rockström et al., 2009), the two leading threats to the environment are biodiversity loss and climate change. Biodiversity loss is largely captured in our Biodiversity & Habitat issue category (25%), though the indicators in Ecosystem Services (10%) and Fisheries (10%) also reflect threats to this planetary boundary. Within Climate Change (40%), the emissions trends are roughly weighted according to their relative contributions to climate forcing – another empirically determined weighting. The balance of the weight within Ecosystem Vitality lies with Pollution Emissions (5%), Agriculture (5%), and Water Resources (5%). Although we are aware of the importance of these issue categories, the low weights given to them here are due mainly to the paucity of indicators, lack of recent measurements, and low data quality. As new data become available for measuring these issue categories, different weights may emerge in future versions of the EPI.

6. MATERIALITY

Not every indicator is applicable to every country. Countries differ in natural resource endowments, geography, and physical characteristics. This is most evidently the case for countries that are landlocked or have very short coastlines, *viz.*, those where the coastline-to-land area ratio < 0.01. This materiality filter applies to 51 countries, of which 44 are included in the 2020 EPI, and these countries are not given scores on *marine protected areas* or any of the indicators in the Fisheries issue category.

7. MISSING DATA

Even datasets that meet our inclusion criterion for country coverage may have missing data. For data and countries to which our materiality filter applies, this is not an issue. Other data may not be relevant in every country, as for *tree cover loss* in countries with no starting tree cover or the *growth rate in F-gas emissions* in countries that do not produce these greenhouse gases. In yet other cases, as with the *Species Protection Index* and *Species Habitat Index*, the metric cannot be reliably calculated for small countries. In all these types of missing data, the EPI simply assigns a weight of zero to these indicators and redistributes the weight to the other indicators within each issue category during the aggregation step.

Some issue categories, however, suffer from a dearth of good data, resulting in only a single indicator. This is the case for Waste Management, Agriculture, and Water Resources (Figure 15-2). Missing data in these issue categories are problematic, and we must decide how to impute values. In doing so, we consider the reasons why the data are missing, especially whether countries had an opportunity to collect and report their data and failed to do so. Imputation may occur by means of regional averages, predictive models, or other assumptions. We describe details on the imputation of missing values for *controlled solid waste*, *Sustainable Nitrogen Management Index*, wastewater treatment rate, and connection rate to sewage in the online Technical Appendix.

8. BACKCASTING

Time series data allow for powerful within-country analysis, tracking changes in environmental outcomes either associated with policy or in need of further attention. We regret that we cannot currently use the 2020 methods to calculate annual EPI scores, for two major reasons. First, not all of our underlying data exist as time series. Second, our metrics have incongruent beginning and end years. Extrapolating synchronized time series for all datasets is beyond the scope of our analysis and would likely produce misleading results, as they could reflect our extrapolation method rather than on-the-ground conditions. Holding values constant across a common time horizon would likewise mask real-world changes in performance and give a false impression of country performance. We recommend that those interested in longitudinal analysis rely on specific issue categories or indicators for which time series are available. The data for these can be downloaded at our website, epi.yale.edu.

In the absence of annual scores, the 2020 EPI calculates scores based on the most recent year for which data are available, sometimes referred to as the "current" score. To give some reference for how performance changes over time, we also backcast a score using data approximately ten years prior to the most recent data, if available, sometimes referred to as the "baseline" score. For simplicity, we most often discuss the differences between the current and baseline scores as the ten-year change in performance. We describe further details about temporal coverage and backcasting in the online Technical Appendix.

9. GLOBAL SCORECARD

Beyond country-level scores, the 2020 EPI also reports scores on global performance. Where feasible, we aggregate data to the global level and construct indicator scores using the same transformations and targets as for the country scores. For most indicators, we are able to construct scores for both the most recent year and the baseline year. Unlike performance, which is most relevant in a country-level context, the global scorecard is most useful for assessing the current state of the world and progress toward international targets.

10. CHANGES FROM THE 2018 EPI

Every iteration of the EPI requires changes to the methodology. Innovation allows the EPI to take advantage of the latest advances in environmental science and analysis. We introduce new datasets, better standardizations, expanded country coverage, and other updates to increase the sophistication and usefulness of the index. Not every innovation endures, however, and the 2020 EPI, like previous iterations, learns from and drops experiments that are obsolete or problematic. In the interest of a more robust tool, we welcome feedback on every version of the EPI.

Changes in methodology between versions of the EPI mean that historical EPI scores are not comparable. Differences in EPI scores across EPI iterations are largely due to additions and subtractions of indicators, new weighting schemes, and other aspects of the methodology – not necessarily to decreased or increased performance. We therefore admonish users not to compare EPI scores or sub-scores across versions. Attempting to assemble time series or panel data of EPI scores from current and past versions of the EPI is strictly inappropriate. True within-country changes in performance are better assessed by using the 2020 EPI baseline scores or by inspecting time series of the raw data, when available.

10.1 SUBSTITUTIONS

Substitutions affect three indicators. First, we previously used two separate metrics on $PM_{2.5}$: *exposure* and *exceedance*. In order to harmonize all of the exposure risk indicators in the Environmental Health policy objective, we have replaced these metrics with the *ambient* $PM_{2.5}$ DALY rate from IHME. Second, we currently rely on a novel metric based on the *Marine Trophic Index*. Whereas our previous metric was our own contrivance, this new metric, described in Chapter 10, was developed by our data provider, Sea Around Us, who submitted it as an official indicator to the Inter-agency and Expert Group on Sustainable Development Goal Indicators.

10.2 DELETIONS AND ADDITIONS

We have increased the number of indicators used in the EPI from 24 to 32, with one deletion and nine additions.

- In Air Quality, we add *ozone exposure* as a new indicator.
- In Waste Management, itself a new issue category, we introduce our novel metric on *controlled solid waste*.
- In Biodiversity & Habitat, we add the *Biodiversity Habitat Index* for vascular plants, an indicator our provider, CSIRO, will continue to develop.
- We have renamed our previous issue category, Forests, as Ecosystem Services, as we've added two pilot indicators on *grassland* and *wetland losses*.
- In Fisheries, we've reintroduced *fish caught by trawling*.
- Climate Change contains the most changes to any of our issue categories. We dropped the indicator on *CO_2 emissions from power,* as the underlying data are not open source, one of our inclusion criteria. We've expanded the suite of greenhouse gases tracked to include F-gases, and we've introduced three new indicators meant to provide a performance signal on *CO_2 emissions from land cover*, *greenhouse gas emissions intensity trend*, and *greenhouse gas emissions per capita*.

10.3 REVISIONS

While retaining the broad constructs, we refined the calculations behind many of our indicators in ways that substantially improve accuracy and ease of interpretation. First, we changed how we define *marine protected areas*, excluding many areas that might have previously been so designated despite offering no actual protection to marine resources. Second, we fixed the algorithm for intersecting protected areas with *terrestrial biomes*, eliminating errors that previously generated inaccurate boundaries. These changes influence country scores in the Biodiversity & Habitat issue category. Third, we radically rethought how we handle emissions of greenhouse gases and air pollutants. In 2018, we attempted to balance three aspects related to performance: emission intensity trends, absolute emission intensity, and the level of economic development in most countries. Our calculations were complex at the sacrifice of interpretability and without the benefit of being particularly useful. Our metrics in the 2020 EPI are more straightforward and approach gauging emissions in an almost entirely different way. This new method affects indicators in the Climate Change and Pollution Emissions issue categories. We describe these methods in greater detail within each chapter and in the online Technical Appendix.

10.4 OTHER REFINEMENTS

Further refinements to the 2020 EPI involve a number of other adjustments common to all updates to our methodology. First, we revisit all data partners for the latest updates to their datasets. Second, we occasionally find alternative data providers that offer more recent, accurate, or complete data. Third, we may come to different conclusions on which indicators merit transformation, and we have chosen not to adjust *marine protected areas* for skewness, given that this over-rewards countries with very poor performance. Fourth, we adjust the targets for some indicators. Fifth, the weight scheme adjusts for deletion and addition of indicators, empirical analyses of global data, and subjective considerations. Sixth, the new suite of indicators requires examining which materiality filters are required. In 2020, retaining the materiality filter for marine indicators is still warranted, but we have chosen not to continue filtering for forest resources – or introducing new materiality filters for other ecosystems – on the grounds that small endowments of forests, grasslands, and wetlands should be more dear and deserving of protection in those countries where they remain. Complete details about all of our choices are described in the online Technical Appendix, and as always, we invite feedback on how we might sharpen our thinking and decisions in future versions of the EPI.

Chapter 16. References

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LINKS

DATA SOURCES

Institute for Health Metrics and Evaluation

World Database of Protected Areas

WWF Terrestrial Ecoregions of the World

Marine Regions

CSIRO Data Access Portal

Map of Life Indicators

ProtectedSeas

Global Forest Watch Interactive Map

Global Mangrove Watch - Ocean Data Viewer

Freshwater Ecosystems Explorer

Sea Around Us

Potsdam Institute for Climate (PIK) PRIMAP-hist Dataset

FLINTpro Global Run

Community Emissions Data System (CEDS)

UNSD Environmental Indicators

OECD Data

Eurostat

World Bank Databank

International Monetary Fund World Economic Outlook Database

United Nations Population Division

Worldwide Governance Indicators

The World Bank, Doing Business: Measuring Business Regulations

2020 Index of Economic Freedom

EXPERT CONTRIBUTORS

Esri Living Atlas of the World

Institute for Health Metrics and Evaluation

Commonwealth Scientific and Industrial Research Organisation

Map of Life

Google Earth Outreach

Global Forest Watch

Global Mangrove Watch

The Mullion Group

Sea Around Us

Jakub Nowosad, Ph.D.

Appalachian Laboratory, University of Maryland Center for Environmental Science

Xin Zhang, Ph.D.

JRC Competence Centre on Composite Indicators and Scoreboards (COIN)

YALE CENTER FOR ENVIRONMENTAL LAW & POLICY

The Yale Center for Environmental Law & Policy, a joint undertaking between Yale Law School and the Yale School of Forestry & Environmental Studies, advances fresh thinking and analytically rigorous approaches to environmental decisionmaking across disciplines, sectors, and boundaries. In addition to its research activities, the center aims to serve as a locus for connection and collaboration by all members of the Yale University community who are interested in environmental law and policy issues. The center supports a wide-ranging program of teaching, research, and outreach on local, regional, national, and global pollution control and natural resource management issues. These efforts involve faculty, staff, and student collaboration and are aimed at shaping academic thinking and policymaking in the public, private, and NGO sectors. envirocenter.yale.edu

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The Center for International Earth Science Information Network (CIESIN) is part of the Earth Institute at Columbia University. CIESIN works at the intersection of the social, natural, and information sciences, and specializes in online data and information management, spatial data integration and training, and interdisciplinary research related to human interactions in the environment. Since 1989, scientists, decision-makers, and the public have relied on the information resources at CIESIN to better understand the changing relationship between human beings and the environment. From its offices at Columbia's Lamont-Doherty Earth Observatory campus in Palisades, New York, CIESIN continues to focus on applying state-of-the-art information technology to pressing interdisciplinary data, information, and research problems related to human interactions in the environment. www.ciesin.columbia.edu

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DISCLAIMERS

The 2020 Environmental Performance Index tracks national environmental results on a quantitative basis, measuring proximity to policy targets using the best data available. Data constraints and methodological considerations make our project an ongoing effort, and we strive for improvements with every edition of the Index.

This report provides a narrative summary and analysis of the 2020 EPI, and we refer the reader to our website, epi.yale.edu, to explore the results in greater depth. We post all of our data online for download as well as a Technical Appendix and other materials that document our methods, assumptions, and decisions. Comments, suggestions, feedback, and referrals to better data sources are welcome at epi@yale.edu.

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


Environmental
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