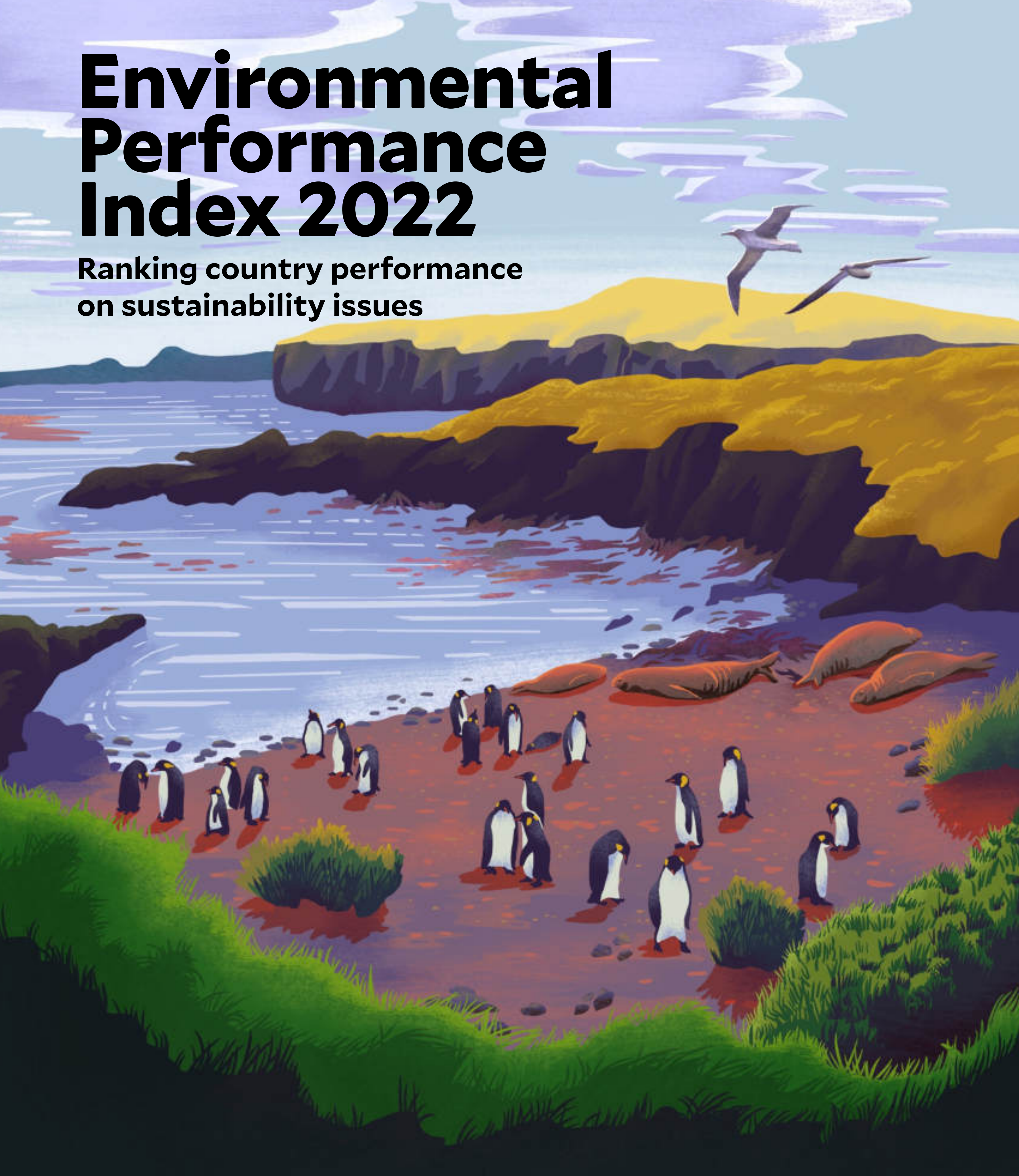
Environmental Performance Index 2022

Ranking country performance on sustainability issues



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EPI

The Environmental Performance Index

The 2022 Environmental Performance Index (EPI) provides a data-driven summary of the state of sustainability around the world. Using 40 performance indicators across 11 issue categories, the EPI ranks 180 countries on their progress toward improving environmental health, protecting ecosystem vitality, and mitigating climate change. 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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Cover Art

The cover of the 2022 EPI, by Lindsey Kernodle, celebrates one of the greatest environmental success stories of the past decade: global progress toward meeting Aichi Biodiversity Target 11 by protecting 10% of coastal and marine areas. Marine protected areas are vital to preserve biodiversity, sustain fish catch, and mitigate climate change. The work continues to ensure that every country meets its biodiversity and habitat targets.

The illustration depicts Marion Island, part of the Prince Edward Islands of South Africa. In 2013, the islands were declared a marine protected area. Marion Island is a critical breeding habitat for millions of sea birds and other wildlife. An ongoing intervention is trying to eradicate invasive mice that are harming bird populations.

Intellectual Property

Environmental Performance Index

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Abbreviations

ABNJ Areas Beyond National Jurisdiction

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

CIESIN Center for International Earth Science Information Network

CLRTAP Convention on Long-Range Transboundary Air Pollution

CO Carbon monoxide

CO_2 Carbon dioxide

COP Conference of the Parties (UNFCCC)

COVID-19 Coronavirus disease of 2019

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)

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

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)

MDG Millennium Development Goal

MFA Material flow accounting

MODIS Moderate-resolution imaging spectroradiometer

MPA Marine Protected Area

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 ($NO + NO_2$)

NOAA National Oceanic and Atmospheric Administration (U.S.)

NUE Nitrogen use efficiency

OECD Organization for Economic Co-operation and Development

PARI Protected Area Representativeness Index

Abbreviations

PIK Potsdam Institute for Climate Impact Research

PM2.5 Particulate matter having a diameter ≤2.5 microns

PPP Purchasing power parity

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

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

VOC Volatile organic compounds

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

Scientists across the world have provided new evidence and understanding of the environmental challenges that we face at global, national, and local levels. They have documented how the build-up of emissions — including air pollution, effluent flows into waterways, mismanaged waste, chemical releases, and greenhouse gas emissions — harms human health and ecosystems. Of particular note, the recent Sixth Assessment Report from the Intergovernmental Panel on Climate Change makes clear the urgent need to address the threat of climate change.

Carefully constructed and methodologically rigorous environmental indicators allow us to track trends, identify emerging pollution problems, gauge the success of policy interventions, and ensure that our investments in environmental protection offer the greatest returns possible. Data-driven metrics promise to enhance environmental decision-making and steer the world toward a more sustainable future — but only if policymakers embrace fact-based analysis and act on the insights that emerge from the data.

The 2022 Environmental Performance Index (EPI) offers a data-rich sustainability scorecard that translates cutting-edge scientific findings into policy insights.

Using 40 performance indicators, the EPI ranks 180 countries on their national efforts to protect environmental health, enhance ecosystem vitality, and mitigate climate change.

These indicators measure how close countries are to meeting internationally established sustainability targets for specific environmental issues. While the overall EPI scores provide a way to spotlight sustainability leaders and call out laggards, the accompanying disaggregated data offers a more refined tool for identifying policy weaknesses and anomalies, as well as proven programs that countries can adopt from their top-performing peers.

With a methodology refined over two decades that builds on the most recent data, the EPI enables decision-makers to recognize the drivers of top-tier performance. Analysis of the EPI data demonstrates that financial resources, good governance, human development, and regulatory quality matter for elevating a country's sustainability. Highlighting these connections, the EPI helps to promote sustainable development in support of a more environmentally secure and equitable future (Figure ES-1).

Leaders and Laggards

High-scoring countries exhibit longstanding and continuing investments in policies that protect environmental health, preserve biodiversity and habitat, conserve natural resources, and decouple greenhouse gas emissions from economic growth. Denmark tops the 2022 rankings — an achievement rooted in strong performance across nearly all issues tracked by the EPI, with notable leadership in efforts to promote a clean energy future and sustainable agriculture. The United Kingdom and Finland place 2nd and 3rd, both earning high scores for slashing greenhouse gas emissions in recent years.

Lagging its peers, the United States places 20th out of 22 wealthy democracies in the Global West and 43rd overall. This relatively low ranking reflects the rollback of environmental protections during the Trump Administration. In particular, its withdrawal from the Paris Climate Agreement and weakened methane emissions rules meant the United States lost precious time to mitigate climate change while many of its peers in the developed world enacted policies to significantly reduce their greenhouse gas emissions.

Innovations in the EPI methodology continue to shed light on new environmental issues and identify worrying trends — especially as data coverage improves in the developing world. Based on the latest scientific insights and environmental data, India ranks at the bottom of all countries in the 2022 EPI, with low scores across a range of critical issues. Deteriorating air quality and rapidly rising greenhouse gas emissions pose especially urgent challenges. Many bottom-tier countries face war and other sources of unrest as well as a lack of financial resources to invest in environmental infrastructure.

Insufficient Climate Action

In the 2021 Glasgow Climate Pact, the global community established a target of net-zero greenhouse gas emissions by mid-century and committed to more ambitious climate policies in pursuit of this aim. The 2022 EPI supports these goals with a new indicator that projects countries' progress toward reaching net-zero emissions in 2050.

The groundbreaking analysis undergirding this metric shows that only a handful of countries — including Denmark and the United Kingdom — are currently slated to reach greenhouse gas neutrality by 2050. Many other nations are headed in the wrong direction, with rapidly rising greenhouse gas emissions in major countries like China, India, and Russia. The *projected emissions in 2050* metric is a tool that policymakers, the media, business leaders, non-governmental organizations, and the public can use to gauge the adequacy of national policies, spotlight the largest contributors

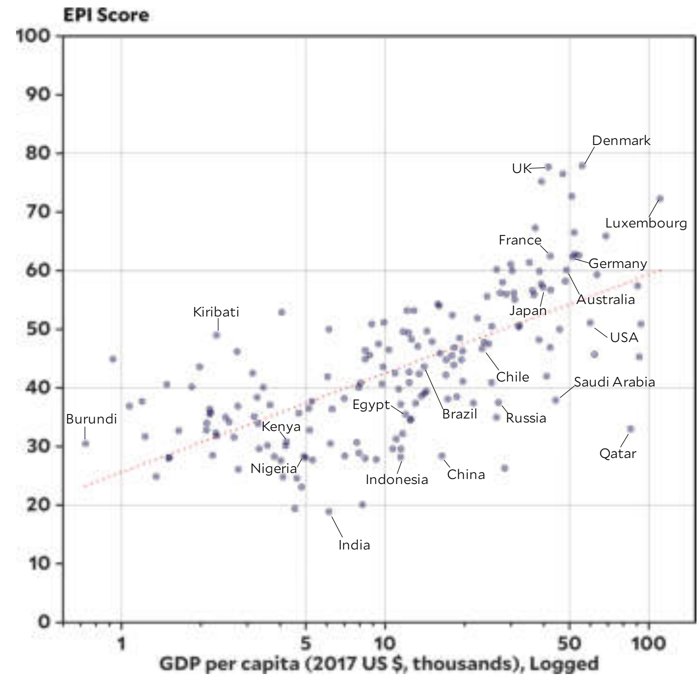

Figure ES-1. EPI scores are correlated with country wealth, although some countries outperform their economic peers while others lag.

to climate change, and galvanize support to improve the emissions trajectories of those who are off-track.

EPI projections indicate that just four countries — China, India, the United States, and Russia — will account for over 50% of residual global greenhouse gas emissions in 2050 if current trends hold. A total of 24 countries will be responsible for nearly 80% of 2050 emissions unless decision-makers strengthen climate policies and emissions trajectories change.

COVID-19 and Sustainability

Economic and societal disruptions stemming from the COVID-19 pandemic continue to add to the challenge of meeting the sustainability imperative. Although remarkable improvements in air quality and reductions in greenhouse gas emissions followed early lockdowns and fundamental shifts in economic activities, these gains came at a terrible cost in terms of human health and economic well-being. Policymakers now have a chance to rebuild their economies and societies on a more sustainable basis that preserves the pandemic-induced gains in environmental health and ecosystem vitality — but the latest data suggest that policymakers across much of the world are squandering this opportunity.

Air pollution has rebounded to pre-pandemic levels almost everywhere, as have many countries' greenhouse gas emissions. COVID-19 has also pushed the world further away from a circular economy, generating millions of tons of plastic waste as healthcare systems and people use facemasks, plastic food containers, and personal protective equipment.

Enhanced Environmental Insights

Ongoing advancements in environmental monitoring and data reporting enable the 2022 EPI to introduce several innovative metrics. Among the data breakthroughs are four new air quality indicators that track exposure to sulfur dioxide, nitrogen oxides, carbon monoxide, and volatile organics.

New metrics that gauge *recycling rates* and *ocean plastic pollution* join the Waste Management issue category, tracking countries' efforts to attain closed-loop economies. In recognition of the critical role of agriculture in promoting healthy societies, the 2022 EPI also includes a pilot indicator on *sustainable pesticide use*. As policymakers around the world adopt a more empirical approach to governance, the EPI's new insights promise to support the transformations necessary for a sustainable future.

A Comprehensive Environmental Index

The Environmental Performance Index distills data on many sustainability issues into a single score for each country — as well as providing a more disaggregated picture of specific environmental issues. Every iteration of the EPI incorporates the best available data and expands the scope of the sustainability scorecard as new research and insights emerge.

As the most comprehensive global environmental analysis ever published, the 2022 EPI leverages 40 performance indicators grouped into 11 issue categories (Figure ES-2). These issue categories are in turn aggregated into 3 policy objectives: Environmental Health, Ecosystem Vitality, and Climate Change. To make the EPI metrics broadly accessible, the EPI team transforms the raw environmental data into indicators that place countries on a 0–100 scale from worst to best performance. Scores for all 180 countries included in the EPI are fully discussed in the report and can be explored on our website: epi.yale.edu.

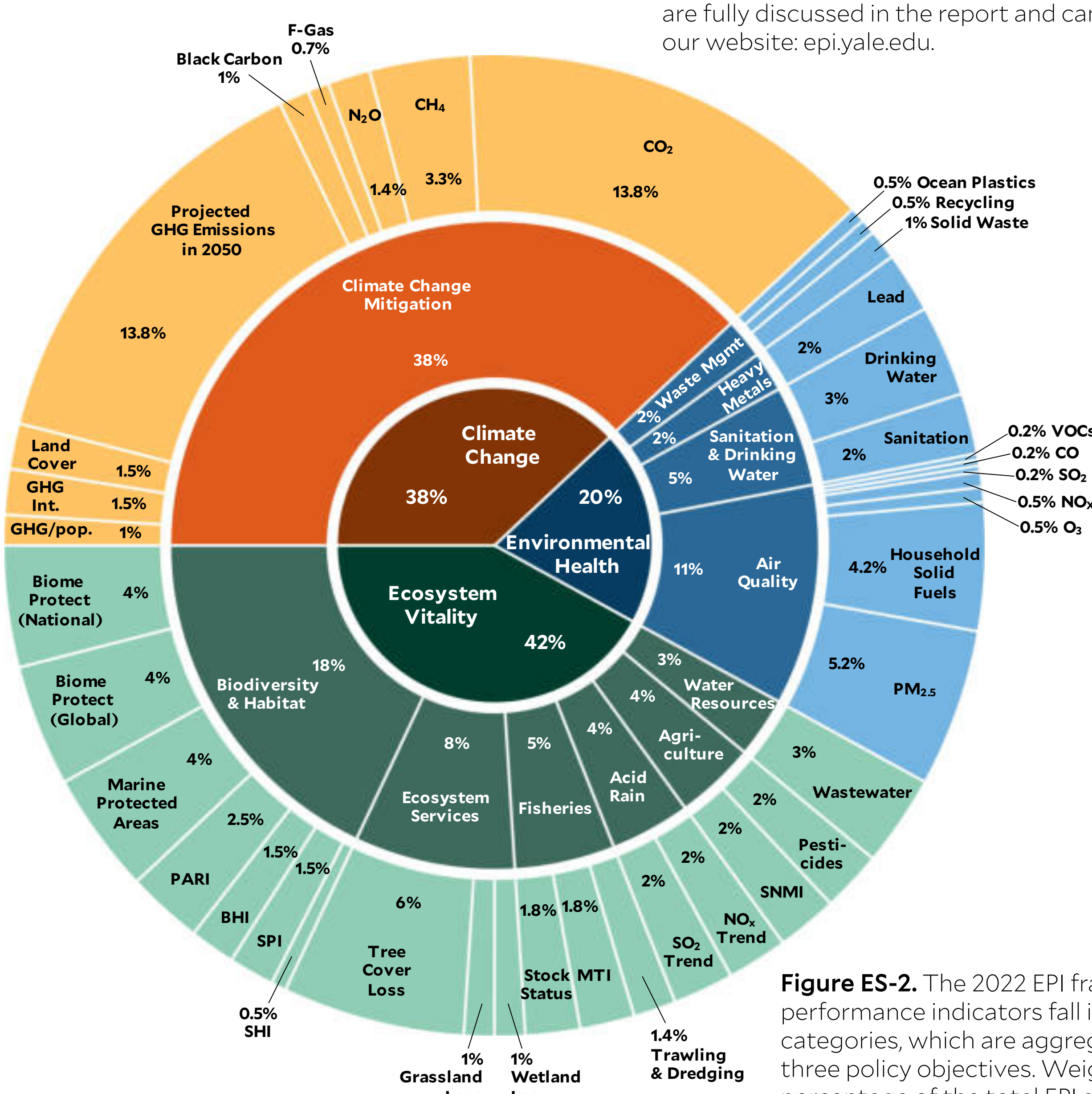

Figure ES-2. The 2022 EPI framework. 40 performance indicators fall into 11 issue categories, which are aggregated into three policy objectives. Weights show the percentage of the total EPI score.

Table ES-1. 2022 EPI rank, score, and regional rank (REG) for 180 countries.

RANK	COUNTRY	SCORE	REG
1	Denmark	77.9	1
2	United Kingdom	77.7	2
3	Finland	76.5	3
4	Malta	75.2	4
5	Sweden	72.7	5
6	Luxembourg	72.3	6
7	Slovenia	67.3	1
8	Austria	66.5	7
9	Switzerland	65.9	8
10	Iceland	62.8	9
11	Netherlands	62.6	10
12	France	62.5	11
13	Germany	62.4	12
14	Estonia	61.4	2
15	Latvia	61.1	3
16	Croatia	60.2	4
17	Australia	60.1	13
18	Slovakia	60.0	5
19	Czech Republic	59.9	6
20	Norway	59.3	14
21	Belgium	58.2	15
22	Cyprus	58.0	7
23	Italy	57.7	16
24	Ireland	57.4	17
25	Japan	57.2	1
26	New Zealand	56.7	18
27	Spain	56.6	19
28	Bahamas	56.2	1
28	Greece	56.2	8
30	Romania	56.0	9
31	Lithuania	55.9	10
32	Seychelles	55.6	1
33	Hungary	55.1	11
34	North Macedonia	54.3	12
35	Botswana	54.0	2
36	Barbados	53.2	2
36	St. Vincent and Grenadines	53.2	2
38	São Tomé and Príncpe	52.9	3
39	Antigua and Barbuda	52.4	4
39	United Arab Emirates	52.4	1
41	Bulgaria	51.9	13
42	Dominica	51.2	5
43	United States of America	51.1	20
44	Namibia	50.9	4
44	Singapore	50.9	2
46	Poland	50.6	14
47	Panama	50.5	6
48	Portugal	50.4	21
49	Belize	50.0	7
49	Canada	50.0	22
51	Gabon	49.7	5
52	Ukraine	49.6	1
53	Saint Lucia	49.4	8
54	Kiribati	49.0	3
55	Belarus	48.5	2
56	Armenia	48.3	3
57	Israel	48.2	2
58	Grenada	47.9	9
59	Trinidad and Tobago	47.8	10
60	Cuba	47.5	11
60	Djibouti	47.5	6
62	Albania	47.1	15
63	Montenegro	46.9	16
63	South Korea	46.9	4
65	Chile	46.7	12
66	Ecuador	46.5	13
67	Venezuela	46.4	14
68	Costa Rica	46.3	15
69	Zimbabwe	46.2	7
70	Suriname	45.9	16
71	Brunei Darussalam	45.7	5
72	Jamaica	45.6	17
73	Mexico	45.5	18
74	Taiwan	45.3	6
75	Central African Republic	44.9	8
75	Eswatini	44.9	8
77	Equatorial Guinea	44.8	10
77	Mauritius	44.8	10
79	Serbia	43.9	17
80	Tonga	43.8	7
81	Afghanistan	43.6	1
81	Brazil	43.6	19
81	Jordan	43.6	3
84	Moldova	42.7	4
85	Bhutan	42.5	2
85	Comoros	42.5	12
87	Colombia	42.4	20
87	Kuwait	42.4	4
89	Dominican Republic	42.2	21
90	Bahrain	42.0	5
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92	Argentina	41.1	22
93	Kazakhstan	40.9	5
93	Paraguay	40.9	23
95	El Salvador	40.8	24
96	Tunisia	40.7	6
97	Malawi	40.6	14
98	Guinea-Bissau	40.2	15
99	Bolivia	40.1	25
99	Republic of Congo	40.1	16
101	Peru	39.8	26
102	Bosnia and Herzegovina	39.4	18
103	Georgia	39.1	6
104	Azerbaijan	38.6	7
105	Guyana	38.5	27
106	Zambia	38.4	17
107	Uzbekistan	38.2	8
108	Thailand	38.1	8
109	Saudi Arabia	37.9	7
110	Nicaragua	37.7	28
110	Niger	37.7	18
112	Russia	37.5	9
113	Maldives	37.4	3
113	Micronesia	37.4	9
113	Uruguay	37.4	29
116	South Africa	37.2	19
117	Tajikistan	37.1	10
118	Turkmenistan	37.0	11
119	Dem. Rep. Congo	36.9	20
119	Vanuatu	36.9	10
121	Honduras	36.5	30
122	Gambia	36.4	21
122	Samoa	36.4	11
124	Marshall Islands	36.2	12
125	Uganda	35.8	22
126	Kyrgyzstan	35.7	12
127	Burkina Faso	35.5	23
127	Egypt	35.5	8
129	Timor-Leste	35.1	13
130	Malaysia	35.0	14
130	Solomon Islands	35.0	14
132	Sri Lanka	34.7	4
133	Iran	34.5	9
134	Tanzania	34.2	24
135	Togo	34.0	25
136	Senegal	33.9	26
137	Qatar	33.0	10
138	Côte d'Ivoire	32.8	27
138	Rwanda	32.8	27
140	Sierra Leone	32.7	29
141	Lesotho	32.3	30
142	Lebanon	32.2	11
143	Ethiopia	31.8	31
144	Eritrea	31.7	32
144	Mozambique	31.7	32
146	Guinea	31.6	34
147	Fiji	31.3	16
148	Kenya	30.8	35
149	Laos	30.7	17
149	Oman	30.7	12
151	Angola	30.5	36
151	Burundi	30.5	36
153	Cameroon	30.2	38
154	Cambodia	30.1	18
155	Algeria	29.6	13
155	Benin	29.6	39
155	Mongolia	29.6	19
158	Philippines	28.9	20
159	Mali	28.5	40
160	China	28.4	21
160	Morocco	28.4	14
162	Nepal	28.3	5
162	Nigeria	28.3	41
164	Indonesia	28.2	22
165	Chad	28.1	42
165	Mauritania	28.1	42
167	Guatemala	28.0	31
167	Madagascar	28.0	44
169	Iraq	27.8	15
170	Ghana	27.7	45
171	Sudan	27.6	16
172	Turkey	26.3	19
173	Haiti	26.1	32
174	Liberia	24.9	46
175	Papua New Guinea	24.8	23
176	Pakistan	24.6	6
177	Bangladesh	23.1	7
178	Viet Nam	20.1	24
179	Myanmar	19.4	25
180	India	18.9	8

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

Chapter 1. Introduction

1. Data-driven environmental insights

Scientific progress and evolving technologies offer the prospect of moving the world toward a more sustainable future, but a persistent disconnect between research findings and actionable policy insights continues to hold back environmental progress. World leaders need more refined tools that allow them to better understand sustainability challenges, data, and trends — and which provide a firmer foundation for policy choices. By carefully measuring environmental performance, highlighting critical results, identifying leaders and laggards, and spotlighting best practices in the policy domain, carefully constructed metrics can support transformative change and signal the path toward sustainable development.

The Environmental Performance Index (EPI) gives countries the information and tools they need to track progress toward meeting the UN sustainable development goals (SDGs) and other critical policy targets, adopt policies and programs that improve the environmental well-being of their citizens and the health of the ecosystems on which all life depends, identify top-performing peers to whom they might look for guidance, and ensure maximum returns on environmental investments. Using comprehensive and accessible metrics, the EPI captures country-level performance and historical trends in climate change, ecosystem vitality, and environmental public health. The 2022 EPI ranks 180 countries based on 40 performance indicators across 11 environmental issue categories. As the most comprehensive environmental analysis ever compiled, the 2022 EPI empowers policymakers, researchers, engaged citizens, business leaders, non-governmental organization officials, and the media to track trends in sustainability and enhance environmental decision-making.

Our era is defined by ever-more-powerful data analytics and greater transparency, positioning individuals and organizations around the world to demand that their governments validate environmental performance programs and progress with data. The quantitative targets laid out in the Sustainable Development Goals, the Paris Climate Agreement, and the Convention on Biological Diversity demonstrated that policymakers now face intense scrutiny over the results they report regarding both international and national environmental commitments. The rise of sustainability metrics provides a mechanism for holding governments that fail to meet their pledges accountable. Empirically grounded analyses also promise to improve environmental policies in countries making good-faith efforts to advance sustainability by making it easier for policymakers to spot problems, communicate with stakeholders, explain complex scientific concepts, identify best practices, and derive the greatest benefits from their investments in environmental solutions.

Data can make environmental governance more effective — but only if decision-makers have clear and analytically-rigorous information provided on a comparable basis that allows for diligent benchmarking and thus clear signals about relative performance. In this regard, the 2022 EPI offers a way to track country performance on an array of critical environmental challenges.

All data-derived performance analyses build on underlying assumptions and methodological choices, and thus the leadership picture presented here could be challenged from a number of perspectives. The EPI team encourages readers to treat overall scores as a foundation for deeper conversations and data disaggregation. Analyses of issue category and index sub-scores are often useful to identify the specific issues holding countries back from a more sustainable future. Country rankings also promote healthy competition between nations striving to lead their peers on sustainability issues. By championing a data-driven and more efficient environmental policy paradigm, the 2022 EPI report and analyses equip actors within and outside of government with the tools needed to address the most urgent sustainability issues facing their countries today.

2. Measuring Climate Performance

Recognizing the urgency of the threat of climate change, world leaders pledged at the 26th Conference of Parties in November 2021 to put their countries on track for net-zero greenhouse gas (GHG) emissions by mid-century. To achieve this goal, nations will need to redouble their efforts to reduce emissions, expand carbon sinks, improve energy efficiency, and invest in clean energy infrastructure. While some nations have spelled out their plans for the transformative change required to get to net-zero emissions by 2050, far fewer have put their emissions on the downward trajectory that will be required to hit the net-zero GHG target.

Success in this endeavor is essential to the global response to climate change. The 2022 EPI therefore includes a new metric based on recent GHG emissions trends to project how close countries will be to the net-zero target in 2050. Leveraging the latest data, this major methodological advancement in the EPI framework provides critical new tools for tracking country-by-country and global progress on climate change. The EPI's groundbreaking findings show that only a handful of countries — including Denmark and the United Kingdom — are currently slated to meet the net-zero GHG commitment, while many others are headed in the wrong direction (Figure 1-1). Despite the UK's strong performance, experts question whether its recent trends will hold into the future (UK Climate Change Committee, 2021). The *projected emissions levels in 2050* indicator therefore offers a tool that policymakers, the media, business leaders, non-governmental organizations, and the public can use to gauge the adequacy of climate policies and programs around the world. With a carefully constructed analytic framework based on current trends and actual data, the metric provides a way to track progress and hold national leaders accountable for their GHG emissions pledges.

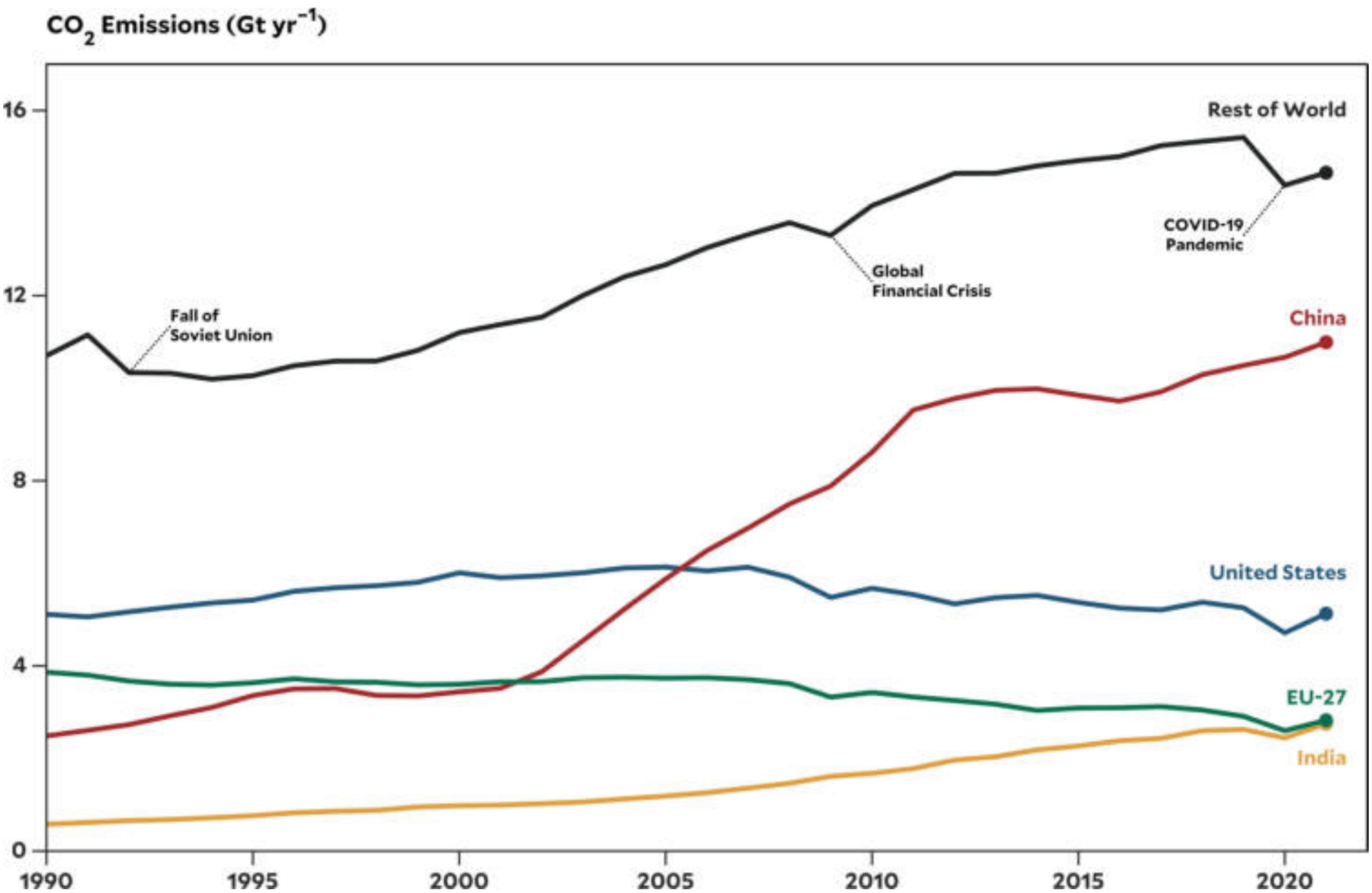
3. New Insights for Improving Air Quality

Air pollution remains a critical public health challenge in many nations. Reimagining how policymakers can use metrics to improve air quality, the 2022 EPI introduces several new indicators that more acutely emphasize trends in environmental health. Existing metrics insufficiently monitor exposure to a broad suite of air pollutants, hindering the ability of decision-makers to holistically address the public health impacts of poor air quality. To support new emissions control policies and ensure implemented solutions realize meaningful gains in environmental health, the 2022 EPI tracks exposure to four additional air pollutants: nitrogen oxides, sulfur dioxide, carbon monoxide, and volatile organic compounds. These innovative metrics demonstrate that most of the world's population breathes unsafe air. Although air quality in many countries continues to deteriorate, this new framework of indicators offers policymakers a toolkit to reverse unsustainable trends. The report provides further information about air quality in Chapter 5.

4. Enhanced Environmental Measurement

The inability to measure environmental degradation makes sustainability policies less effective. Since its inception, the EPI has strived to translate the latest advances in environmental research into actionable policy insights. The 2022 EPI includes several additional innovations to support empirically-founded sustainability policymaking. To expand the scope of waste management guidance, the 2022 report introduces new indicators on *recycling rates* and *ocean plastic pollution*. Unsustainable waste disposal threatens sensitive ecosystems and impedes efforts to achieve circular economies. Mindful of the critical role that agricultural systems play in healthy societies, the report also introduces a pilot indicator on *sustainable pesticide use*. Pesticide mismanagement threatens to

Figure 1-1. Carbon dioxide (CO_2) emissions for select countries and entities. *Source: Global Carbon Budget 2021.*



contaminate drinking water and reduce ecosystem vitality. Until now, countries have lacked data on their agricultural systems' performance. The 2022 EPI's innovative metrics promise to deliver high-impact policy insights to decision-makers as they strive to keep ahead of emerging sustainability trends.

With each report iteration, EPI researchers refresh data sources, convene leading sustainability researchers, and engage with data partners to ensure that the latest scientific insights undergird analyses. In addition to the new climate, air quality, waste management, and agriculture indicators, the 2022 EPI also leverages cutting-edge data on *wetland* and *grassland loss*. In Fisheries, indicators now better account for the environmental impacts of dredging. And in the Biodiversity & Habitat indicators, analyses incorporate significantly updated data on the extent of protected areas. These and other changes are further described throughout the report and in the online Technical Appendix. The EPI team strives to continually expand and enhance the project, welcoming suggestions and feedback on how future reports can incorporate new data and methods to continue to drive policy action on critical environmental issues.

5. Limitations and a Call for Better Data

Empirical insights can enhance environmental governance, yet numerous important issues lack the data necessary to support effective policies. As EPI reports have highlighted for over twenty years, policymaking will benefit from better data collection, reporting, and verification across a range of environmental issues. Information gaps are particularly severe in agriculture, freshwater quality, chemical exposure, and ecosystem protection. The EPI continues to call for world leaders and data organizations to close these gaps with stronger investments in environmental information frameworks.

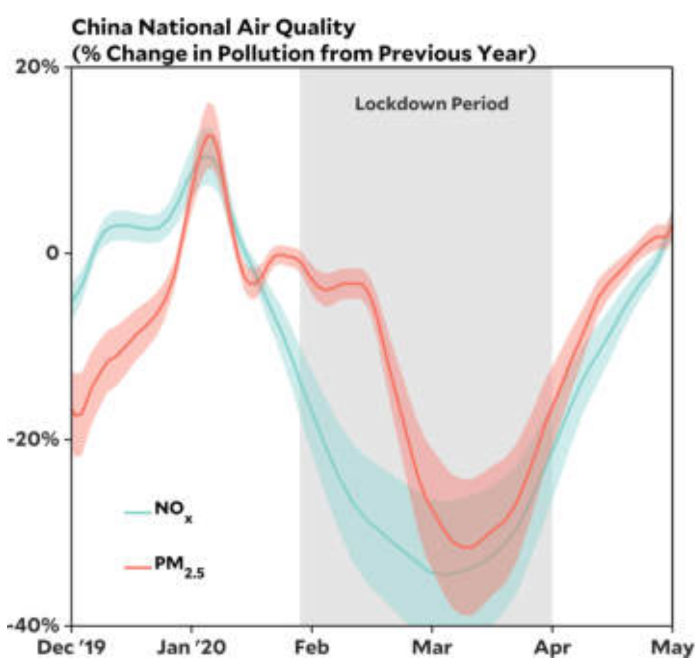
Countries may perform well in environmental metrics by outsourcing their polluting activities and discounting trade in goods and services. Currently, the EPI tracks environmental performance within country borders and does not account for the transboundary spillover of pollution. The 2022 EPI makes strides to capture countries' exploitation of the global commons with the introduction of new climate and *ocean plastic pollution* indicators. However, environmental spillovers are difficult to quantify and remain poorly represented in current metrics of environmental performance. Recent efforts to quantify transboundary effects, like the Global Commons Stewardship Index (SDSN et al., 2021, Wendling et al. 2021), indicate a significant interest in closing these knowledge gaps. The EPI team continues to collaborate in developing spillover metrics and anticipates including these groundbreaking insights in future reports.

6. COVID-19 and Sustainability Trends

Unprecedented disruptions in every aspect of daily life have altered sustainability trajectories around the globe. Economies and societies continue to reel from the impacts of the COVID-19 pandemic, introducing both setbacks and opportunities for policymakers striving to enhance environmental governance. Every new lockdown demonstrates a link between human activity and environmental degradation (Abubakar et al., 2021), with reduced travel resulting in less pollution and the return of wildlife to populated areas. Remarkable improvements in air quality, water quality, and biodiversity have followed the pandemic, albeit at terrible costs in terms of human life and societal wellbeing. As policymakers work to recover their economies and restart their societies, they have the chance to build back better and implement reforms that put their countries on the path toward a more sustainable future. But to date, the opportunity to transform our production and consumption patterns has largely been missed.

As countries strive to rebuild their economies, leaders are learning that a return to status quo policies will erase the environmental gains achieved during the past few years. Residents in cities around the world saw brighter skies, breathed cleaner air, and enjoyed quieter neighborhoods when traffic and shipping decreased in early 2020. Animal life and activity in many urban areas reached levels not seen in many decades.

Figure 1-2. Improvements and rebound in air pollution during COVID-19 lockdowns in China. *Source: Copernicus*.

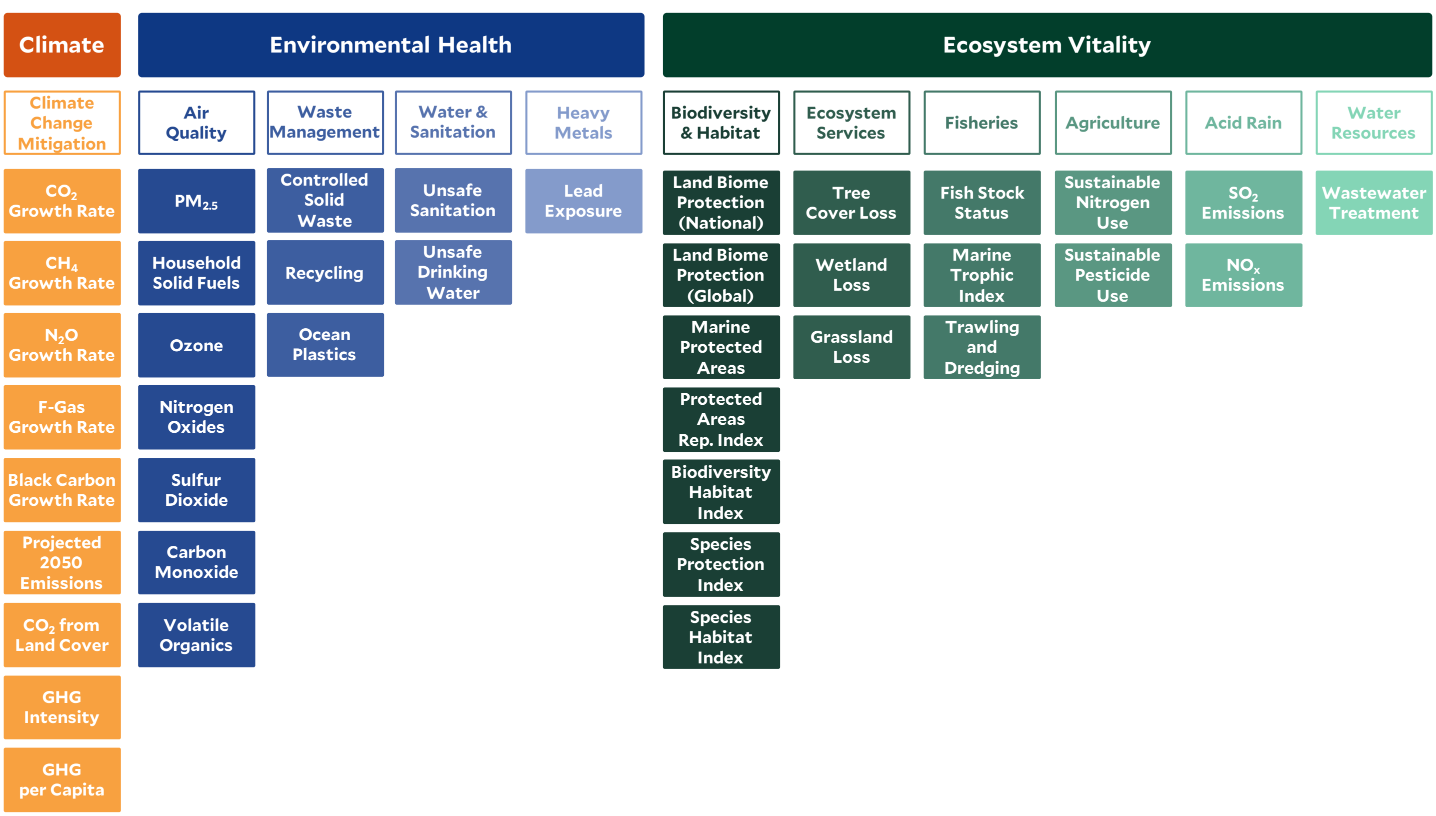


Concentrations of harmful air pollutants like NO_X fell by nearly 60% and particulate matter by over 30% in cities worldwide (Venter et al., 2020). But over the past year, the end of lockdowns and return to pre-pandemic levels of travel and manufacturing have caused air pollution to rise. Nowhere is this rebound effect more striking than in China, where significant improvements in air quality achieved during early 2020 were erased by the year's end, with continued deterioration in 2021 (Figure 1-2). Policymakers seeking to sustain gains achieved during the early pandemic should capitalize on new patterns of transportation that emerged during the pandemic such as biking and walking (Kraus and Koch, 2021; Nikitas et al., 2021). Conversely, air pollution may rise beyond pre-pandemic levels if commuters are reluctant to return to mass-transit modes of transportation (Baer and Larkin, 2021; Sahraei et al., 2021).

The COVID-19 pandemic has driven the world further away from a circular economy, dramatically increasing plastic use and waste mismanagement as the world took safety measures that resulted in alarming increases in waste production. Healthcare systems' reliance on personal-protective equipment has generated eight million tons of plastic waste since the pandemic began, with more than 25 thousand tons entering the ocean (Peng et al., 2021). At the pandemic's height, the world discarded 3.4 billion facemasks every day (Benson et al., 2021b). COVID-19 has reversed the global momentum to combat plastic use and pollution, presenting new challenges to policymakers as they work to reduce waste and move their countries toward a closed-loop economy.

On no topic is the chance to deliver post-pandemic transformative change more urgently needed than in climate change policy. After 2020's record-setting drop in global greenhouse gas emissions, 2021 emissions rebounded to pre-pandemic levels (Friedlingstein et al., 2022). Global values obscure striking and important country-level trends: whereas China and India's 2021 emissions were 5.5% and 4.4% greater than 2019 values, the United States' and the European Union's 2021 emissions fell below their 2019 levels (Figure 1-1). These downward emissions trends suggest that pandemic-era economic stimulus measures enacted by the United States and European Union may be successfully encouraging climate transitions. However, neither the United States nor the collective European Union are on track to meet the international climate target of net-zero emissions by 2050. As policymakers continue to grapple with the evolving pandemic, global supply chain issues, and the energy crisis caused by the Russian invasion of Ukraine, opportunities abound to adopt greener energy systems and work toward more sustainable economies in general.

Figure 1-3. The 2022 EPI Framework, illustrating 3 policy objectives, 11 issue categories, and 40 indicators.



7. 2022 EPI Overview

Tracking performance across environmental domains helps decision-makers develop comprehensive sustainability policies. As a composite index, the 2022 Environmental Performance Index distills country-level data on 40 specific indicators into 11 issue categories, 3 policy objectives, and an overall EPI score (Figure 1-3). The data come from trusted sources such as international organizations (including the World Bank, the Potsdam Institute for Climate Impact Research, and others), non-governmental organizations, and academic researchers. Leading sustainability experts validate these data before the EPI research team incorporates them into its analyses.

The EPI transforms data into broadly accessible indicators with scores ranging between 0 and 100, from worst to best performance. A perfect 100 score indicates that a country has achieved an internationally recognized sustainability target or the expert consensus of good performance. For each country, the EPI then weights and aggregates scores for 40 indicators into issue categories and policy objectives. Recognizing the significance of the climate crisis on human and environmental wellbeing, an enhanced emphasis on countries' climate performance is a central feature of the 2022 EPI report, which introduces Climate Change as a new policy objective.

A world scorecard also records global trends for each indicator. The EPI's results — along with the policy insights and peer comparisons they support — translate the latest scientific insights into useful tools for enhancing environmental governance in 180 countries around the globe.

Data and metrics are most powerful when tied to specific issues, policies, and countries. Chapter 2 provides a high-level overview of results, highlighting key findings of the 2022 EPI, global and regional performance, and leaders and laggards among peer groups. Chapter 3 explores the drivers of good environmental performance, presenting compelling insights that explain the economic, governance, and social characteristics of top-performing countries. Chapters 4–14 discuss the results for each issue category, providing detailed explanations of who scores well and why. Chapter 15 reviews the EPI methodology, assumptions, and provides an overview of the report's Technical Appendix.

Further details about the 2022 EPI report, analyses, and data are available from the project's website at epi.yale.edu.

Chapter 2. Results

Presenting national, regional, and global scores of sustainability performance across a wide scope of issues, the Environmental Performance Index provides policy insights on a variety of levels. Decision-makers can use top-level EPI scores to analyze overall environmental trends. As a composite index, the EPI also provides more specific insights on performance within three policy objectives, 11 issue categories, and 40 specific environmental metrics. When the available data extend across sufficient time, the EPI also provides information on performance trends, applying current methodologies to quantify performance approximately ten years ago. These trends can demonstrate how a country has progressed over time, or highlight critical issues in which a country is backsliding.

Policymakers often find value in comparing scores across countries. To enable this analysis, the EPI team converts scores into national rankings that highlight leaders and laggards around the world, identifying countries that out- or underperform their peers. The EPI proposes several peer groups based on geographic, economic, and social variables, but countries are also encouraged to define their own peers. A global scorecard further emphasizes sustainability issues that will benefit from more international coöperation and captures where nations have collectively made progress toward meeting environmental targets.

This section provides a high-level overview of the 2022 EPI results, with subsequent chapters exploring the state of specific issue categories in greater detail. All of the EPI results and data are freely available to explore, download, and analyze at the project website, epi.yale.edu.

1. Insights from the 2022 EPI

Policy Objectives

Tracking the rising focus on climate change as a central policy concern, the 2022 EPI introduces a revised framework that elevates Climate Change alongside Environmental Health and Ecosystem Vitality as a core policy objective. This new emphasis on climate performance anticipates major policy discussions surrounding country commitments to mitigating greenhouse gas emissions. The EPI team stresses that climate change is linked to the other policy objectives, exacerbating public health, biodiversity loss, agricultural inefficiency, and many other environmental issues.

Country scores in Climate Change span a wide range, with Denmark at 92.4 and Iraq at 8.8 (Figure 2-1). Scores in Environmental Health range from Iceland at 94.7 to Lesotho at 10.9, whereas scores in Ecosystem Vitality span Austria's 73.9 to the Solomon Islands' 14.6. The distribution of scores suggest that many countries have more successfully improved Environmental Health than they have mitigated Climate Change or enhanced Ecosystem Vitality. Figure 2-1 also demonstrates that strong performance in one policy objective is generally associated with success in the others, implying that common political, economic, and social factors might be driving or hampering success across environmental domains. Chapter 3 of this report further explores the determinants of success in sustainability issues.

Geography is a strong predictor of country performance. As one illustrative approach, the EPI team defines countries into the following eight regions: (1) Asia-Pacific; (2) Eastern Europe; (3) Former Soviet States; (4) Global West; (5) Greater Middle East; (6) Latin America & the Caribbean; (7) Southern Asia; and (8) Sub-Saharan Africa. Figure 2-2 illustrates how overall EPI scores relate to Environmental Health scores across these eight regions. Two distinct clusters emerge at both high and low scores. Whereas countries in the Global West score highly in both dimensions, Sub-Saharan African countries generally perform poorly.

Figure 2-1. The relationship between sub-scores on the 2022 EPI's three policy objectives: Environmental Health, Ecosystem Vitality, and Climate Change.

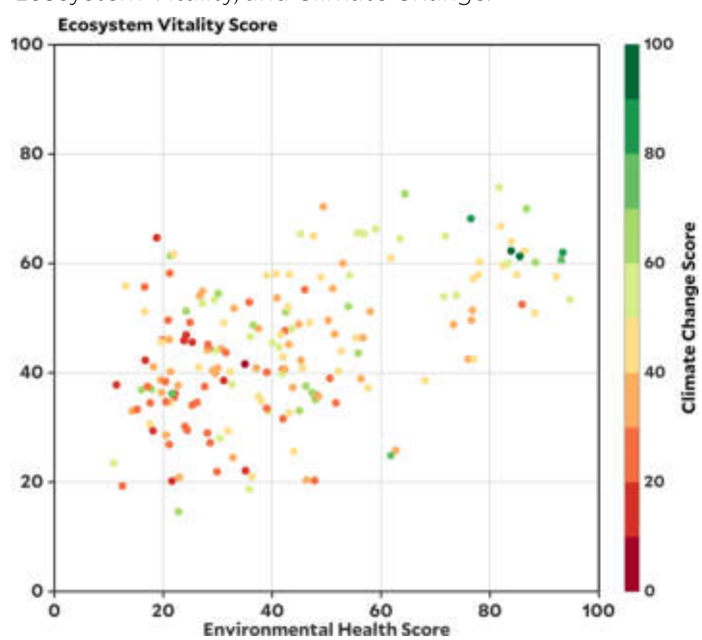


Figure 2-2. The relationship between Environmental Health and overall EPI scores in the 2022 EPI, by region.

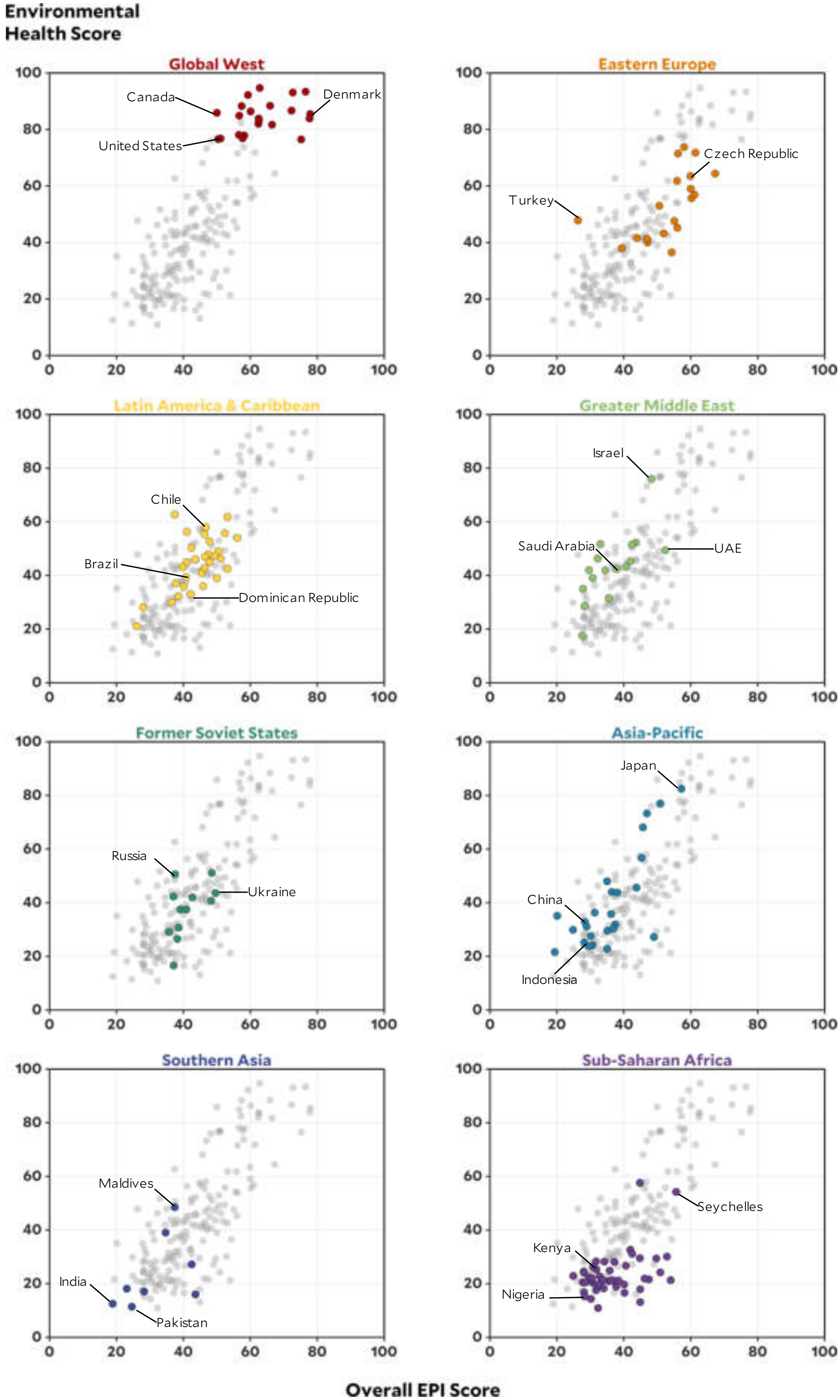


Figure 2-3. The relationship between Ecosystem Vitality and overall EPI scores in the 2022 EPI, by region.

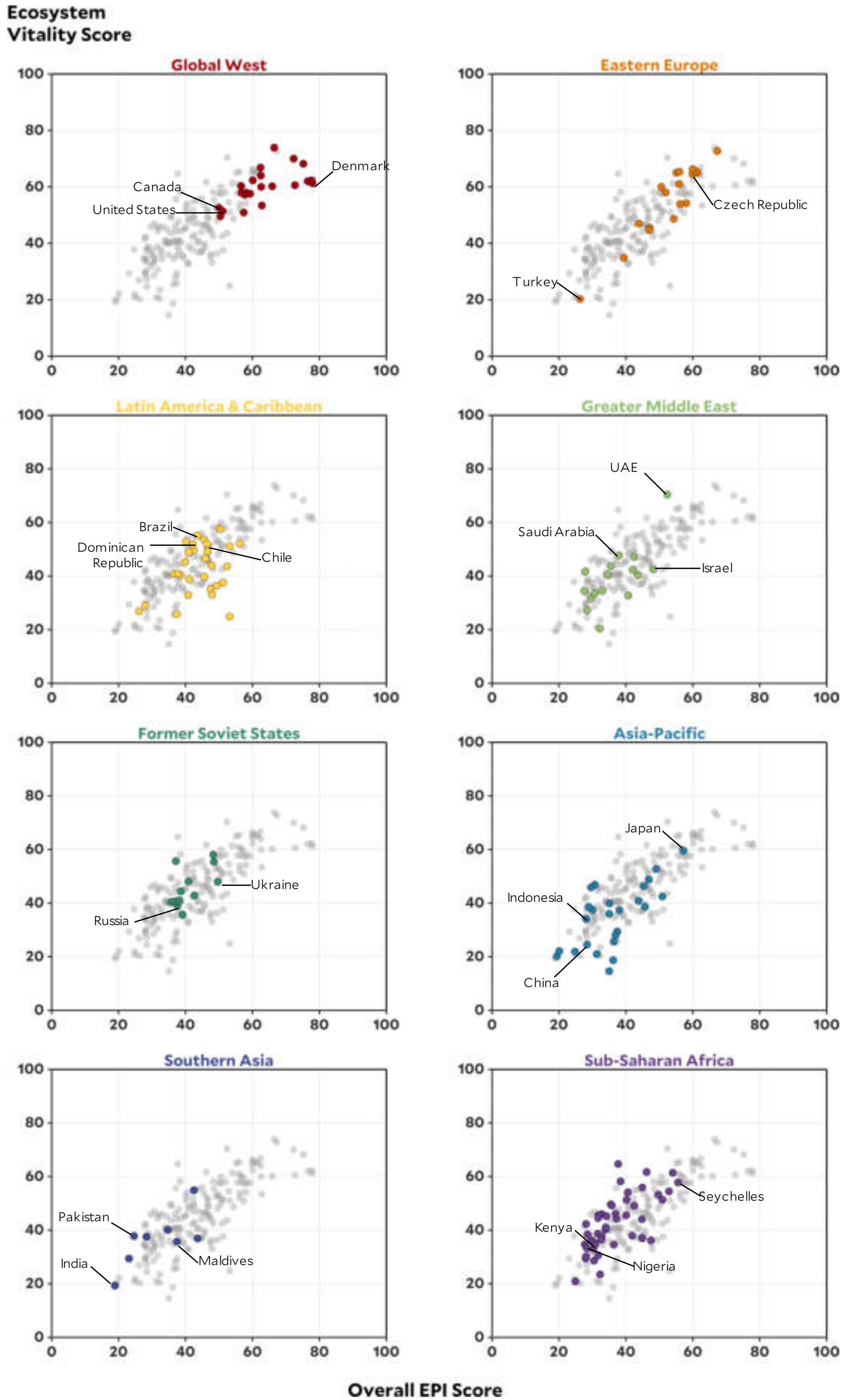
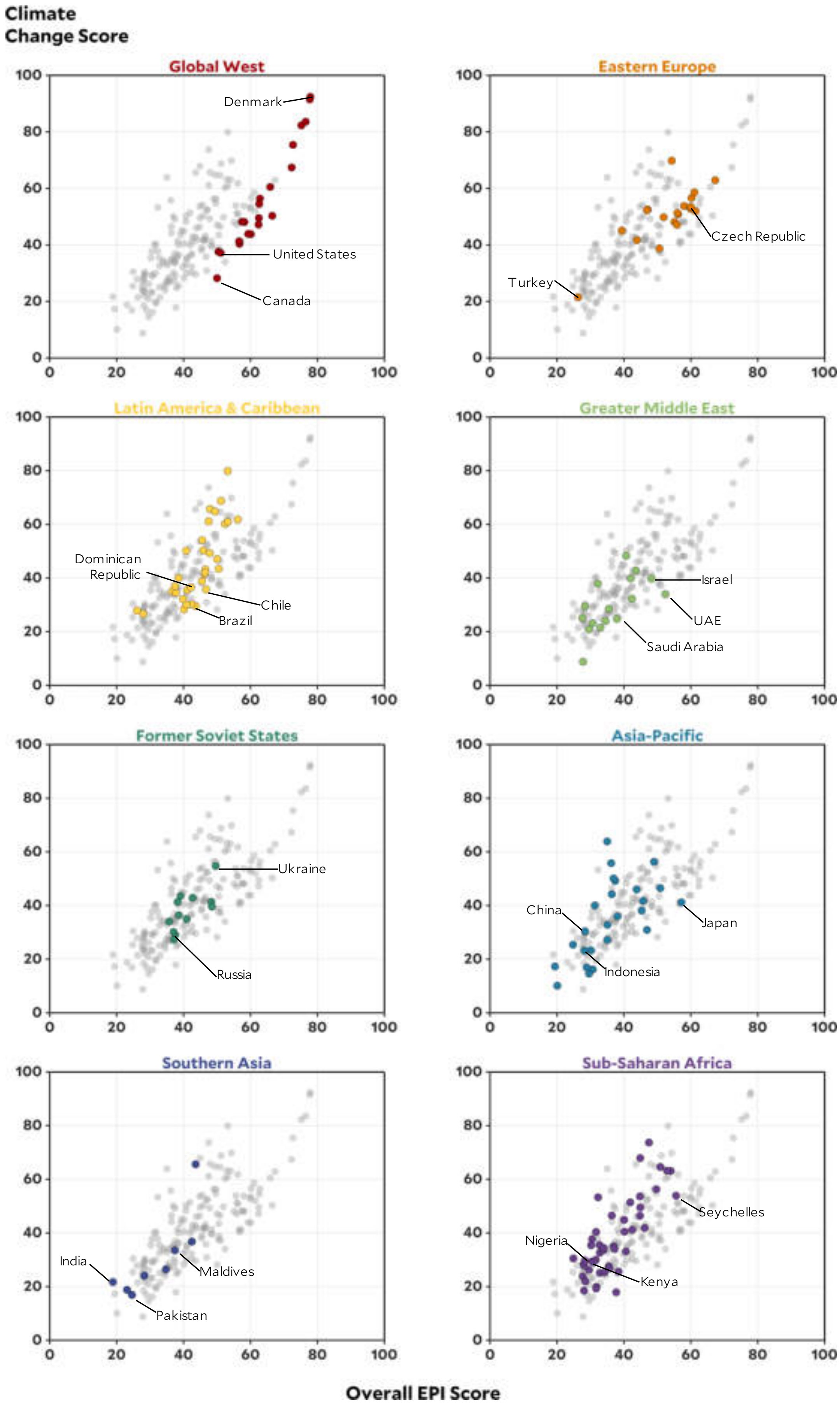


Figure 2-4. The relationship between Climate Change and overall EPI scores in the 2022 EPI, by region.



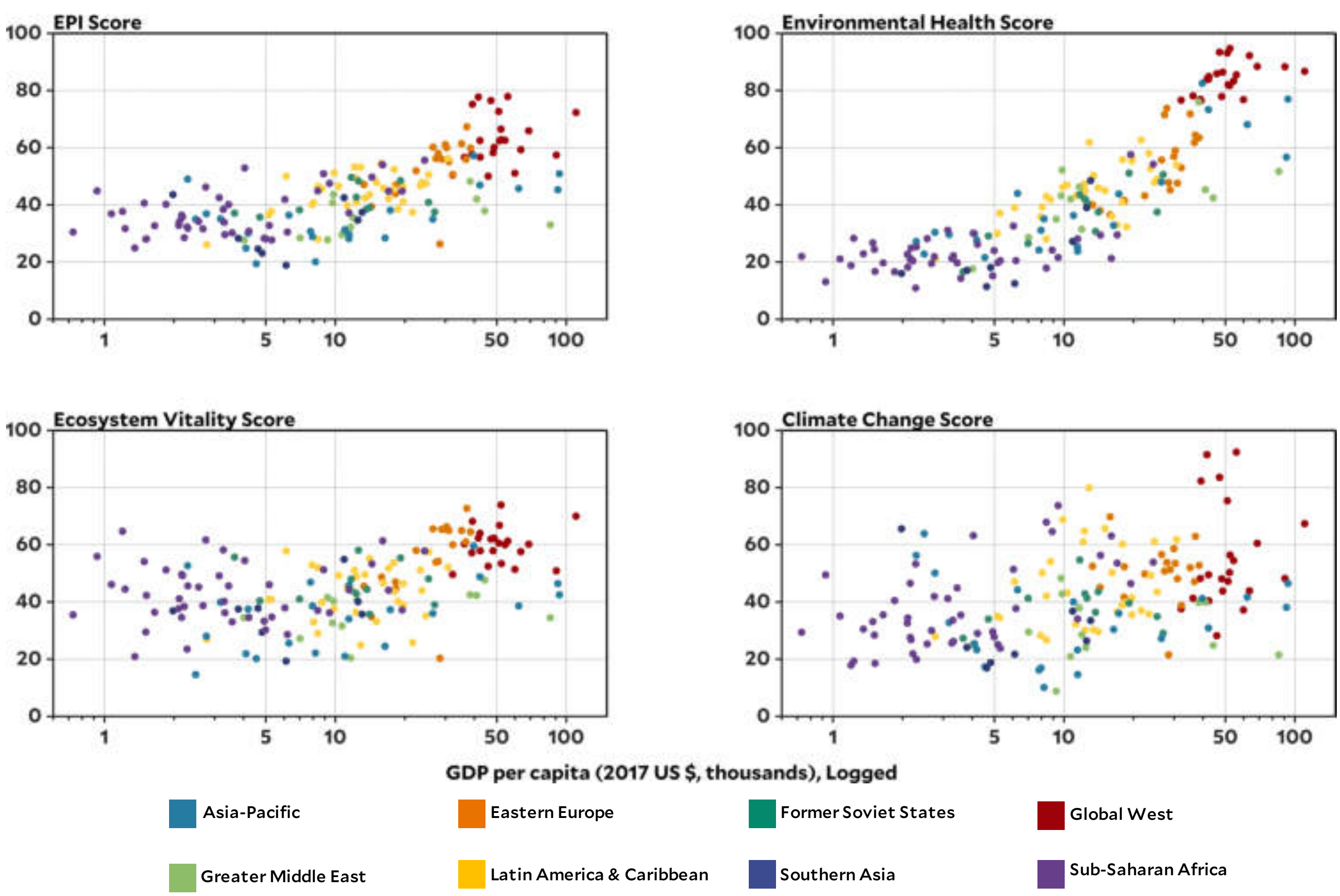
Similar patterns hold for relationships between countries' Ecosystem Vitality and EPI scores (Figure 2-3) and Climate Change and EPI scores (Figure 2-4), with countries in the Global West performing well. However, the clustering is not as pronounced. For Climate Change in particular, several countries in the Global West — including the United States and Canada — markedly underperform their peers and also the top-performers of other geographic groups. These low scores stress the fact that many major developed countries must rapidly reduce their greenhouse gas emissions if the world is to avoid the potentially devastating effects of climate change.

Country Wealth

Financial resources are an important determinant of a country's environmental performance, as illustrated in Figure 2-5. EPI scores show a strong correlation with country wealth, as do relationships with Environmental Health and to a lesser extent Ecosystem Vitality. A consistent finding of environmental research is that implementing and fine-tuning sustainability policies requires funding. Public health infrastructure — such as water treatment plants and smokestack scrubbers — needs investments that many developing countries cannot yet make. Habitat and natural resource conservation similarly requires financial resources to enforce regulations and resist economic pressure to unsustainably consume stocks and reserves of natural capital, like forests and freshwater.

Country performance in the Climate Change policy objective is less correlated with GDP *per capita*. Although some of the highest-scoring nations are wealthy (e.g., Denmark and the United Kingdom), many countries earn scores lower than their much less-wealthy peers. Development has historically come at the expense of the environment, with countries harnessing the energy of coal, oil, and natural gas combustion to power rapidly growing industries. The weak association suggests that many developed countries have yet to fully decouple economic growth from fossil fuel consumption.

Figure 2-5. The relationship between GDP per capita, EPI scores, and policy objective scores for the 2022 EPI.



The wide range in Climate Change scores at any level of wealth indicates that countries can look to their top-performing peers for strategies to grow their economies without sacrificing environmental wellbeing. Good environmental performance depends not only on financial resources, but also factors such as good governance, accountable leaders, well-crafted regulations, and engaged societies. Chapter 3 of this report more fully explores these drivers of environmental success.

2. Global Scorecard

Trends in global performance serve to focus international policy discussion on critical environmental issues. Analyzing data for all countries and territories, the EPI research team presents a scorecard that captures global performance on the 2022 indicators. The scorecard also displays baseline scores derived from applying the same methodology to data from approximately 10 years prior to current measurements. Combining the current and baseline scores, policymakers can infer trends that highlight areas where the world has made progress and point to issues that need more concerted sustainability interventions.

Figure 2-6 shows the world is still far from meeting international sustainability goals, although we are making progress on many issues. Notable headway in establishing marine protected areas and reducing black carbon, sulfur dioxide, and nitrogen oxide emissions occurred in the past decade. In other areas, such as waste management and fisheries, global progress has been slow or stalled. More worrying yet are areas where the world has backslid in environmental performance, such as ecosystem services and carbon dioxide emissions from land cover change. Policy insights emerge from scrutinizing these performance trends in more detail, as discussed briefly below and in more depth within subsequent chapters.

Climate Change Mitigation

Global progress to reduce greenhouse gas emissions is deeply insufficient to meet the net-zero target by mid-century, as established in the 2021 Glasgow Climate Pact. Although the EPI's trends-based indicators show that greenhouse gas emissions are not rising as quickly as they were 10 years ago, the world scores extremely poorly on the *projected greenhouse gas emissions in 2050* indicator. EPI analyses project that all but a handful of countries will fail to meet international climate commitments in the coming decades. Over 50% of greenhouse gas emissions in 2050 will come from just four countries: China, India, the United States, and Russia. A total of 24 countries — the "dirty two-dozen" — will account for nearly 80% of 2050 emissions unless more ambitious climate policies are adopted and emissions trajectories improve. One sign of progress is declining black carbon emissions, which have fallen as the world's coal consumption has plateaued and even begun to decline in recent years (IEA, 2020). The 2022 EPI's new climate analyses serve as a warning sign that current policies need to be strengthened if the world is to avert the worst effects of climate change in the coming decades.

Air Quality

Poor air quality is one of the most serious global public health issues, resulting in over 6 million premature deaths each year (Health Effects Institute, 2020). Over 99% of the global population still breathes unsafe air (World Health Organization, 2022). Despite steady, if slow, progress to reduce ozone exposure and household use of solid fuels, the world has not gained much ground toward mitigating particulate matter ($PM_{2.5}$) exposure. Similarly, exposure to other noxious pollutants like sulfur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), and volatile organic compounds has only marginally improved in recent years. Many of the countries with low scores in the overall EPI also place near the bottom of the Air Quality issue category, including India and Pakistan. Urbanization and industrialization in these and other countries continue to emit dangerous levels of air pollutants, presenting a challenge to policymakers as they aim to develop sustainability.

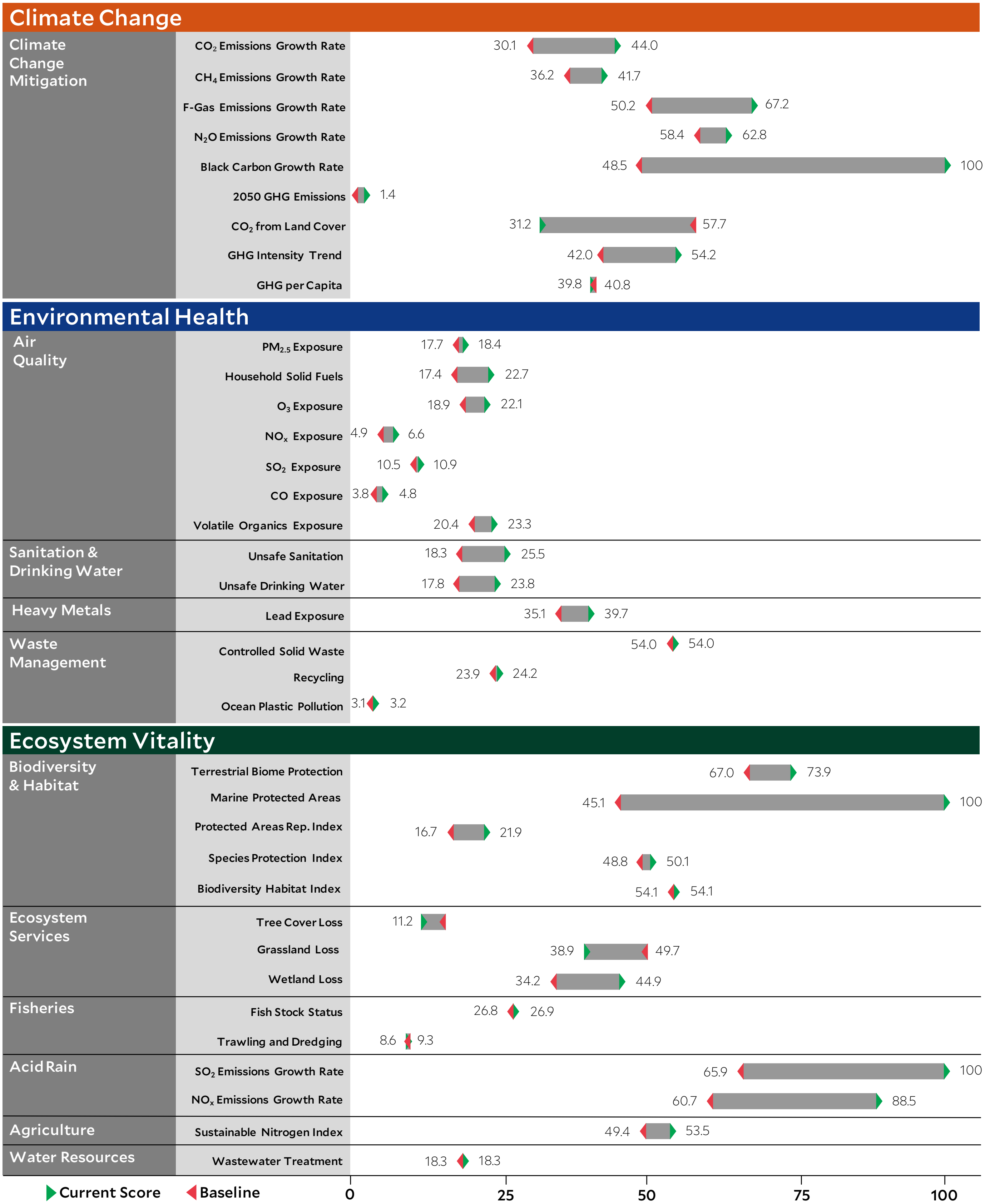
Sanitation & Drinking Water

Over 2 billion people — nearly 25% of the world's population — currently drink unsafe water, and nearly 3.6 billion people lack access to basic sanitation services like sewage treatment. Without clean water, morbidity and mortality remain high in many regions of the globe, particularly Sub-Saharan Africa and Southern Asia. The world has made only modest progress in reducing poor health outcomes from inadequate Sanitation & Drinking Water. Countries striving to improve their water and sanitation infrastructure under Sustainable Development Goal 6 often lack the financial or engineering capacity to adequately achieve healthy standards, illustrating the importance of international aid in the form of funding and technology sharing. Global and national leaders must take considerable action to expand safe drinking water and sanitation access to the billions of people who suffer from the lack of these services.

Heavy Metals

Heavy metal exposure contributes to poor health outcomes in many regions, although concerted efforts to phase out lead use in fuel, paints, and plumbing has successfully reduced global morbidity and mortality. Algeria was the last country to phase out leaded gasoline use in 2021, capping a significant global achievement that will prevent over 1 million premature deaths and save countries' economies $2 trillion every year (Tsai and Hatfield, 2011). However, lead exposure continues to undermine public health in all corners of the globe. Even in wealthy

Figure 2-6. Global scorecard showing the world's aggregated performance. Current scores are based on most recent data, and baseline scores use data from roughly ten years prior. Scores of 100 indicate the world has met the international sustainability target for good performance, while a zero score indicates the world is performing at or below the target for worst performance. All indicator targets are detailed in the online Technical Appendix.



countries like the United States, lead plumbing and legacy emissions have impacted nearly half of the population in measurable ways (McFarland et al., 2022). Lead use in battery production and recycling further contributes to lead exposure in many Sub-Saharan African and Asia-Pacific countries. New policies to sustainably manage metal waste must join the enforcement of existing regulations to minimize the health threats of heavy metals.

Waste Management

Waste mismanagement imposes a significant burden on ecosystems and threatens to undermine public health. Few other issue categories show as stark a divide in performance between developed and developing countries as Waste Management. Industrialized countries in the Global West score highly in this issue category, whereas countries in Southern Asia and Sub-Saharan Africa earn low scores. Worldwide, just over 50% of municipal solid waste is disposed of in ways that minimize environmental risks, including water contamination and greenhouse gas emissions. The world has made very little progress in increasing *recycling rates*, and gains toward mitigating *ocean plastic pollution* have been reversed by rising single-use plastic consumption during the COVID-19 pandemic. Recognizing the lack of comprehensive waste management data in many countries, the EPI calls on policymakers to enhance monitoring of waste generation, disposal, and recycling.

Biodiversity & Habitat

Remarkable progress toward reaching some Biodiversity & Habitat goals contrasts with persistent obstacles to meeting others. Countries have now conserved 10% of the world's coastline and marine areas, exceeding the Aichi Biodiversity Target 11 earlier this decade. However, the world failed to meet the companion target of preserving 17% of terrestrial areas by 2020, despite adding 22 million square kilometers of protections — roughly equivalent to the size of Russia (UNEP-WCMC et al., 2018). Belize earns the top rank in Biodiversity & Habitat, far surpassing international targets for *marine* and *terrestrial protected areas*. Many other countries in the Global West score highly, thanks in part to the European Union's Natura 2000 initiative that protects 18% of land and 6% of marine areas. Low global scores in the *Protected Areas Representativeness Index* and other measures of ecological health, however, demonstrate that policymakers must work further to ensure that conservation schemes include habitat for a diversity of species.

Ecosystem Services

Pervasive *tree cover loss* results in poor global performance in the Ecosystem Services issue category. Expanding agricultural land, forest fires, and natural resource consumption drive forest destruction throughout the world. Loss of tropical tree cover is particularly pronounced, with over 11 million hectares of forests lost in 2021. Boreal forests in Russia also experienced unprecedented loss in recent years, driven primarily by wildfires in a warming climate (Tyukavina et al., 2022). *Grassland loss* also remains high, while global *wetland loss* seems to have slowed and even reversed since 2017. The advent of new remote sensing techniques and analyses — like Google's Dynamic World database — promises to advance policies by providing more accurate and timely information on forest, grassland, and wetland extent.

Fisheries

The health of global fisheries remains poor. Nearly 75% of catch comes from stocks that are collapsed or exploited, threatening to undermine an important nutritional source for many countries in the developing world. The world has made little collective progress toward adopting more sustainable fishing gear, with fleets in many countries continuing to use trawling nets that indiscriminately catch marine life and dredging methods that destroy sensitive habitats along the ocean floor. While few countries earn high scores in this issue category, several small island nations like Cabo Verde and the Maldives outperform the world due to their effective permitting processes that protect fish stocks.

Acid Rain

Ecosystems in many parts of the developed world are slowly recovering from the acidification of prior decades, yet other regions must make greater effort to reduce emissions of acid rain precursors. The high global scores in sulfur dioxide (SO_2) and nitrogen oxides (NO_X) emissions growth rates masks uneven global progress. Emissions continue to rise in major countries like India and Indonesia, although even these poor-performing countries have shown a decelerating growth rate in the past decade. Nevertheless, nearly 30% of countries still exhibit rising emissions. Despite overall global progress in this issue category, many countries would benefit by reducing SO_2 and NO_X emissions from vehicles and energy production. Adopting electric vehicles and expanding renewable energy generation would also lead to improved scores in the Air Quality and Climate Change Mitigation issue categories.

Agriculture

Pesticide and fertilizer application to farmland can increase crop yields and reduce pest infestations, but current use patterns undermine ecosystem health by polluting soil and water with chemical residues. Modest gains in the global *Sustainable Nitrogen Management Index* score reflects increased crop yields rather than improved fertilizer use efficiency. Leaders in this issue category include Denmark and Argentina, which have achieved more efficient agrochemical use through scientific insights and coöperatives like the Asociación de

Table 2-1. 2022 EPI global rankings, scores, and regional rankings (REG) for 180 countries.

RANK	COUNTRY	SCORE	REG
1	Denmark	77.9	1
2	United Kingdom	77.7	2
3	Finland	76.5	3
4	Malta	75.2	4
5	Sweden	72.7	5
6	Luxembourg	72.3	6
7	Slovenia	67.3	1
8	Austria	66.5	7
9	Switzerland	65.9	8
10	Iceland	62.8	9
11	Netherlands	62.6	10
12	France	62.5	11
13	Germany	62.4	12
14	Estonia	61.4	2
15	Latvia	61.1	3
16	Croatia	60.2	4
17	Australia	60.1	13
18	Slovakia	60.0	5
19	Czech Republic	59.9	6
20	Norway	59.3	14
21	Belgium	58.2	15
22	Cyprus	58.0	7
23	Italy	57.7	16
24	Ireland	57.4	17
25	Japan	57.2	1
26	New Zealand	56.7	18
27	Spain	56.6	19
28	Bahamas	56.2	1
28	Greece	56.2	8
30	Romania	56.0	9
31	Lithuania	55.9	10
32	Seychelles	55.6	1
33	Hungary	55.1	11
34	North Macedonia	54.3	12
35	Botswana	54.0	2
36	Barbados	53.2	2
36	St. Vincent and Grenadines	53.2	2
38	São Tomé and Príncpe	52.9	3
39	Antigua and Barbuda	52.4	4
39	United Arab Emirates	52.4	1
41	Bulgaria	51.9	13
42	Dominica	51.2	5
43	United States of America	51.1	20
44	Namibia	50.9	4
44	Singapore	50.9	2
46	Poland	50.6	14
47	Panama	50.5	6
48	Portugal	50.4	21
49	Belize	50.0	7
49	Canada	50.0	22
51	Gabon	49.7	5
52	Ukraine	49.6	1
53	Saint Lucia	49.4	8
54	Kiribati	49.0	3
55	Belarus	48.5	2
56	Armenia	48.3	3
57	Israel	48.2	2
58	Grenada	47.9	9
59	Trinidad and Tobago	47.8	10
60	Cuba	47.5	11
60	Djibouti	47.5	6
62	Albania	47.1	15
63	Montenegro	46.9	16
63	South Korea	46.9	4
65	Chile	46.7	12
66	Ecuador	46.5	13
67	Venezuela	46.4	14
68	Costa Rica	46.3	15
69	Zimbabwe	46.2	7
70	Suriname	45.9	16
71	Brunei Darussalam	45.7	5
72	Jamaica	45.6	17
73	Mexico	45.5	18
74	Taiwan	45.3	6
75	Central African Republic	44.9	8
75	Eswatini	44.9	8
77	Equatorial Guinea	44.8	10
77	Mauritius	44.8	10
79	Serbia	43.9	17
80	Tonga	43.8	7
81	Afghanistan	43.6	1
81	Brazil	43.6	19
81	Jordan	43.6	3
84	Moldova	42.7	4
85	Bhutan	42.5	2
85	Comoros	42.5	12
87	Colombia	42.4	20
87	Kuwait	42.4	4
89	Dominican Republic	42.2	21
90	Bahrain	42.0	5
91	Cabo Verde	41.9	13
92	Argentina	41.1	22
93	Kazakhstan	40.9	5
93	Paraguay	40.9	23
95	El Salvador	40.8	24
96	Tunisia	40.7	6
97	Malawi	40.6	14
98	Guinea-Bissau	40.2	15
99	Bolivia	40.1	25
99	Republic of Congo	40.1	16
101	Peru	39.8	26
102	Bosnia and Herzegovina	39.4	18
103	Georgia	39.1	6
104	Azerbaijan	38.6	7
105	Guyana	38.5	27
106	Zambia	38.4	17
107	Uzbekistan	38.2	8
108	Thailand	38.1	8
109	Saudi Arabia	37.9	7
110	Nicaragua	37.7	28
110	Niger	37.7	18
112	Russia	37.5	9
113	Maldives	37.4	3
113	Micronesia	37.4	9
113	Uruguay	37.4	29
116	South Africa	37.2	19
117	Tajikistan	37.1	10
118	Turkmenistan	37.0	11
119	Dem. Rep. Congo	36.9	20
119	Vanuatu	36.9	10
121	Honduras	36.5	30
122	Gambia	36.4	21
122	Samoa	36.4	11
124	Marshall Islands	36.2	12
125	Uganda	35.8	22
126	Kyrgyzstan	35.7	12
127	Burkina Faso	35.5	23
127	Egypt	35.5	8
129	Timor-Leste	35.1	13
130	Malaysia	35.0	14
130	Solomon Islands	35.0	14
132	Sri Lanka	34.7	4
133	Iran	34.5	9
134	Tanzania	34.2	24
135	Togo	34.0	25
136	Senegal	33.9	26
137	Qatar	33.0	10
138	Côte d'Ivoire	32.8	27
138	Rwanda	32.8	27
140	Sierra Leone	32.7	29
141	Lesotho	32.3	30
142	Lebanon	32.2	11
143	Ethiopia	31.8	31
144	Eritrea	31.7	32
144	Mozambique	31.7	32
146	Guinea	31.6	34
147	Fiji	31.3	16
148	Kenya	30.8	35
149	Laos	30.7	17
149	Oman	30.7	12
151	Angola	30.5	36
151	Burundi	30.5	36
153	Cameroon	30.2	38
154	Cambodia	30.1	18
155	Algeria	29.6	13
155	Benin	29.6	39
155	Mongolia	29.6	19
158	Philippines	28.9	20
159	Mali	28.5	40
160	China	28.4	21
160	Morocco	28.4	14
162	Nepal	28.3	5
162	Nigeria	28.3	41
164	Indonesia	28.2	22
165	Chad	28.1	42
165	Mauritania	28.1	42
167	Guatemala	28.0	31
167	Madagascar	28.0	44
169	Iraq	27.8	15
170	Ghana	27.7	45
171	Sudan	27.6	16
172	Turkey	26.3	19
173	Haiti	26.1	32
174	Liberia	24.9	46
175	Papua New Guinea	24.8	23
176	Pakistan	24.6	6
177	Bangladesh	23.1	7
178	Viet Nam	20.1	24
179	Myanmar	19.4	25
180	India	18.9	8

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Cooperativas Argentinas. These countries are also among their regions' most prolific exporters of agricultural goods, demonstrating that countries can maintain high crop output without sacrificing sustainability. Despite the addition of a new indicator on *sustainable pesticide use*, global data on agriculture practices remain sparse. The EPI calls upon country leaders and data organizations to enhance monitoring of this sector and support new sustainable agricultural insights.

Water Resources

World rates of wastewater treatment remain low, as reflected by the global score in the 2022 EPI's Water Resources issue category. The Global West greatly outperforms all other regions, although notable leaders like Singapore and the United Arab Emirates score much higher than their geographic peers. Most countries in Southern Asia and Sub-Saharan Africa receive scores of zero, indicating the need for better civil infrastructure throughout the developing world. The EPI team underscores that global data inventories for freshwater indicators remain incomplete, precluding comprehensive coverage of this important issue. Policymakers should strive to expand data collection and monitoring of wastewater treatment rates to meet SDG6 (Clean Water and Sanitation) and improve public health.

3. Global Rankings

A consistent finding across Environmental Performance Index reports and other environmental analyses is that wealthy democracies rise to the top of rankings. The 2022 EPI results reflect this pattern. Countries that perform well have demonstrated a commitment to all areas of sustainability, supporting policy goals with strong regulations and financial investments that lead to real-world gains in environmental performance. Even the top-performing countries, however, have room for improvement. Many leaders in Environmental Health rank poorly in Climate Change. Performance in Ecosystem Vitality remains similarly spotty, reflecting a need for greater investments in decarbonization, biodiversity preservation, and habitat conservation around the globe. To meet the sustainability imperative, high-performing countries must maintain their momentum while also disseminating best policy practices to those countries falling behind on the road to a sustainable future.

Denmark emerges as the top-performing country in the overall EPI scores, reflecting strong performance across many of the issues tracked by the EPI with notable world leadership in climate and sustainable agriculture. For example, Denmark has set a national target of reducing 2030 emissions by 70% compared to the 1990 level and has adopted a comprehensive policy agenda to deliver on this commitment, including recently expanded GHG taxes. The country is one of only a handful projected by The 2022 EPI's analyses to reach zero greenhouse gas emissions before 2050.

Other high-scoring nations include the United Kingdom and Finland, both of which earn top rankings due to their strong climate change performance driven by policies that have substantially cut greenhouse gas emissions in recent years. Malta, the 4th-ranked country, lags its peers in terms of Environmental Health, but outperforms many European countries in its Climate Change Performance. While these countries appear to be sharply curtailing emissions, recent trends may simply reflect policymakers picking the "low-hanging fruit." For instance, the UK has achieved substantial reductions over the past decade from replacing coal with natural gas. Some experts question whether the nation will continue to be able to maintain the same pace of emissions reductions now that most coal plants have been retired (UK Climate Change Committee, 2021). Sweden places 5th, with high scores and global leadership in air and water quality.

Lagging its peers in the developed world, the United States places 20th of 22 countries in the Global West and 43rd out of 180 countries in the 2022 EPI. This relatively low ranking reflects poor performance in Climate Change. Although U.S. greenhouse gas emissions are declining, the high starting point means that current trends are not enough to meaningfully mitigate climate change. The United States, along with China, India, and Russia, will account for over 50% of global greenhouse gas emissions in 2050 unless decision-makers in these countries strengthen climate change policies and accelerate decarbonization efforts. While the data indicate the U.S. has made progress in other areas, like air quality and marine protected areas, the aggregate ranking puts it behind most wealthy western democracies, including France (12th), Germany (13th), Australia (17th), Italy (23rd), and Japan (25th).

The lowest scores go to India (18.9), Myanmar (19.4), Viet Nam (20.1), Bangladesh (23.1), and Pakistan (24.6). Most low scoring countries are those that have prioritized economic growth over sustainability, or those that are struggling with civil unrest and other crises. India, with increasingly dangerous air quality and rapidly rising greenhouse gas emissions, falls to the bottom of rankings for the first time. China places 161st, earning an overall EPI score of 28.4. China and India are projected to be the largest and second-largest emitters of greenhouse gases in 2050, despite recently promising to curb emissions growth rates. Other low-scorers suffer from poverty or ineffective governance. Haiti, ranking 174th, suffers from lax enforcement of environmental laws in the wake of civil unrest (Human Rights Watch, 2021). Low EPI scores demonstrate that these countries require a broad reframing of national sustainability efforts, with a particular emphasis on decarbonization, improving air quality, increasing waste management, and preserving biodiversity.

Trends in scores further spotlight whether countries are making progress toward meeting sustainability targets, or whether environmental conditions are deteriorating over time. Malta has achieved the greatest performance boost over the past decade, rising 25.4 points in the overall EPI. Other movers include the United Kingdom (+23) and Finland (+21). Countries with rising performance over time show a consistent pattern. While Environmental Health scores have remained more-or-less constant during the past decade, improved performance in Ecosystem Vitality and Climate Change has propelled these countries upward in the rankings.

Meanwhile, Burundi (-13), Nepal (-10.3), Vanuatu (-9.2), and other countries have seen backsliding performance over the past decade. This drop is largely due to deteriorating climate change performance. Nepal's greenhouse gas emissions have risen nearly 250% since 2010 as the country seeks to broaden electricity access (Suman, 2021). Policy proposals on the horizon, however, offer pathways to mitigating emissions by investing in localized programs to decarbonize the Nepalese economy (Bishwokarma et al., 2021).

Map 2-1. Rankings in the 2022 Environmental Performance Index for 180 countries.

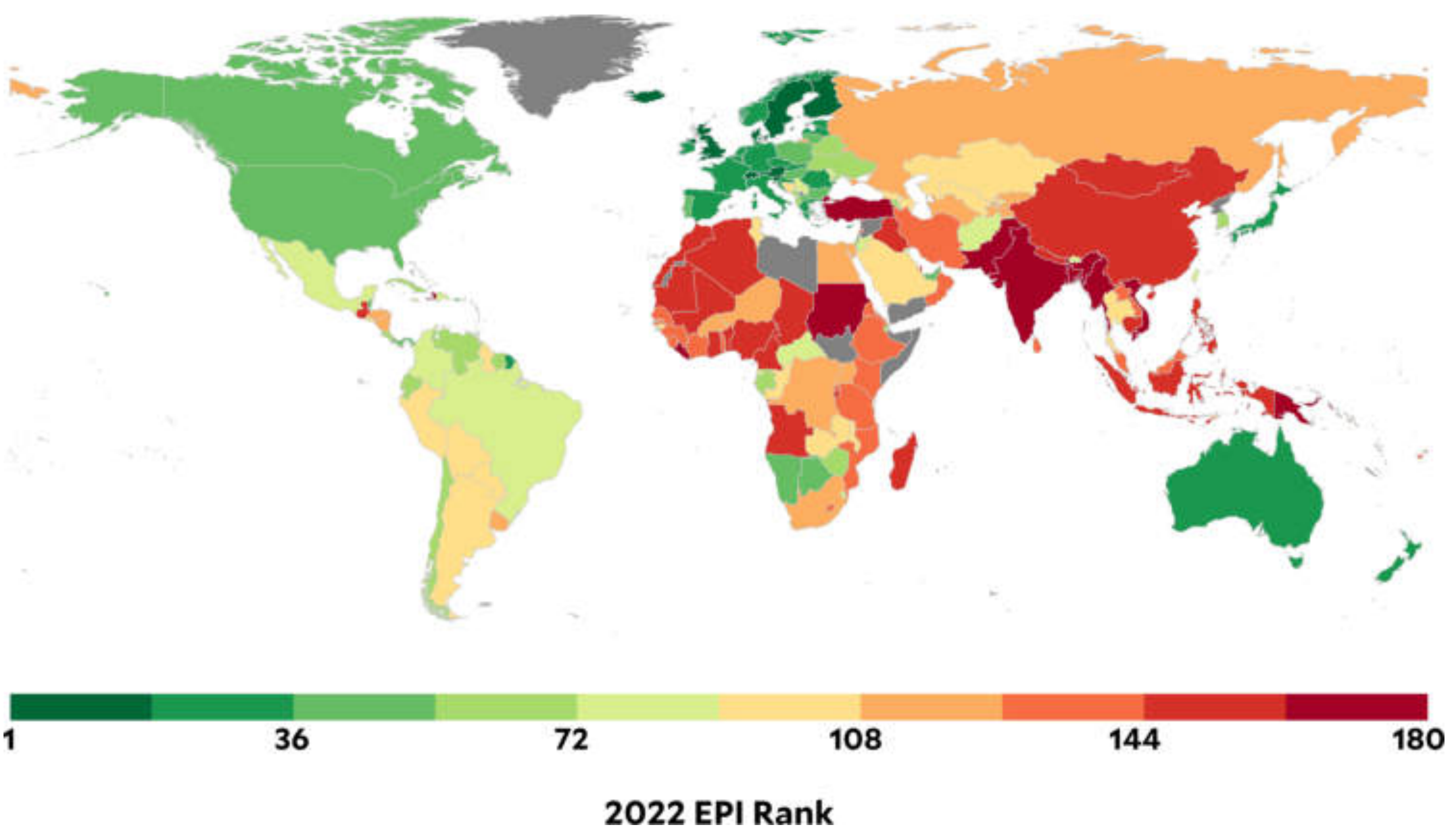


Table 2-2. Environmental Health global rankings, scores, and regional rankings (REG) for 180 countries.

RANK	COUNTRY	SCORE	REG
1	Iceland	94.7	1
2	Finland	93.4	2
3	Sweden	93.1	3
4	Norway	92.2	4
5	Switzerland	88.4	5
6	Ireland	88.3	6
7	Luxembourg	86.7	7
8	Australia	86.4	8
9	Canada	85.9	9
10	Denmark	85.5	10
11	New Zealand	84.9	11
12	France	83.9	12
12	United Kingdom	83.9	12
14	Netherlands	83.3	14
15	Japan	82.5	1
16	Germany	82.0	15
17	Austria	81.7	16
18	Spain	78.1	17
19	Belgium	77.9	18
20	Singapore	77.0	2
21	Italy	76.9	19
22	United States of America	76.8	20
23	Portugal	76.6	21
24	Malta	76.5	22
25	Israel	76.0	1
26	Cyprus	73.8	1
27	South Korea	73.3	3
28	Estonia	71.8	2
29	Greece	71.5	3
30	Brunei Darussalam	68.1	4
31	Slovenia	64.4	4
32	Czech Republic	63.5	5
33	Uruguay	62.7	1
34	Barbados	61.8	2
34	Lithuania	61.8	6
36	Slovakia	59.0	7
37	Chile	58.0	3
38	Mauritius	57.6	1
39	Latvia	56.9	8
40	Taiwan	56.7	5
41	Argentina	56.3	4
42	Antigua and Barbuda	55.8	5
43	Croatia	55.7	9
44	Costa Rica	55.4	6
45	Seychelles	54.2	2
46	Bahamas	54.0	7
47	Poland	53.0	10
48	Trinidad and Tobago	52.7	8
49	Jordan	52.2	2
50	Qatar	51.7	3
51	Kuwait	51.5	4
52	Belarus	51.1	1
53	Russia	50.6	2
54	Colombia	50.3	9
55	United Arab Emirates	49.4	5
56	Panama	49.0	10
57	Maldives	48.5	1
58	Malaysia	48.0	6
59	Cuba	47.9	11
60	Turkey	47.8	11
61	Hungary	47.6	12
62	Saint Lucia	47.3	12
63	Ecuador	46.9	13
64	Lebanon	46.3	6
65	Dominica	46.2	14
66	Brazil	46.0	15
67	Tonga	45.6	7
68	Bahrain	45.3	7
69	Romania	45.2	13
70	Grenada	45.0	16
71	Paraguay	44.9	17
72	Samoa	44.0	8
73	Thailand	43.8	9
74	Ukraine	43.6	3
75	Bulgaria	43.2	14
75	Tunisia	43.2	8
77	Peru	43.1	18
78	Venezuela	42.9	19
79	St. Vincent and Grenadines	42.5	20
80	Saudi Arabia	42.4	9
81	Turkmenistan	42.3	4
82	Algeria	42.0	10
82	Moldova	42.0	5
84	Iran	41.9	11
85	Jamaica	41.8	21
86	Serbia	41.6	15
87	Montenegro	41.3	16
88	Mexico	40.9	22
89	Armenia	40.7	6
90	Albania	40.0	17
91	El Salvador	39.3	23
92	Belize	39.0	24
92	Oman	39.0	12
92	Sri Lanka	39.0	2
95	Bosnia and Herzegovina	38.0	18
96	Georgia	37.5	7
96	Kazakhstan	37.5	7
98	Nicaragua	37.1	25
99	North Macedonia	36.5	19
100	Fiji	36.3	10
101	Suriname	36.0	26
102	Bolivia	35.8	27
102	Marshall Islands	35.8	11
104	Viet Nam	35.1	12
105	Iraq	35.0	13
106	Dominican Republic	33.0	28
107	China	32.8	13
108	Cabo Verde	32.6	3
109	Guyana	32.3	29
110	Micronesia	31.9	14
111	Egypt	31.5	14
112	Comoros	31.1	4
112	Philippines	31.1	15
114	Azerbaijan	30.7	9
115	Vanuatu	30.4	16
116	São Tomé and Príncpe	30.1	5
117	Honduras	30.0	30
118	Papua New Guinea	29.9	17
119	Timor-Leste	29.6	18
120	Equatorial Guinea	29.5	6
121	Gabon	29.4	7
122	Kyrgyzstan	29.1	10
123	Morocco	28.6	15
124	Mozambique	28.3	8
125	Tanzania	28.2	9
126	Guatemala	28.1	31
126	South Africa	28.1	10
128	Cambodia	27.6	19
129	Bhutan	27.2	3
129	Kiribati	27.2	20
131	Malawi	26.7	11
132	Uzbekistan	26.5	11
133	Kenya	26.2	12
134	Ethiopia	25.3	13
134	Indonesia	25.3	21
136	Uganda	24.9	14
137	Madagascar	24.4	15
138	Laos	24.2	22
138	Namibia	24.2	16
140	Mauritania	24.0	17
141	Mongolia	23.8	23
142	Liberia	22.9	18
143	Solomon Islands	22.8	24
144	Rwanda	22.7	19
145	Benin	22.2	20
146	Burundi	22.0	21
147	Zimbabwe	21.9	22
148	Djibouti	21.6	23
148	Myanmar	21.6	25
150	Botswana	21.3	24
150	Gambia	21.3	24
150	Senegal	21.3	24
153	Zambia	21.2	27
154	Dem. Rep. Congo	21.1	28
154	Haiti	21.1	32
156	Burkina Faso	20.9	29
157	Angola	20.5	30
157	Ghana	20.5	30
159	Mali	20.4	32
160	Côte d'Ivoire	19.8	33
161	Republic of Congo	19.7	34
161	Sierra Leone	19.7	34
163	Guinea	19.5	36
164	Niger	18.8	37
165	Togo	18.2	38
166	Bangladesh	18.1	4
167	Eswatini	17.9	39
168	Sudan	17.6	16
169	Eritrea	17.5	40
170	Nepal	17.1	5
171	Chad	16.7	41
172	Guinea-Bissau	16.6	42
172	Tajikistan	16.6	12
174	Afghanistan	16.0	6
175	Nigeria	15.2	43
176	Cameroon	14.3	44
177	Central African Republic	13.1	45
178	India	12.5	7
179	Pakistan	11.4	8
180	Lesotho	10.9	46

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

Table 2-3. Ecosystem Vitality global rankings, scores, and regional rankings (REG) for 180 countries.

RANK	COUNTRY	SCORE	REG
1	Austria	73.9	1
2	Slovenia	72.7	1
3	United Arab Emirates	70.4	1
4	Luxembourg	70.0	2
5	Malta	68.2	3
6	Germany	66.8	4
7	Slovakia	66.3	2
8	Croatia	65.6	3
9	Latvia	65.4	4
9	Romania	65.4	4
11	Estonia	65.0	6
11	Hungary	65.0	6
13	Niger	64.7	1
14	Czech Republic	64.5	8
15	France	64.0	5
16	Australia	62.3	6
16	United Kingdom	62.3	6
18	Finland	62.0	8
19	Zimbabwe	61.7	2
20	Botswana	61.4	3
21	Denmark	61.3	9
22	Lithuania	61.0	9
23	Sweden	60.6	10
24	Spain	60.3	11
25	Switzerland	60.2	12
26	Netherlands	60.0	13
26	Poland	60.0	10
28	Japan	59.6	1
29	Zambia	58.2	4
30	Armenia	58.1	1
31	Bulgaria	58.0	11
32	Belgium	57.9	14
32	New Zealand	57.9	14
34	Belize	57.8	1
34	Seychelles	57.8	5
36	Norway	57.6	16
37	Panama	57.5	2
38	Italy	57.2	17
39	Central African Republic	55.9	6
40	Tajikistan	55.7	2
41	Belarus	55.4	3
42	Brazil	55.2	3
43	Bhutan	54.9	1
44	São Tomé and Príncpe	54.5	7
45	Cyprus	54.2	12
46	Malawi	54.1	8
47	Greece	53.9	13
48	Mexico	53.7	4
49	Iceland	53.4	18
50	Gabon	53.3	9
51	Bolivia	52.9	5
52	Kiribati	52.7	2
53	Canada	52.5	19
54	Bahamas	52.1	6
55	Venezuela	52.0	7
56	Dominican Republic	51.8	8
57	United States of America	51.4	20
58	Namibia	51.3	10
59	Chile	51.2	9
59	Guinea-Bissau	51.2	11
61	St. Vincent and Grenadines	51.1	10
62	Ireland	50.9	21
63	Burkina Faso	49.6	12
63	Colombia	49.6	11
63	Portugal	49.6	22
66	Ecuador	49.2	12
66	Uganda	49.2	13
68	Comoros	49.1	14
69	Paraguay	48.9	13
70	South Korea	48.8	3
71	North Macedonia	48.7	14
72	Kazakhstan	48.1	4
73	Ukraine	48.0	5
74	Saudi Arabia	47.7	2
75	Kuwait	47.1	3
76	Serbia	47.0	15
77	Laos	46.9	4
78	Suriname	46.6	14
79	Costa Rica	46.4	15
79	Taiwan	46.4	5
81	Dem. Rep. Congo	46.1	15
82	Côte d'Ivoire	46.0	16
83	Mongolia	45.9	6
84	Ethiopia	45.6	17
84	Republic of Congo	45.6	17
86	Albania	45.5	16
87	Peru	45.2	16
87	Tanzania	45.2	19
89	Montenegro	44.7	17
90	Mozambique	44.5	20
91	Azerbaijan	44.4	6
92	South Africa	44.2	21
93	Equatorial Guinea	44.1	22
94	Trinidad and Tobago	44.0	17
95	Egypt	43.7	4
96	Antigua and Barbuda	43.6	18
97	Moldova	42.9	7
98	Israel	42.5	5
98	Singapore	42.5	7
100	Bahrain	42.3	6
100	Chad	42.3	23
102	Iraq	41.6	7
103	Togo	41.1	24
104	Uzbekistan	41.0	8
105	Honduras	40.9	19
105	Nicaragua	40.9	19
105	Tonga	40.9	8
108	Turkmenistan	40.7	9
109	Iran	40.6	8
110	Kyrgyzstan	40.4	10
111	Jordan	40.3	9
112	Guyana	40.2	21
112	Senegal	40.2	25
114	Sri Lanka	40.1	2
115	Timor-Leste	39.9	9
116	Jamaica	39.8	22
117	Russia	39.0	11
118	Argentina	38.9	23
119	Guinea	38.7	26
120	Brunei Darussalam	38.6	10
120	Philippines	38.6	10
122	Mali	38.4	27
123	Cabo Verde	37.9	28
124	Pakistan	37.8	3
125	Rwanda	37.7	29
126	Dominica	37.6	24
127	Cambodia	37.5	12
127	Nepal	37.5	4
129	Thailand	37.3	13
130	Mauritius	37.2	30
131	Eswatini	37.0	31
132	Afghanistan	36.9	5
133	Saint Lucia	36.4	25
133	Sierra Leone	36.4	32
135	Benin	36.2	33
135	Djibouti	36.2	33
137	Malaysia	36.0	14
138	Georgia	35.7	12
138	Maldives	35.7	6
140	Burundi	35.5	35
141	Cuba	35.1	26
142	Bosnia and Herzegovina	34.8	18
143	Ghana	34.7	36
144	Gambia	34.6	37
144	Kenya	34.6	37
146	Qatar	34.5	10
146	Sudan	34.5	10
148	Indonesia	34.1	15
149	Oman	33.5	12
150	Nigeria	33.3	39
151	Grenada	33.1	27
152	Cameroon	33.0	40
152	El Salvador	33.0	28
154	Tunisia	32.7	13
155	Algeria	31.6	14
156	Eritrea	30.6	41
157	Mauritania	30.2	42
158	Madagascar	29.5	43
159	Bangladesh	29.4	7
159	Micronesia	29.4	16
161	Guatemala	29.0	29
162	Angola	28.6	44
163	Vanuatu	28.0	17
164	Morocco	27.2	15
165	Haiti	26.9	30
166	Uruguay	25.8	31
167	Samoa	25.6	18
168	Barbados	24.9	32
169	China	24.5	19
170	Lesotho	23.5	45
171	Viet Nam	22.1	20
172	Papua New Guinea	21.9	21
173	Fiji	21.0	22
174	Liberia	20.9	46
175	Lebanon	20.4	16
176	Turkey	20.3	19
177	Myanmar	20.2	23
178	India	19.3	8
179	Marshall Islands	18.7	24
180	Solomon Islands	14.6	25

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

Table 2-4. Climate Change global rankings, scores, and regional rankings (REG) for 180 countries.

RANK	COUNTRY	SCORE	REG
1	Denmark	92.4	1
2	United Kingdom	91.5	2
3	Finland	83.6	3
4	Malta	82.3	4
5	Barbados	79.9	1
6	Sweden	75.4	5
7	Djibouti	73.7	1
8	North Macedonia	69.8	1
9	Dominica	68.8	2
10	Eswatini	67.9	2
11	Luxembourg	67.4	6
12	Grenada	65.7	3
13	Afghanistan	65.6	1
14	Saint Lucia	64.8	4
15	Namibia	64.6	3
16	Solomon Islands	63.9	1
17	São Tomé and Príncpe	63.2	4
18	Botswana	63.1	5
19	Slovenia	62.9	2
20	Bahamas	61.8	5
21	Cuba	61.1	6
22	St. Vincent and Grenadines	61.0	7
23	Switzerland	60.5	7
24	Antigua and Barbuda	60.2	8
25	Latvia	58.6	3
26	Croatia	56.6	4
27	Iceland	56.4	8
28	Gabon	56.3	6
28	Kiribati	56.3	2
30	Marshall Islands	55.8	3
31	Ukraine	54.7	1
32	Netherlands	54.5	9
33	Jamaica	54.1	9
34	Seychelles	53.9	7
35	Cyprus	53.8	5
36	Equatorial Guinea	53.6	8
37	Slovakia	53.5	6
38	Lesotho	53.3	9
39	Czech Republic	52.8	7
40	Albania	52.5	8
41	Montenegro	52.3	9
42	Estonia	52.0	10
43	Cabo Verde	51.4	10
44	Romania	51.3	11
45	Greece	50.8	12
46	Suriname	50.3	10
46	Austria	50.3	10
48	El Salvador	50.2	11
49	Vanuatu	50.1	4
50	Bulgaria	49.8	13
51	Central African Republic	49.5	11
51	France	49.5	11
53	Trinidad and Tobago	49.3	12
54	Micronesia	49.2	5
55	Tunisia	48.3	1
56	Ireland	48.2	12
56	Italy	48.2	12
58	Belgium	48.1	14
58	Hungary	48.1	14
60	Germany	47.2	15
61	Belize	47.1	13
61	Lithuania	47.1	15
63	Gambia	46.5	12
63	Singapore	46.5	6
65	Mauritius	46.4	13
66	Tonga	46.0	7
67	Bosnia and Herzegovina	45.1	16
68	Republic of Congo	44.9	14
69	Samoa	44.2	8
70	Norway	43.9	16
71	Australia	43.8	17
72	Georgia	43.6	2
73	Panama	43.5	14
74	Ecuador	43.2	15
75	Moldova	42.9	3
76	Jordan	42.8	2
77	Venezuela	42.1	16
78	Zimbabwe	41.9	15
79	Serbia	41.7	17
79	Brunei Darussalam	41.7	9
81	Costa Rica	41.5	17
82	Armenia	41.4	4
83	Spain	41.3	18
83	Uzbekistan	41.3	5
85	Comoros	41.2	16
85	Japan	41.2	10
87	Guinea-Bissau	40.5	17
88	Eritrea	40.4	18
88	New Zealand	40.4	19
90	Guyana	40.0	18
90	Fiji	40.0	11
92	Bahrain	39.9	3
93	Israel	39.8	4
94	Belarus	39.6	6
95	Mexico	38.9	19
96	Poland	38.8	18
97	Taiwan	38.1	12
98	Lebanon	37.9	5
99	Angola	37.7	19
100	Portugal	37.6	20
101	United States of America	37.2	21
102	Uruguay	37.0	20
103	Bhutan	36.8	2
104	Dominican Republic	36.5	21
105	Azerbaijan	36.4	7
106	Thailand	36.0	13
107	Chile	35.8	22
108	Sierra Leone	35.5	20
108	Argentina	35.5	23
110	Cameroon	35.4	21
111	Dem. Rep. Congo	35.1	22
112	Honduras	35.0	24
113	Kazakhstan	34.9	8
114	Nicaragua	34.5	25
115	Togo	34.4	23
116	South Africa	34.1	24
117	United Arab Emirates	34.0	6
117	Kyrgyzstan	34.0	9
119	Senegal	33.6	25
120	Maldives	33.5	3
121	Malawi	33.1	26
122	Timor-Leste	32.8	14
123	Rwanda	32.6	27
124	Kuwait	32.3	7
125	Peru	32.2	26
126	South Korea	30.9	15
127	Liberia	30.5	28
128	China	30.4	16
129	Colombia	30.2	27
129	Turkmenistan	30.2	10
131	Paraguay	30.1	28
132	Guinea	30.0	29
133	Nigeria	29.6	30
133	Brazil	29.6	29
135	Morocco	29.5	8
136	Burundi	29.4	31
137	Russia	29.1	11
138	Kenya	29.0	32
139	Egypt	28.5	9
140	Madagascar	28.4	33
141	Bolivia	28.3	30
142	Canada	28.2	22
143	Haiti	27.9	31
144	Mauritania	27.8	34
145	Burkina Faso	27.6	35
146	Tajikistan	27.3	12
147	Malaysia	27.2	17
148	Uganda	26.8	36
149	Guatemala	26.7	32
150	Sri Lanka	26.4	4
151	Benin	26.2	37
152	Zambia	25.6	38
153	Papua New Guinea	25.4	18
154	Tanzania	25.3	39
155	Côte d'Ivoire	25.1	40
155	Sudan	25.1	10
157	Saudi Arabia	24.8	11
158	Nepal	24.1	5
159	Iran	24.0	12
160	Ghana	23.8	41
161	Cambodia	23.3	19
162	Oman	23.2	13
162	Indonesia	23.2	20
164	Mali	21.9	42
165	India	21.7	6
166	Qatar	21.5	14
166	Turkey	21.5	19
168	Algeria	20.9	15
169	Ethiopia	19.9	43
170	Mozambique	19.3	44
171	Bangladesh	18.8	7
172	Chad	18.5	45
173	Niger	17.9	46
174	Myanmar	17.3	21
175	Pakistan	16.9	8
175	Philippines	16.9	22
177	Laos	16.2	23
178	Mongolia	14.6	24
179	Viet Nam	10.1	25
180	Iraq	8.8	16

Asia-Pacific **Eastern Europe** **Former Soviet States** **Global West**

Greater Middle East **Latin America & Caribbean** **Southern Asia** **Sub-Saharan Africa**

4. Regional Rankings

Policymakers often find rankings within "peer groups" to be useful for benchmarking performance and identifying best practices that others have adopted which might be worth emulating. Regional groupings are one example of a useful peer group, especially when facilitating multilateral action. The 2022 EPI constructs rankings for eight regions, as illustrated in Map 2-2.

Global West

The Global West achieves the highest median score (62.5) among all regions, placing just ahead of Eastern Europe. Countries in the Global West occupy 14 out of the top 20 positions in the 2022 EPI rankings. These countries generally score very highly in Environmental Health, although performance in Ecosystem Vitality and Climate Change is more mixed. Even the top-scoring countries in the Global West can improve. For example, Denmark, which places first among all countries in the EPI, ranks 144th in Ecosystem Services and 122nd in Fisheries. Even as Denmark recovers from widespread historical tree cover loss, experts caution that climate change must factor into reforestation plans (Stanturf et al., 2018). Although the United States places 43rd out of 180 countries in the EPI, it reaches only 20th out of 22 countries in the Global West. This low ranking stems from poor performance in Climate Change and Ecosystem Services. The United States also falls to the bottom of the Global West in Waste Management, reflecting low recycling rates and high emissions of ocean plastics relative to other wealthy countries.

Canada falls to the bottom rank within the Global West, placing 49th out of 180 countries in the overall EPI. It remains one of the few countries in this region that has yet to achieve steadily declining greenhouse gas emissions. Despite being one of the world's largest producers of hydroelectric power, oil and gas exploration continues to play an important role in the Canadian economy, presenting a unique challenge as leaders look to decarbonize (Davis et al., 2018). While some experts advocate for a more gradual phaseout of Canada's fossil fuel infrastructure (Janzen et al., 2020), others call for a quicker transition to renewable energies (MacArthur et al., 2020).

Eastern Europe

Eastern European countries generally perform well in the 2022 EPI, propelling the region to a median score of 55.9. Six countries place into the top 20 rankings, including Slovenia (7th), Estonia (14th), and Latvia (15th). Regional average scores are particularly high for Acid Rain and Biodiversity & Habitat. Many countries also earn high scores in Agriculture, an important economic sector for the region. Agricultural extensions in many of these countries continue to educate farmers on conservation farming techniques (FAO, 2019).

Slovenia, the highest scoring Eastern European nation in the 2022 EPI, earns its spot in part due to ambitious habitat conservation efforts. Under the European Union's

Map 2-2. EPI-defined world regions.

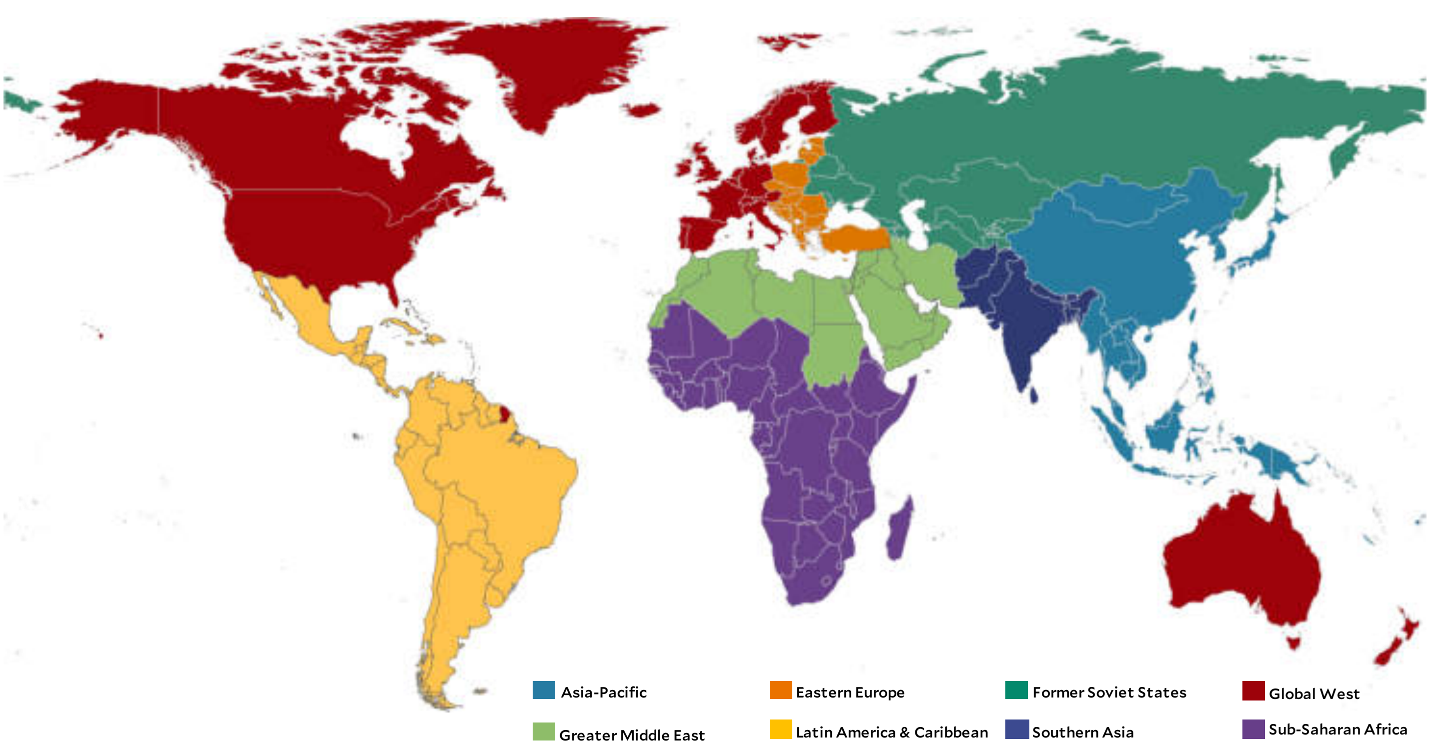


Table 2-5. EPI scores and regional rankings.

LATIN AMERICA & CARIBBEAN		
Country	Score	Reg. Rank
Bahamas	56.2	1
St. Vincent and Grenadines	53.2	2
Barbados	53.2	2
Antigua and Barbuda	52.4	4
Dominica	51.2	5
Panama	50.5	6
Belize	50.0	7
Saint Lucia	49.4	8
Grenada	47.9	9
Trinidad and Tobago	47.8	10
Cuba	47.5	11
Chile	46.7	12
Ecuador	46.5	13
Venezuela	46.4	14
Costa Rica	46.3	15
Suriname	45.9	16
Jamaica	45.6	17
Mexico	45.5	18
Brazil	43.6	19
Colombia	42.4	20
Dominican Republic	42.2	21
Argentina	41.1	22
Paraguay	40.9	23
El Salvador	40.8	24
Bolivia	40.1	25
Peru	39.8	26
Guyana	38.5	27
Nicaragua	37.7	28
Uruguay	37.4	29
Honduras	36.5	30
Guatemala	28.0	31
Haiti	26.1	32

EASTERN EUROPE		
Country	Score	Reg. Rank
Slovenia	67.3	1
Estonia	61.4	2
Latvia	61.1	3
Croatia	60.2	4
Slovakia	60.0	5
Czech Republic	59.9	6
Cyprus	58.0	7
Greece	56.2	8
Romania	56.0	9
Lithuania	55.9	10
Hungary	55.1	11
North Macedonia	54.3	12
Bulgaria	51.9	13
Poland	50.6	14
Albania	47.1	15
Montenegro	46.9	16
Serbia	43.9	17
Bosnia and Herzegovina	39.4	18
Turkey	26.3	19

SOUTHERN ASIA		
Country	Score	Reg. Rank
Afghanistan	43.6	1
Bhutan	42.5	2
Maldives	37.4	3
Sri Lanka	34.7	4
Nepal	28.3	5
Pakistan	24.6	6
Bangladesh	23.1	7
India	18.9	8

GLOBAL WEST		
Country	Score	Reg. Rank
Denmark	77.9	1
United Kingdom	77.7	2
Finland	76.5	3
Malta	75.2	4
Sweden	72.7	5
Luxembourg	72.3	6
Austria	66.5	7
Switzerland	65.9	8
Iceland	62.8	9
Netherlands	62.6	10
France	62.5	11
Germany	62.4	12
Australia	60.1	13
Norway	59.3	14
Belgium	58.2	15
Italy	57.7	16
Ireland	57.4	17
New Zealand	56.7	18
Spain	56.6	19
United States of America	51.1	20
Portugal	50.4	21
Canada	50.0	22

FORMER SOVIET STATES		
Country	Score	Reg. Rank
Ukraine	49.6	1
Belarus	48.5	2
Armenia	48.3	3
Moldova	42.7	4
Kazakhstan	40.9	5
Georgia	39.1	6
Azerbaijan	38.6	7
Uzbekistan	38.2	8
Russia	37.5	9
Tajikistan	37.1	10
Turkmenistan	37.0	11
Kyrgyzstan	35.7	12

ASIA-PACIFIC		
Country	Score	Reg. Rank
Japan	57.2	1
Singapore	50.9	2
Kiribati	49.0	3
South Korea	46.9	4
Brunei Darussalam	45.7	5
Taiwan	45.3	6
Tonga	43.8	7
Thailand	38.1	8
Micronesia	37.4	9
Vanuatu	36.9	10
Samoa	36.4	11
Marshall Islands	36.2	12
Timor-Leste	35.1	13
Malaysia	35.0	14
Solomon Islands	35.0	14
Fiji	31.3	16
Laos	30.7	17
Cambodia	30.1	18
Mongolia	29.6	19
Philippines	28.9	20
China	28.4	21
Indonesia	28.2	22
Papua New Guinea	24.8	23
Viet Nam	20.1	24
Myanmar	19.4	25

SUB-SAHARAN AFRICA		
Country	Score	Reg. Rank
Seychelles	55.6	1
Botswana	54.0	2
São Tomé and Príncpe	52.9	3
Namibia	50.9	4
Gabon	49.7	5
Djibouti	47.5	6
Zimbabwe	46.2	7
Central African Republic	44.9	8
Eswatini	44.9	8
Equatorial Guinea	44.8	10
Mauritius	44.8	10
Comoros	42.5	12
Cabo Verde	41.9	13
Malawi	40.6	14
Guinea-Bissau	40.2	15
Republic of Congo	40.1	16
Zambia	38.4	17
Niger	37.7	18
South Africa	37.2	19
Dem. Rep. Congo	36.9	20
Gambia	36.4	21
Uganda	35.8	22
Burkina Faso	35.5	23
Tanzania	34.2	24
Togo	34.0	25
Senegal	33.9	26
Côte d'Ivoire	32.8	27
Rwanda	32.8	27
Sierra Leone	32.7	29
Lesotho	32.3	30
Ethiopia	31.8	31
Eritrea	31.7	32
Mozambique	31.7	32
Guinea	31.6	34
Kenya	30.8	35
Angola	30.5	36
Burundi	30.5	36
Cameroon	30.2	38
Benin	29.6	39
Mali	28.5	40
Nigeria	28.3	41
Chad	28.1	42
Mauritania	28.1	42
Madagascar	28.0	44
Ghana	27.7	45
Liberia	24.9	46

GREATER MIDDLE EAST		
Country	Score	Reg. Rank
United Arab Emirates	52.4	1
Israel	48.2	2
Jordan	43.6	3
Kuwait	42.4	4
Bahrain	42.0	5
Tunisia	40.7	6
Saudi Arabia	37.9	7
Egypt	35.5	8
Iran	34.5	9
Qatar	33.0	10
Lebanon	32.2	11
Oman	30.7	12
Algeria	29.6	13
Morocco	28.4	14
Iraq	27.8	15
Sudan	27.6	16

Natura 2000 initiative, Slovenia has protected over 30% of its territories — more than any other European nation (Evans, 2012). These efforts have led some observers to call Slovenia the "Park of Europe" (Marot et al., 2013).

While many Eastern European nations attain high scores, Turkey emerges as an exception. Placing far below its peers, and most other countries, at 172nd, Turkey earns a 2022 EPI score of just 26.3. This poor performance reflects Turkey's struggle to adequately conserve its natural resources and failure to mitigate rising greenhouse gas emissions (Hockenos, 2019; Turhan et al., 2016). The EPI's innovative indicator, *projected emissions in 2050*, suggests that Turkey will be the 11th largest source of greenhouse gas emissions by midcentury unless its trajectory improves.

Latin America & the Caribbean

Countries in Latin America & the Caribbean are broadly distributed across the rankings, but the region overall achieves the third-highest median score (45.8). Twenty-one of the thirty-two nations in this region fall within the top half of rankings. The region scores better on Environmental Health, and to some extent Climate Change, than it does on Ecosystem Vitality. Exceptions to this pattern include Belize — the top-ranked country for Biodiversity & Habitat — and Argentina, Uruguay, and Paraguay — which are among the top ten ranking countries in Agriculture.

The Bahamas is the highest scoring nation in Latin America & the Caribbean, earning an EPI score of 56.2 and a rank of 28 out of 180 countries. The island nation has nearly flattened its greenhouse gas emissions trajectory, pledging as part of its Paris Agreement Nationally Determined Contribution (NDC) to reduce 2030 emissions by 30% compared to its business-as-usual trajectory. The Bahamas is also a peer-leader in habitat conservation. The country has met the Aichi Biodiversity Target of protecting 10% of its coastal and marine areas, further pledging to protect 20% under the Caribbean Challenge Initiative (Knowles et al., 2017). The Bahamas have also designated 34% of its terrestrial ecosystems as protected area, far exceeding the Aichi Target of 17%.

Lagging far behind its peers, Haiti ranks 173rd with a score

Figure 2-7. Distribution of regional scores on the EPI. Numbers shown are regional medians.

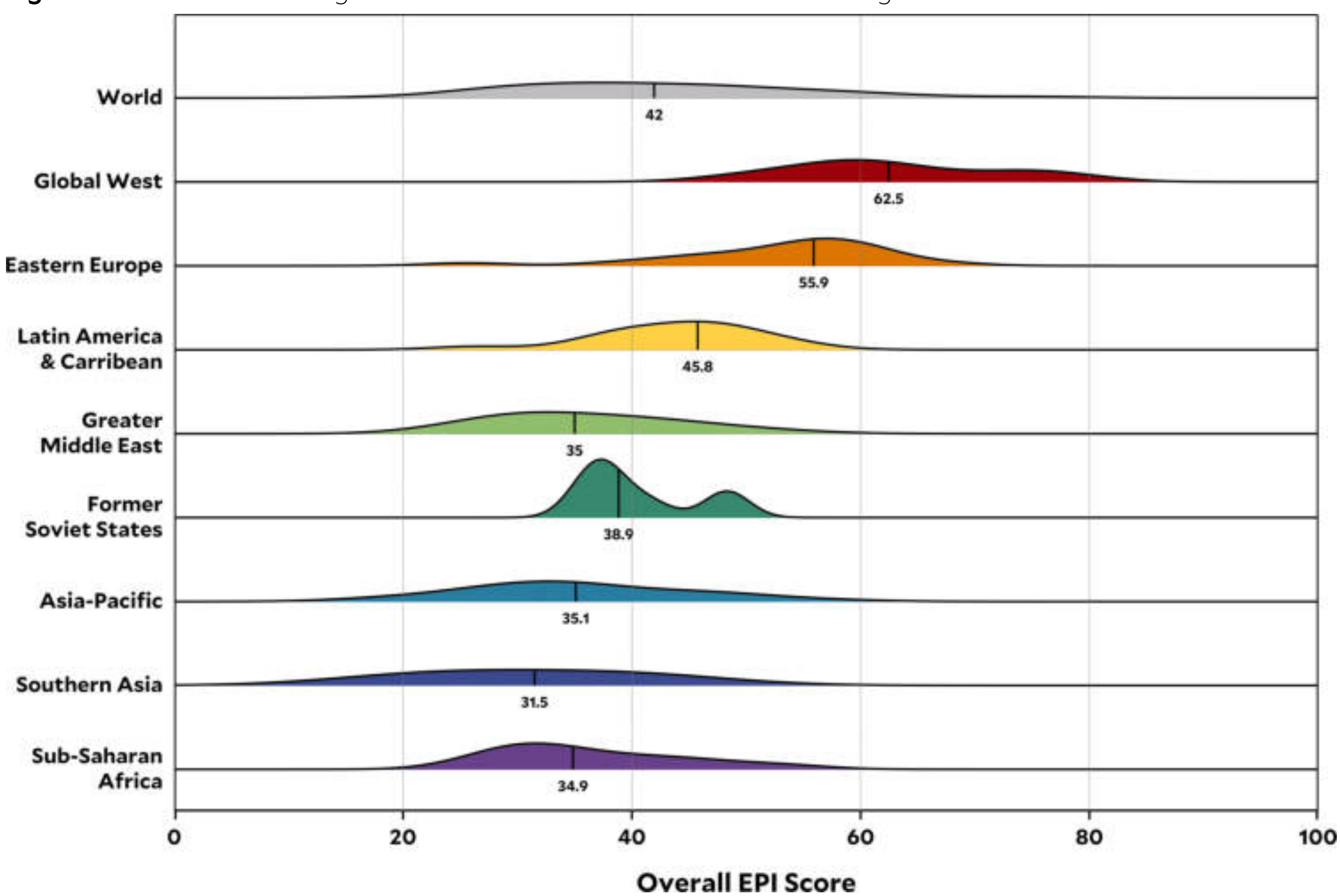


Table 2-6. Environmental Health scores and regional rankings.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Uruguay	62.7	1
Barbados	61.8	2
Chile	58.0	3
Argentina	56.3	4
Antigua and Barbuda	55.8	5
Costa Rica	55.4	6
Bahamas	54.0	7
Trinidad and Tobago	52.7	8
Colombia	50.3	9
Panama	49.0	10
Cuba	47.9	11
Saint Lucia	47.3	12
Ecuador	46.9	13
Dominica	46.2	14
Brazil	46.0	15
Grenada	45.0	16
Paraguay	44.9	17
Peru	43.1	18
Venezuela	42.9	19
St. Vincent and Grenadines	42.5	20
Jamaica	41.8	21
Mexico	40.9	22
El Salvador	39.3	23
Belize	39.0	24
Nicaragua	37.1	25
Suriname	36.0	26
Bolivia	35.8	27
Dominican Republic	33.0	28
Guyana	32.3	29
Honduras	30.0	30
Guatemala	28.1	31
Haiti	21.1	32

EASTERN EUROPE

Country	Score	Reg. Rank
Cyprus	73.8	1
Estonia	71.8	2
Greece	71.5	3
Slovenia	64.4	4
Czech Republic	63.5	5
Lithuania	61.8	6
Slovakia	59.0	7
Latvia	56.9	8
Croatia	55.7	9
Poland	53.0	10
Turkey	47.8	11
Hungary	47.6	12
Romania	45.2	13
Bulgaria	43.2	14
Serbia	41.6	15
Montenegro	41.3	16
Albania	40.0	17
Bosnia and Herzegovina	38.0	18
North Macedonia	36.5	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Maldives	48.5	1
Sri Lanka	39.0	2
Bhutan	27.2	3
Bangladesh	18.1	4
Nepal	17.1	5
Afghanistan	16.0	6
India	12.5	7
Pakistan	11.4	8

GLOBAL WEST

Country	Score	Reg. Rank
Iceland	94.7	1
Finland	93.4	2
Sweden	93.1	3
Norway	92.2	4
Switzerland	88.4	5
Ireland	88.3	6
Luxembourg	86.7	7
Australia	86.4	8
Canada	85.9	9
Denmark	85.5	10
New Zealand	84.9	11
France	83.9	12
United Kingdom	83.9	12
Netherlands	83.3	14
Germany	82.0	15
Austria	81.7	16
Spain	78.1	17
Belgium	77.9	18
Italy	76.9	19
United States of America	76.8	20
Portugal	76.6	21
Malta	76.5	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Belarus	51.1	1
Russia	50.6	2
Ukraine	43.6	3
Turkmenistan	42.3	4
Moldova	42.0	5
Armenia	40.7	6
Georgia	37.5	7
Kazakhstan	37.5	7
Azerbaijan	30.7	9
Kyrgyzstan	29.1	10
Uzbekistan	26.5	11
Tajikistan	16.6	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Japan	82.5	1
Singapore	77.0	2
South Korea	73.3	3
Brunei Darussalam	68.1	4
Taiwan	56.7	5
Malaysia	48.0	6
Tonga	45.6	7
Samoa	44.0	8
Thailand	43.8	9
Fiji	36.3	10
Marshall Islands	35.8	11
Viet Nam	35.1	12
China	32.8	13
Micronesia	31.9	14
Philippines	31.1	15
Vanuatu	30.4	16
Papua New Guinea	29.9	17
Timor-Leste	29.6	18
Cambodia	27.6	19
Kiribati	27.2	20
Indonesia	25.3	21
Laos	24.2	22
Mongolia	23.8	23
Solomon Islands	22.8	24
Myanmar	21.6	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Mauritius	57.6	1
Seychelles	54.2	2
Cabo Verde	32.6	3
Comoros	31.1	4
São Tomé and Príncpe	30.1	5
Equatorial Guinea	29.5	6
Gabon	29.4	7
Mozambique	28.3	8
Tanzania	28.2	9
South Africa	28.1	10
Malawi	26.7	11
Kenya	26.2	12
Ethiopia	25.3	13
Uganda	24.9	14
Madagascar	24.4	15
Namibia	24.2	16
Mauritania	24.0	17
Liberia	22.9	18
Rwanda	22.7	19
Benin	22.2	20
Burundi	22.0	21
Zimbabwe	21.9	22
Djibouti	21.6	23
Botswana	21.3	24
Gambia	21.3	24
Senegal	21.3	24
Zambia	21.2	27
Dem. Rep. Congo	21.1	28
Burkina Faso	20.9	29
Angola	20.5	30
Ghana	20.5	30
Mali	20.4	32
Côte d'Ivoire	19.8	33
Republic of Congo	19.7	34
Sierra Leone	19.7	34
Guinea	19.5	36
Niger	18.8	37
Togo	18.2	38
Eswatini	17.9	39
Eritrea	17.5	40
Chad	16.7	41
Guinea-Bissau	16.6	42
Nigeria	15.2	43
Cameroon	14.3	44
Central African Republic	13.1	45
Lesotho	10.9	46

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Israel	76.0	1
Jordan	52.2	2
Qatar	51.7	3
Kuwait	51.5	4
United Arab Emirates	49.4	5
Lebanon	46.3	6
Bahrain	45.3	7
Tunisia	43.2	8
Saudi Arabia	42.4	9
Algeria	42.0	10
Iran	41.9	11
Oman	39.0	12
Iraq	35.0	13
Egypt	31.5	14
Morocco	28.6	15
Sudan	17.6	16

of 26.1. The nation faces several obstacles to sustainability, including unrest and the lack of financial resources to improve failing infrastructure. Haiti is still working to recover from the devastating environmental impacts of Hurricanes Matthew and Maria between 2016 and 2017 (World Bank, 2017). These storms destroyed drinking water and sanitation facilities across the island, also wiping out renewable energy capacity (Khan, 2016). As Haiti rebuilds, it faces an increasing likelihood of stronger storms in a warming climate (Rubenstein, 2012).

Former Soviet States

Former Soviet States fall toward the middle of international rankings, earning a median score of 38.9. Ukraine, the top-ranking country in this region, places 52nd overall with an EPI score of 49.6. The data underpinning the 2022 EPI analyses do not reflect Russia's invasion of Ukraine, which is widely reported to have caused substantial environmental harm (Subbaraman, 2022). Renewable energy generation was rising rapidly in Ukraine before the war, doubling in just two years to see solar and wind constituting 12.4% of the country's capacity in 2020 (Johansmeyer, 2022). The recent conflict, however, throws Ukraine's pledge of generating 25% renewable energy by 2035 into doubt. Total damage to the country's renewable energy sector already surpasses $1 billion, indicating a significant setback to decarbonization (Johansmeyer, 2022).

Kyrgyzstan falls to the bottom of the regional ranking, placing 126th out of 180 countries with a score of 35.7. This low score reflects poor performance across a wide range of environmental issues, including Air Quality and Waste Management. Lacking effective emissions regulations, industries in Kyrgyzstan emit hazardous air pollutants that threaten urban populations in cities like Bishkek (NDI, 2021). Despite having a population of only one million, the capital city has the second-worst air quality in the world (UNEP, 2022b). Bishkek's bowl-shaped geography traps pollutants emitted from coal combustion, resulting in serious public health impacts for the city's residents.

Greater Middle East

The Greater Middle East exhibits a wide range of environmental performance, with country EPI scores ranging between 27.6 and 52.4 and ranks spanning 39th to 171st. The region earns a median overall EPI score of 35. Many

Figure 2-8. Distribution of regional scores on Environmental Health. Numbers shown are regional medians.

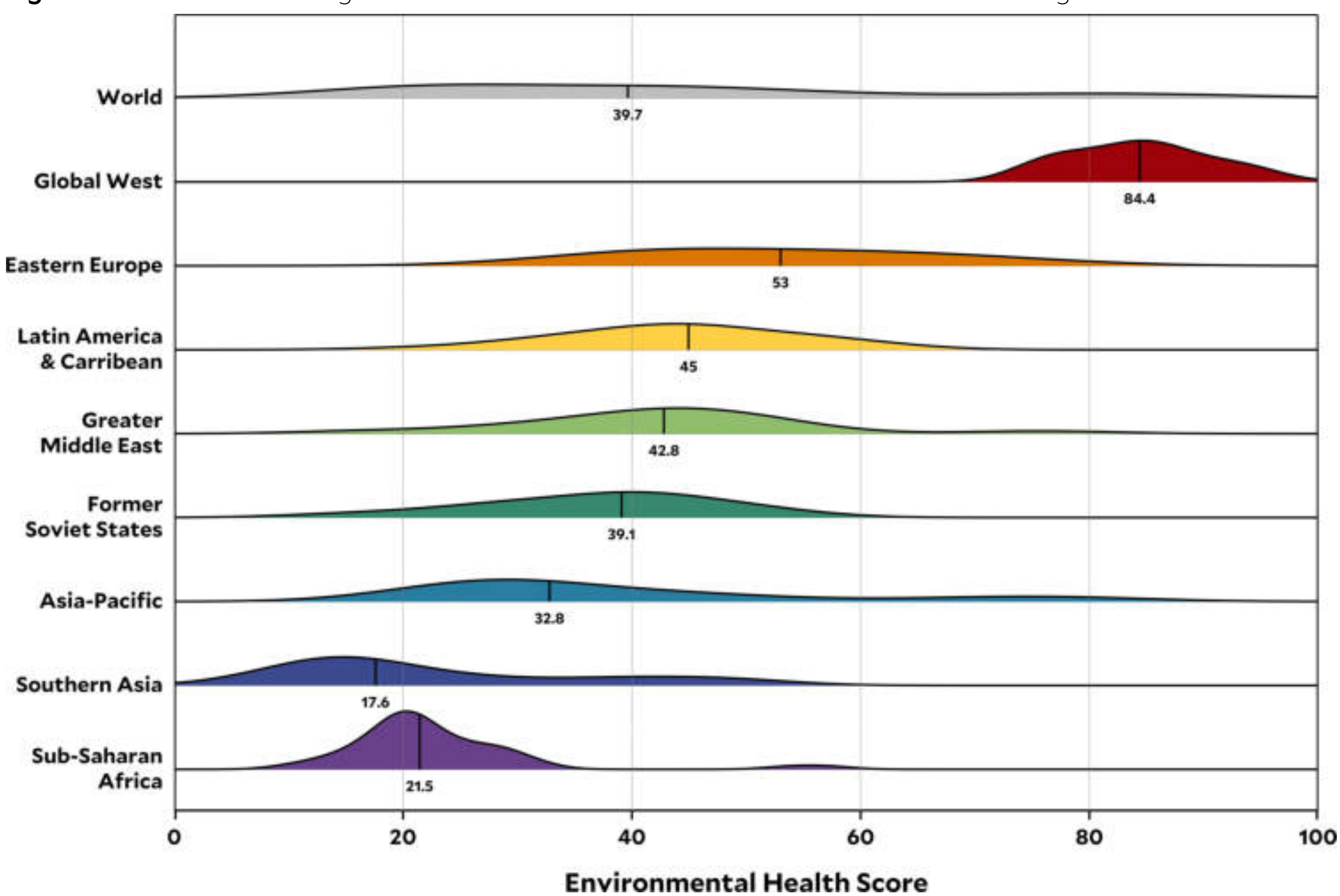


Table 2-7. Ecosystem Vitality scores and regional rankings.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Belize	57.8	1
Panama	57.5	2
Brazil	55.2	3
Mexico	53.7	4
Bolivia	52.9	5
Bahamas	52.1	6
Venezuela	52.0	7
Dominican Republic	51.8	8
Chile	51.2	9
St. Vincent and Grenadines	51.1	10
Colombia	49.6	11
Ecuador	49.2	12
Paraguay	48.9	13
Suriname	46.6	14
Costa Rica	46.4	15
Peru	45.2	16
Trinidad and Tobago	44.0	17
Antigua and Barbuda	43.6	18
Honduras	40.9	19
Nicaragua	40.9	19
Guyana	40.2	21
Jamaica	39.8	22
Argentina	38.9	23
Dominica	37.6	24
Saint Lucia	36.4	25
Cuba	35.1	26
Grenada	33.1	27
El Salvador	33.0	28
Guatemala	29.0	29
Haiti	26.9	30
Uruguay	25.8	31
Barbados	24.9	32

EASTERN EUROPE

Country	Score	Reg. Rank
Slovenia	72.7	1
Slovakia	66.3	2
Croatia	65.6	3
Latvia	65.4	4
Romania	65.4	4
Estonia	65.0	6
Hungary	65.0	6
Czech Republic	64.5	8
Lithuania	61.0	9
Poland	60.0	10
Bulgaria	58.0	11
Cyprus	54.2	12
Greece	53.9	13
North Macedonia	48.7	14
Serbia	47.0	15
Albania	45.5	16
Montenegro	44.7	17
Bosnia and Herzegovina	34.8	18
Turkey	20.3	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Bhutan	54.9	1
Sri Lanka	40.1	2
Pakistan	37.8	3
Nepal	37.5	4
Afghanistan	36.9	5
Maldives	35.7	6
Bangladesh	29.4	7
India	19.3	8

GLOBAL WEST

Country	Score	Reg. Rank
Austria	73.9	1
Luxembourg	70.0	2
Malta	68.2	3
Germany	66.8	4
France	64.0	5
Australia	62.3	6
United Kingdom	62.3	6
Finland	62.0	8
Denmark	61.3	9
Sweden	60.6	10
Spain	60.3	11
Switzerland	60.2	12
Netherlands	60.0	13
Belgium	57.9	14
New Zealand	57.9	14
Norway	57.6	16
Italy	57.2	17
Iceland	53.4	18
Canada	52.5	19
United States of America	51.4	20
Ireland	50.9	21
Portugal	49.6	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Armenia	58.1	1
Tajikistan	55.7	2
Belarus	55.4	3
Kazakhstan	48.1	4
Ukraine	48.0	5
Azerbaijan	44.4	6
Moldova	42.9	7
Uzbekistan	41.0	8
Turkmenistan	40.7	9
Kyrgyzstan	40.4	10
Russia	39.0	11
Georgia	35.7	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Japan	59.6	1
Kiribati	52.7	2
South Korea	48.8	3
Laos	46.9	4
Taiwan	46.4	5
Mongolia	45.9	6
Singapore	42.5	7
Tonga	40.9	8
Timor-Leste	39.9	9
Brunei Darussalam	38.6	10
Philippines	38.6	10
Cambodia	37.5	12
Thailand	37.3	13
Malaysia	36.0	14
Indonesia	34.1	15
Micronesia	29.4	16
Vanuatu	28.0	17
Samoa	25.6	18
China	24.5	19
Viet Nam	22.1	20
Papua New Guinea	21.9	21
Fiji	21.0	22
Myanmar	20.2	23
Marshall Islands	18.7	24
Solomon Islands	14.6	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Niger	64.7	1
Zimbabwe	61.7	2
Botswana	61.4	3
Zambia	58.2	4
Seychelles	57.8	5
Central African Republic	55.9	6
São Tomé and Príncpe	54.5	7
Malawi	54.1	8
Gabon	53.3	9
Namibia	51.3	10
Guinea-Bissau	51.2	11
Burkina Faso	49.6	12
Uganda	49.2	13
Comoros	49.1	14
Dem. Rep. Congo	46.1	15
Côte d'Ivoire	46.0	16
Ethiopia	45.6	17
Republic of Congo	45.6	17
Tanzania	45.2	19
Mozambique	44.5	20
South Africa	44.2	21
Equatorial Guinea	44.1	22
Chad	42.3	23
Togo	41.1	24
Senegal	40.2	25
Guinea	38.7	26
Mali	38.4	27
Cabo Verde	37.9	28
Rwanda	37.7	29
Mauritius	37.2	30
Eswatini	37.0	31
Sierra Leone	36.4	32
Benin	36.2	33
Djibouti	36.2	33
Burundi	35.5	35
Ghana	34.7	36
Gambia	34.6	37
Kenya	34.6	37
Nigeria	33.3	39
Cameroon	33.0	40
Eritrea	30.6	41
Mauritania	30.2	42
Madagascar	29.5	43
Angola	28.6	44
Lesotho	23.5	45
Liberia	20.9	46

GREATER MIDDLE EAST

Country	Score	Reg. Rank
United Arab Emirates	70.4	1
Saudi Arabia	47.7	2
Kuwait	47.1	3
Egypt	43.7	4
Israel	42.5	5
Bahrain	42.3	6
Iraq	41.6	7
Iran	40.6	8
Jordan	40.3	9
Qatar	34.5	10
Sudan	34.5	10
Oman	33.5	12
Tunisia	32.7	13
Algeria	31.6	14
Morocco	27.2	15
Lebanon	20.4	16

countries in the Greater Middle East perform well in Ecosystem Services, but lag behind the world in terms of Heavy Metals exposure and Climate Change. Large variability, however, means that in each issue category, certain countries rise above their peers to achieve sustainability.

The United Arab Emirates is the top-scoring country in the Greater Middle East, driven largely by strong performance in habitat and natural resource conservation. The country places third among 180 countries in Ecosystem Vitality. This high rank results from expansive protected areas, covering over 19% of its land and 11.5% of its coastlines and exclusive economic zones (EEZs) (WDPA, 2020). Having recently worked to protect and restore its wetlands, the United Arab Emirates also scores highly in the Ecosystem Services issue category (Monks, 2019).

With poor performance on most environmental topics, Sudan ranks last among countries in the Greater Middle East. The country exhibits particularly low scores on issues of Environmental Health, such as Air Quality and Sanitation & Drinking Water. It further receives the second-lowest score in Heavy Metals exposure. Residents in Sudan face multiple risks of lead poisoning, from contaminated drinking water to occupational exposure in the petroleum industry (Ismael et al., 2022; Qafisheh et al., 2021).

Asia-Pacific

Asia-Pacific is the third-lowest performing region on the EPI, earning a median score of 35.1. The low median masks outliers that rank far ahead of their peers. Japan, South Korea, and Singapore consistently place alongside other wealthy countries in the Global West, illustrating the importance of financial resources as a determinant of good environmental outcomes.

Japan is the best performing country in the Asia-Pacific region, earning a score of 57.2 and placing 25th overall. This frontrunner status reflects Japan's leadership in Environmental Health and Ecosystem Vitality. Japan boasts the highest life expectancy of any country, in part due to its clean air and water. In the aftermath of the 2011 Fukushima accident, however, Japan began replacing nuclear plants with polluting natural gas and coal plants (Tabuchi, 2020). The country also continues to invest in

Figure 2-9. Distribution of regional scores on Ecosystem Vitality. Numbers shown are regional medians.

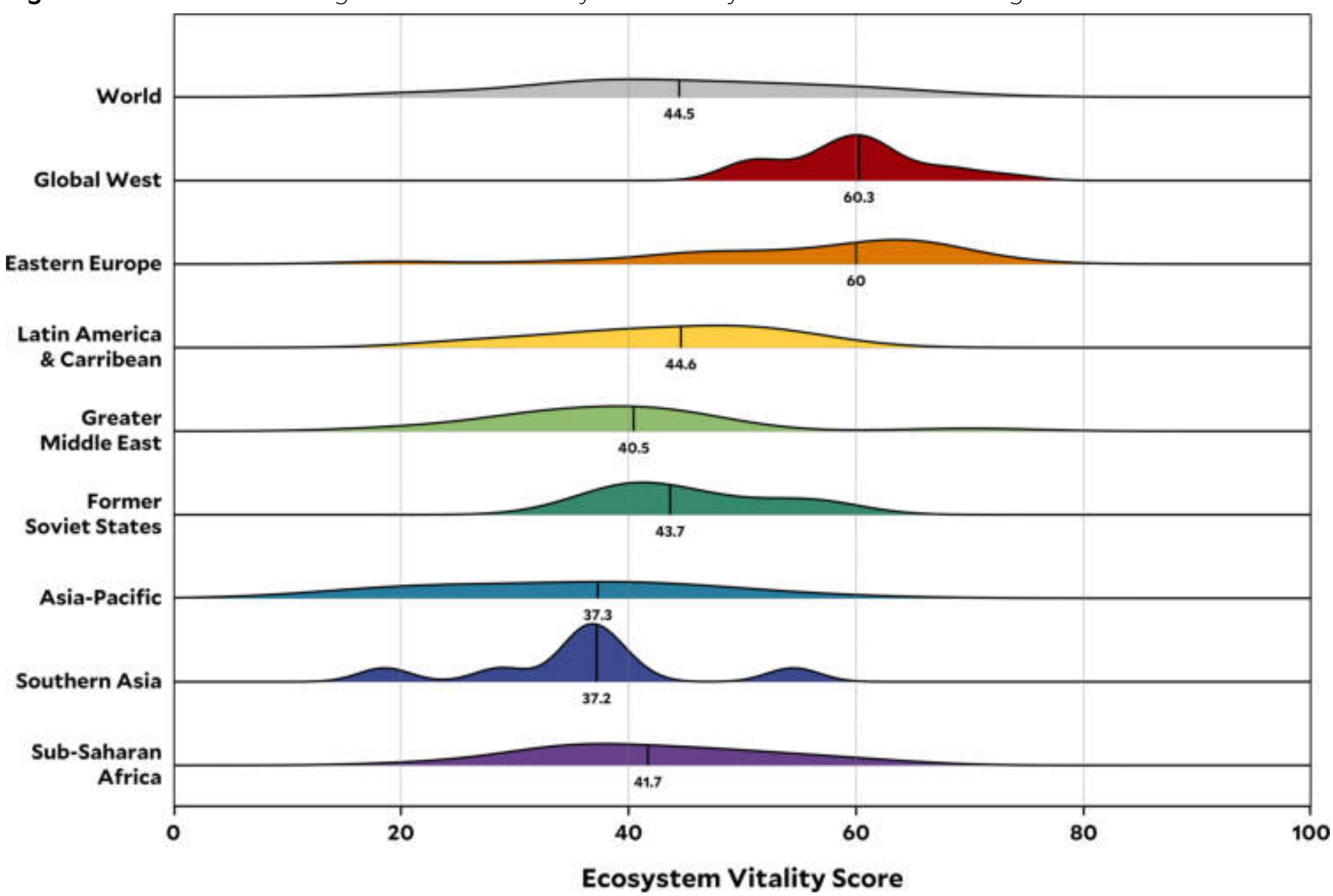


Table 2-8. Climate Change scores and regional rankings.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Barbados	79.9	1
Dominica	68.8	2
Grenada	65.7	3
Saint Lucia	64.8	4
Bahamas	61.8	5
Cuba	61.1	6
St. Vincent and Grenadines	61.0	7
Antigua and Barbuda	60.2	8
Jamaica	54.1	9
Suriname	50.3	10
El Salvador	50.2	11
Trinidad and Tobago	49.3	12
Belize	47.1	13
Panama	43.5	14
Ecuador	43.2	15
Venezuela	42.1	16
Costa Rica	41.5	17
Guyana	40.0	18
Mexico	38.9	19
Uruguay	37.0	20
Dominican Republic	36.5	21
Chile	35.8	22
Argentina	35.5	23
Honduras	35.0	24
Nicaragua	34.5	25
Peru	32.2	26
Colombia	30.2	27
Paraguay	30.1	28
Brazil	29.6	29
Bolivia	28.3	30
Haiti	27.9	31
Guatemala	26.7	32

EASTERN EUROPE

Country	Score	Reg. Rank
North Macedonia	69.8	1
Slovenia	62.9	2
Latvia	58.6	3
Croatia	56.6	4
Cyprus	53.8	5
Slovakia	53.5	6
Czech Republic	52.8	7
Albania	52.5	8
Montenegro	52.3	9
Estonia	52.0	10
Romania	51.3	11
Greece	50.8	12
Bulgaria	49.8	13
Hungary	48.1	14
Lithuania	47.1	15
Bosnia and Herzegovina	45.1	16
Serbia	41.7	17
Poland	38.8	18
Turkey	21.5	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Afghanistan	65.6	1
Bhutan	36.8	2
Maldives	33.5	3
Sri Lanka	26.4	4
Nepal	24.1	5
India	21.7	6
Bangladesh	18.8	7
Pakistan	16.9	8

GLOBAL WEST

Country	Score	Reg. Rank
Denmark	92.4	1
United Kingdom	91.5	2
Finland	83.6	3
Malta	82.3	4
Sweden	75.4	5
Luxembourg	67.4	6
Switzerland	60.5	7
Iceland	56.4	8
Netherlands	54.5	9
Austria	50.3	10
France	49.5	11
Ireland	48.2	12
Italy	48.2	12
Belgium	48.1	14
Germany	47.2	15
Norway	43.9	16
Australia	43.8	17
Spain	41.3	18
New Zealand	40.4	19
Portugal	37.6	20
United States of America	37.2	21
Canada	28.2	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Ukraine	54.7	1
Georgia	43.6	2
Moldova	42.9	3
Armenia	41.4	4
Uzbekistan	41.3	5
Belarus	39.6	6
Azerbaijan	36.4	7
Kazakhstan	34.9	8
Kyrgyzstan	34.0	9
Turkmenistan	30.2	10
Russia	29.1	11
Tajikistan	27.3	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Solomon Islands	63.9	1
Kiribati	56.3	2
Marshall Islands	55.8	3
Vanuatu	50.1	4
Micronesia	49.2	5
Singapore	46.5	6
Tonga	46.0	7
Samoa	44.2	8
Brunei Darussalam	41.7	9
Japan	41.2	10
Fiji	40.0	11
Taiwan	38.1	12
Thailand	36.0	13
Timor-Leste	32.8	14
South Korea	30.9	15
China	30.4	16
Malaysia	27.2	17
Papua New Guinea	25.4	18
Cambodia	23.3	19
Indonesia	23.2	20
Myanmar	17.3	21
Philippines	16.9	22
Laos	16.2	23
Mongolia	14.6	24
Viet Nam	10.1	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Angola	37.7	19
Benin	26.2	37
Botswana	63.1	5
Burkina Faso	27.6	35
Burundi	29.4	31
Cabo Verde	51.4	10
Cameroon	35.4	21
Central African Republic	49.5	11
Chad	18.5	45
Comoros	41.2	16
Côte d'Ivoire	25.1	40
Dem. Rep. Congo	35.1	22
Djibouti	73.7	1
Equatorial Guinea	53.6	8
Eritrea	40.4	18
Eswatini	67.9	2
Ethiopia	19.9	43
Gabon	56.3	6
Gambia	46.5	12
Ghana	23.8	41
Guinea	30.0	29
Guinea-Bissau	40.5	17
Kenya	29.0	32
Lesotho	53.3	9
Liberia	30.5	28
Madagascar	28.4	33
Malawi	33.1	26
Mali	21.9	42
Mauritania	27.8	34
Mauritius	46.4	13
Mozambique	19.3	44
Namibia	64.6	3
Niger	17.9	46
Nigeria	29.6	30
Republic of Congo	44.9	14
Rwanda	32.6	27
São Tomé and Príncpe	63.2	4
Senegal	33.6	25
Seychelles	53.9	7
Sierra Leone	35.5	20
South Africa	34.1	24
Tanzania	25.3	39
Togo	34.4	23
Uganda	26.8	36
Zambia	25.6	38
Zimbabwe	41.9	15

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Tunisia	48.3	1
Jordan	42.8	2
Bahrain	39.9	3
Israel	39.8	4
Lebanon	37.9	5
United Arab Emirates	34.0	6
Kuwait	32.3	7
Morocco	29.5	8
Egypt	28.5	9
Sudan	25.1	10
Saudi Arabia	24.8	11
Iran	24.0	12
Oman	23.2	13
Qatar	21.5	14
Algeria	20.9	15
Iraq	8.8	16

coal plants, projected to cause 200,000 premature deaths over the typical 30-year operation period of the plants (Son et al., 2019).

Ranking 179th out of 180 countries, Myanmar continues to suffer from civil unrest and the lack of a comprehensive sustainability policy. The country has lost 16% of its total tree cover since 2002, driven largely by logging and agricultural expansion (Global Forest Watch, 2022). Political instability has undermined the slow but steady environmental progress seen before the 2021 coup (Nachemson, 2021). As Myanmar navigates challenging political currents, a top priority should be preserving the natural resources on which the country's economy depends (Bax and Lunn, 2021).

Sub-Saharan Africa

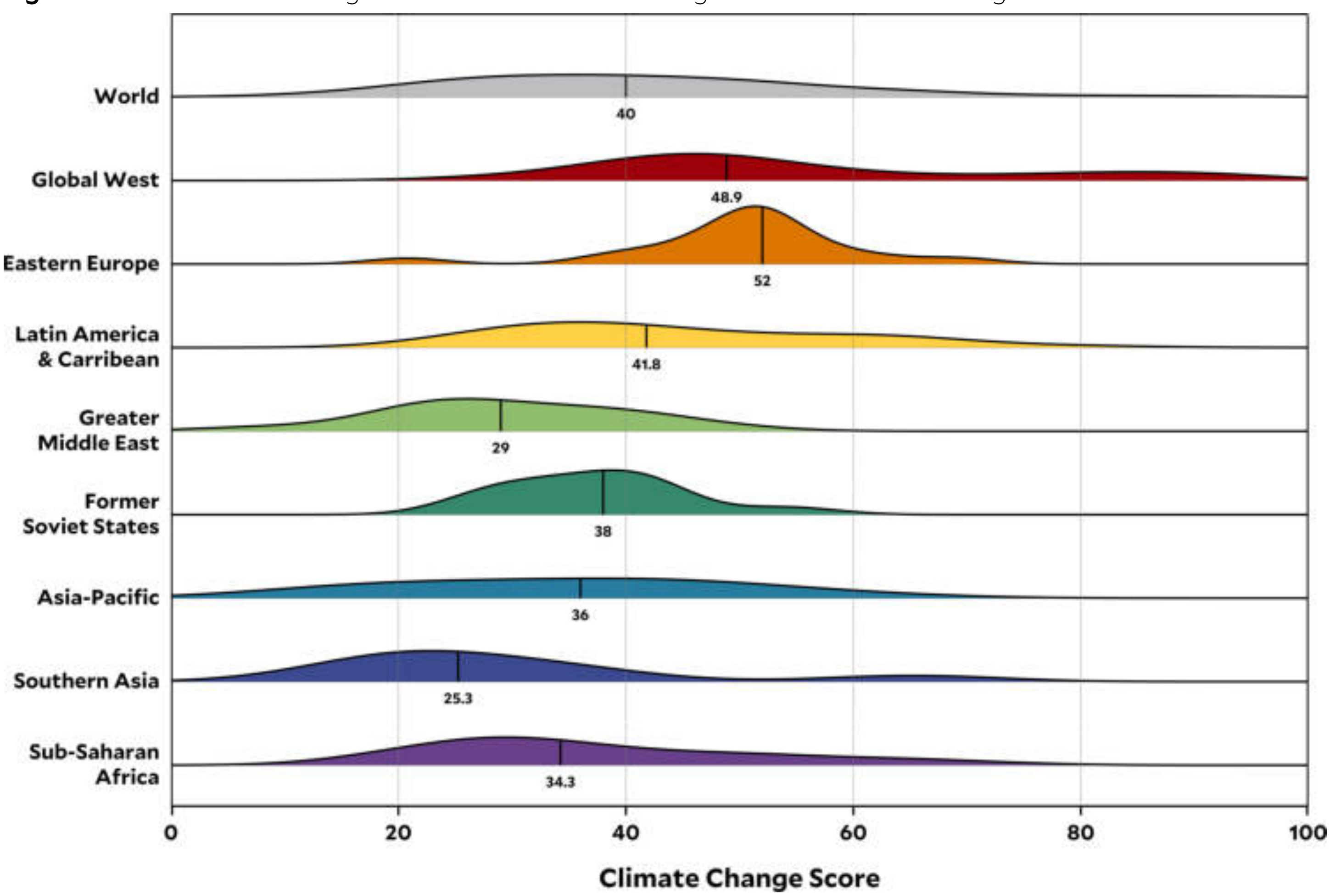
Sub-Saharan Africa is the second-lowest ranking region, although a long tail of high-performing countries demonstrate that more sustainable practices are within reach. The median regional score is 34.9, with scores ranging from 24.9 (Liberia) to 55.6 (Seychelles). Rising populations and expanding urban areas in Sub-Saharan Africa overburden ecosystems and degrade natural resources. Although energy, sanitation, and other civil infrastructure remain inadequate to widely promote environmental health, the region should strive to technologically leapfrog developed countries to attain a more sustainable future. For instance, Botswana — a high performer in the new *projected greenhouse gas emissions in 2050* indicator — plans to reach 15% renewable energy generation by 2030 and 50% by 2036 (IRENA, 2021).

Southern Asia

The spread in Southern Asian countries' EPI scores is one of the greatest of any region, reflecting a wide range of economic development and government effectiveness. While global Fisheries scores remain low, Southern Asia earns the highest median regional score at 31.8 in this issue category. The region is particularly plagued by air pollution. Of the bottom five countries in the Air Quality issue category, three — Pakistan, India, and Nepal — fall within Southern Asia.

For the first time, India falls to the bottom of EPI rankings. The country has some of the world's worst air quality and

Figure 2-10. Distribution of regional scores on Climate Change. Numbers shown are regional medians.



is home to 21 out of the 30 most polluted cities (Ganguly et al., 2021). In response to the growing toll of air pollution, the Indian government instituted the National Clean Air Program that aims to improve air quality by 20–30% by 2024 in the country's 122 worst-affected cities. Some experts doubt the efficacy of the program, however, which lacks detailed information on the technical and financial resources required to succeed (Ganguly et al., 2020). EPI projections further indicate that India will be the second largest emitter of greenhouse gases in 2050, responsible for 11% of residual emissions unless leaders strengthen the country's climate policies.

5. Peer Groups

Beyond regions, the 2022 EPI also provides rankings within peer groups based on shared geographical, commercial, historical, or cultural characteristics. These groupings promote comparative analysis, highlight leaders (and in doing so provide a signal as to where best practices can be found), and spur on laggards to adopt better environmental policies.

We encourage readers to view these groups as a starting point and not an exhaustive list of possible comparisons. Policymakers and researchers seeking to customize their own peer groups can do so using the data and results posted online at epi.yale.edu.

Table 2-9. 2022 Environmental Performance Index peer group rankings, scores, and ten-year changes in score.

Association of Southeast Asian Nations

Rank	Country	Score	10-Yr Change
1	Singapore	50.9	3.7
2	Brunei Darussalam	45.7	7.4
3	Thailand	38.1	7.2
4	Malaysia	35.0	10.3
5	Laos	30.7	-1.3
6	Cambodia	30.1	2.0
7	Philippines	28.9	-7.5
8	Indonesia	28.2	4.1
9	Viet Nam	20.1	-0.6
10	Myanmar	19.4	-3.8

OPEC Countries

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	52.4	15.9
2	Gabon	49.7	-0.3
3	Venezuela	46.4	0.2
4	Equatorial Guinea	44.8	15.3
5	Kuwait	42.4	15.2
6	Republic of Congo	40.1	6.2
7	Saudi Arabia	37.9	9.5
8	Iran	34.5	6.9
9	Angola	30.5	0.2
10	Algeria	29.6	-4.0
11	Nigeria	28.3	-6.1
12	Iraq	27.8	-5.3

La Francophonie

Rank	Country	Score	10-Yr Change
1	Luxembourg	72.3	13.5
2	Switzerland	65.9	8.2
3	France	62.5	6.4
4	Belgium	58.2	6.1
5	Greece	56.2	4.3
6	Romania	56.0	5.3
7	Seychelles	55.6	7.0
8	North Macedonia	54.3	3.6
9	Sao Tome and Principe	52.9	7.0
10	Bulgaria	51.9	4.6
11	Dominica	51.2	10.2
12	Canada	50.0	4.0
13	Gabon	49.7	-0.3
14	Saint Lucia	49.4	0.3
15	Armenia	48.3	4.8
16	Djibouti	47.5	12.9
17	Albania	47.1	9.9
18	Central African Republic	44.9	-0.7
19	Equatorial Guinea	44.8	15.3
19	Mauritius	44.8	10.0
21	Moldova	42.7	-4.8
22	Comoros	42.5	1.0
23	Cabo Verde	41.9	4.8
24	Tunisia	40.7	8.1
25	Guinea-Bissau	40.2	3.5
26	Republic of Congo	40.1	6.2
27	Niger	37.7	-2.8
28	Dem. Rep. Congo	36.9	-0.2
28	Vanuatu	36.9	-9.2
30	Burkina Faso	35.5	2.0
30	Egypt	35.5	6.5
32	Togo	34.0	-2.4
33	Senegal	33.9	-0.9
34	Cote d'Ivoire	32.8	-8.2
34	Rwanda	32.8	-4.2
36	Lebanon	32.2	-4.7
37	Guinea	31.6	0.2
38	Laos	30.7	-1.3
39	Burundi	30.5	-13.0
40	Cameroon	30.2	-2.0
41	Cambodia	30.1	2.0
42	Benin	29.6	-1.6
43	Mali	28.5	-1.8
44	Morocco	28.4	2.6
45	Mauritania	28.1	-3.3
45	Chad	28.1	0.0
47	Madagascar	28.0	-5.4
48	Haiti	26.1	2.4
49	Viet Nam	20.1	-0.6

Arab League

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	52.4	15.9
2	Djibouti	47.5	12.9
3	Jordan	43.6	7.8
4	Comoros	42.5	1.0
5	Kuwait	42.4	15.2
6	Bahrain	42.0	5.7
7	Tunisia	40.7	8.1
8	Saudi Arabia	37.9	9.5
9	Egypt	35.5	6.5
10	Qatar	33.0	-2.3
11	Lebanon	32.2	-4.7
12	Oman	30.7	6.4
13	Algeria	29.6	-4.0
14	Morocco	28.4	2.6
15	Mauritania	28.1	-3.3
16	Iraq	27.8	-5.3
17	Sudan	27.6	1.7

European Union - 27

Rank	Country	Score	10-Yr Change
1	Denmark	77.9	14.9
2	Finland	76.5	21.0
3	Malta	75.2	25.4
4	Sweden	72.7	15.8
5	Luxembourg	72.3	13.5
6	Slovenia	67.3	8.6
7	Austria	66.5	7.2
8	Netherlands	62.6	5.9
9	France	62.5	6.4
10	Germany	62.4	2.2
11	Estonia	61.4	6.1
12	Latvia	61.1	8.2
13	Croatia	60.2	17.2
14	Slovakia	60.0	3.2
15	Czech Republic	59.9	5.2
16	Belgium	58.2	6.1
17	Cyprus	58.0	6.0
18	Italy	57.7	6.0
19	Ireland	57.4	2.5
19	Spain	56.6	7.3
21	Greece	56.2	4.3
22	Romania	56.0	5.3
23	Lithuania	55.9	3.2
24	Hungary	55.1	2.0
25	Bulgaria	51.9	4.6
26	Poland	50.6	0.0
27	Portugal	50.4	-1.6

Emerging Markets

Rank	Country	Score	10-Yr Change
1	Czech Republic	59.9	5.2
2	Greece	56.2	4.3
3	Hungary	55.1	2.0
4	United Arab Emirates	52.4	15.9
5	Poland	50.6	0.0
6	South Korea	46.9	1.8
7	Chile	46.7	6.8
8	Mexico	45.5	12.4
9	Taiwan	45.3	7.0
10	Brazil	43.6	5.4
11	Kuwait	42.4	15.2
12	Colombia	42.4	-0.5
13	Argentina	41.1	7.8
14	Peru	39.8	-0.4
15	Thailand	38.1	7.2
16	Saudi Arabia	37.9	9.5
17	Russia	37.5	1.6
18	South Africa	37.2	10.1
19	Egypt	35.5	6.5
19	Malaysia	35.0	10.3
21	Qatar	33.0	-2.3
22	Philippines	28.9	-7.5
23	China	28.4	11.4
24	Indonesia	28.2	4.1
25	Turkey	26.3	-0.5
26	Pakistan	24.6	1.4
27	India	18.9	-0.6

Least Developed Countries

Rank	Country	Score	10-Yr Change
1	Sao Tome and Principe	52.9	7.0
2	Kiribati	49.0	4.8
3	Djibouti	47.5	12.9
4	Central African Republic	44.9	-0.7
5	Afghanistan	43.6	23.9
6	Comoros	42.5	1.0
7	Bhutan	42.5	-7.9
8	Malawi	40.6	-4.5
9	Guinea-Bissau	40.2	3.5
10	Zambia	38.4	-6.9
11	Niger	37.7	-2.8
12	Dem. Rep. Congo	36.9	-0.2
13	Vanuatu	36.9	-9.2
14	Gambia	36.4	5.6
15	Uganda	35.8	3.1
16	Burkina Faso	35.5	2.0
17	Timor-Leste	35.1	-0.3
18	Solomon Islands	35.0	0.8
19	Tanzania	34.2	3.4
19	Togo	34.0	-2.4
21	Senegal	33.9	-0.9
22	Rwanda	32.8	-4.2
23	Sierra Leone	32.7	7.2
24	Lesotho	32.3	1.4
25	Ethiopia	31.8	3.6
26	Eritrea	31.7	-5.5
27	Mozambique	31.7	0.6
28	Guinea	31.6	0.2
28	Laos	30.7	-1.3
30	Burundi	30.5	-13.0
30	Angola	30.5	0.2
32	Cambodia	30.1	2.0
33	Benin	29.6	-1.6
34	Mali	28.5	-1.8
34	Nepal	28.3	-10.3
36	Mauritania	28.1	-3.3
37	Chad	28.1	0.0
38	Madagascar	28.0	-5.4
39	Sudan	27.6	1.7
40	Haiti	26.1	2.4
41	Liberia	24.9	-4.0
42	Bangladesh	23.1	-1.9
43	Myanmar	19.4	-3.8

Landlocked Developing Countries

Rank	Country	Score	10-Yr Change
1	North Macedonia	54.3	3.6
2	Botswana	54.0	8.2
3	Armenia	48.3	4.8
4	Zimbabwe	46.2	-0.7
5	Central African Republic	44.9	-0.7
6	Eswatini	44.9	1.5
7	Afghanistan	43.6	23.9
8	Moldova	42.7	-4.8
9	Bhutan	42.5	-7.9
10	Kazakhstan	40.9	11.8
11	Paraguay	40.9	-6.0
12	Malawi	40.6	-4.5
13	Bolivia	40.1	0.6
14	Azerbaijan	38.6	-1.3
15	Zambia	38.4	-6.9
16	Uzbekistan	38.2	1.9
17	Niger	37.7	-2.8
18	Tajikistan	37.1	-1.6
19	Turkmenistan	37.0	8.9
19	Uganda	35.8	3.1
21	Kyrgyzstan	35.7	1.2
22	Burkina Faso	35.5	2.0
23	Rwanda	32.8	-4.2
24	Lesotho	32.3	1.4
25	Ethiopia	31.8	3.6
26	Laos	30.7	-1.3
27	Burundi	30.5	-13.0
28	Mongolia	29.6	-5.2
28	Mali	28.5	-1.8
30	Nepal	28.3	-10.3
30	Chad	28.1	0.0

Table 2-9. 2022 Environmental Performance Index peer group rankings, scores, and ten-year changes in score.

Organization of Islamic Cooperation

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	52.4	15.9
2	Gabon	49.7	-0.3
3	Djibouti	47.5	12.9
4	Albania	47.1	9.9
5	Suriname	45.9	-8.0
6	Brunei Darussalam	45.7	7.4
7	Afghanistan	43.6	23.9
7	Jordan	43.6	7.8
9	Comoros	42.5	1.0
10	Kuwait	42.4	15.2
11	Bahrain	42.0	5.7
12	Kazakhstan	40.9	11.8
13	Tunisia	40.7	8.1
14	Guinea-Bissau	40.2	3.5
15	Azerbaijan	38.6	-1.3
16	Guyana	38.5	-6.1
17	Uzbekistan	38.2	1.9
18	Saudi Arabia	37.9	9.5
19	Niger	37.7	-2.8
20	Maldives	37.4	9.0
21	Tajikistan	37.1	-1.6
22	Turkmenistan	37.0	8.9
23	Gambia	36.4	5.6
24	Uganda	35.8	3.1
25	Kyrgyzstan	35.7	1.2
26	Burkina Faso	35.5	2.0
26	Egypt	35.5	6.5
28	Malaysia	35.0	10.3
29	Iran	34.5	6.9
30	Togo	34.0	-2.4
31	Senegal	33.9	-0.9
32	Qatar	33.0	-2.3
33	Cote d'Ivoire	32.8	-8.2
34	Sierra Leone	32.7	7.2
35	Lebanon	32.2	-4.7
36	Mozambique	31.7	0.6
37	Guinea	31.6	0.2
38	Oman	30.7	6.4
39	Cameroon	30.2	-2.0
40	Benin	29.6	-1.6
40	Algeria	29.6	-4.0
42	Mali	28.5	-1.8
43	Morocco	28.4	2.6
44	Nigeria	28.3	-6.1
45	Indonesia	28.2	4.1
46	Chad	28.1	0.0
46	Mauritania	28.1	-3.3
48	Iraq	27.8	-5.3
49	Sudan	27.6	1.7
50	Turkey	26.3	-0.5
51	Pakistan	24.6	1.4
52	Bangladesh	23.1	-1.9

G-20

Rank	Country	Score	10-Yr Change
1	United Kingdom	77.7	23.0
2	France	62.5	6.4
3	Germany	62.4	2.2
4	Australia	60.1	10.3
5	Italy	57.7	6.0
6	Japan	57.2	3.2
7	United States of America	51.1	3.3
8	Canada	50.0	4.0
9	South Korea	46.9	1.8
10	Mexico	45.5	12.4
11	Brazil	43.6	5.4
12	Argentina	41.1	7.8
13	Saudi Arabia	37.9	9.5
14	Russia	37.5	1.6
15	South Africa	37.2	10.1
16	China	28.4	11.4
17	Indonesia	28.2	4.1
18	Turkey	26.3	-0.5
19	India	18.9	-0.6

Commonwealth of Nations

Rank	Country	Score	10-Yr Change
1	United Kingdom	77.7	23.0
2	Malta	75.2	25.4
3	Australia	60.1	10.3
4	Cyprus	58.0	6.0
5	New Zealand	56.7	-0.4
6	Bahamas	56.2	9.8
7	Seychelles	55.6	7.0
7	Botswana	54.0	8.2
9	Barbados	53.2	12.7
10	Saint Vincent & Grenadines	53.2	8.9
11	Antigua and Barbuda	52.4	9.7
12	Dominica	51.2	10.2
13	Singapore	50.9	3.7
14	Namibia	50.9	16.4
15	Canada	50.0	4.0
16	Belize	50.0	-2.1
17	Saint Lucia	49.4	0.3
18	Kiribati	49.0	4.8
19	Grenada	47.9	7.1
20	Trinidad and Tobago	47.8	19.0
21	Brunei Darussalam	45.7	7.4
22	Jamaica	45.6	-2.0
23	Eswatini	44.9	1.5
24	Mauritius	44.8	10.0
25	Tonga	43.8	-3.0
26	Malawi	40.6	-4.5
26	Guyana	38.5	-6.1
28	Zambia	38.4	-6.9
29	Maldives	37.4	9.0
30	South Africa	37.2	10.1
31	Vanuatu	36.9	-9.2
32	Gambia	36.4	5.6
33	Samoa	36.4	-7.4
34	Uganda	35.8	3.1
35	Malaysia	35.0	10.3
36	Solomon Islands	35.0	0.8
37	Sri Lanka	34.7	-2.6
38	Tanzania	34.2	3.4
39	Rwanda	32.8	-4.2
40	Sierra Leone	32.7	7.2
40	Lesotho	32.3	1.4
42	Mozambique	31.7	0.6
43	Fiji	31.3	-3.7
44	Kenya	30.8	-1.8
45	Cameroon	30.2	-2.0
46	Nigeria	28.3	-6.1
46	Ghana	27.7	-6.1
48	Papua New Guinea	24.8	0.2
49	Pakistan	24.6	1.4
50	Bangladesh	23.1	-1.9
51	India	18.9	-0.6

Organization of Ibero-American States

Rank	Country	Score	10-Yr Change
1	Spain	56.6	7.3
2	Panama	50.5	9.9
3	Portugal	50.4	-1.6
4	Cuba	47.5	6.8
5	Chile	46.7	6.8
6	Ecuador	46.5	9.2
7	Venezuela	46.4	0.2
7	Costa Rica	46.3	4.0
9	Mexico	45.5	12.4
10	Equatorial Guinea	44.8	15.3
11	Brazil	43.6	5.4
12	Colombia	42.4	-0.5
13	Dominican Republic	42.2	-3.1
14	Argentina	41.1	7.8
15	Paraguay	40.9	-6.0
16	El Salvador	40.8	7.6
17	Bolivia	40.1	0.6
18	Peru	39.8	-0.4
19	Nicaragua	37.7	-0.9
20	Uruguay	37.4	3.3
21	Honduras	36.5	7.2
22	Guatemala	28.0	-3.0

Small Island Developing States

Rank	Country	Score	10-Yr Change
1	Bahamas	56.2	9.8
2	Seychelles	55.6	7.0
3	Barbados	53.2	12.7
4	Saint Vincent & Grenadines	53.2	8.9
5	Sao Tome and Principe	52.9	7.0
6	Antigua and Barbuda	52.4	9.7
7	Dominica	51.2	10.2
7	Singapore	50.9	3.7
9	Belize	50.0	-2.1
10	Saint Lucia	49.4	0.3
11	Kiribati	49.0	4.8
12	Grenada	47.9	7.1
13	Trinidad and Tobago	47.8	19.0
14	Cuba	47.5	6.8
15	Suriname	45.9	-8.0
16	Jamaica	45.6	-2.0
17	Mauritius	44.8	10.0
18	Tonga	43.8	-3.0
19	Comoros	42.5	1.0
20	Dominican Republic	42.2	-3.1
21	Bahrain	42.0	5.7
22	Cabo Verde	41.9	4.8
23	Guinea-Bissau	40.2	3.5
24	Guyana	38.5	-6.1
25	Maldives	37.4	9.0
26	Micronesia	37.4	-5.9
26	Vanuatu	36.9	-9.2
28	Samoa	36.4	-7.4
29	Marshall Islands	36.2	0.7
30	Timor-Leste	35.1	-0.3
31	Solomon Islands	35.0	0.8
32	Fiji	31.3	-3.7
33	Haiti	26.1	2.4
34	Papua New Guinea	24.8	0.2

OECD Countries

Rank	Country	Score	10-Yr Change
1	Denmark	77.9	14.9
2	United Kingdom	77.7	23.0
3	Finland	76.5	21.0
4	Sweden	72.7	15.8
5	Luxembourg	72.3	13.5
6	Slovenia	67.3	8.6
7	Austria	66.5	7.2
7	Switzerland	65.9	8.2
9	Iceland	62.8	4.4
10	Netherlands	62.6	5.9
11	France	62.5	6.4
12	Germany	62.4	2.2
13	Estonia	61.4	6.1
14	Latvia	61.1	8.2
15	Australia	60.1	10.3
16	Slovakia	60.0	3.2
17	Czech Republic	59.9	5.2
18	Norway	59.3	5.8
19	Belgium	58.2	6.1
20	Italy	57.7	6.0
21	Ireland	57.4	2.5
22	Japan	57.2	3.2
23	New Zealand	56.7	-0.4
24	Spain	56.6	7.3
25	Greece	56.2	4.3
26	Lithuania	55.9	3.2
26	Hungary	55.1	2.0
28	United States of America	51.1	3.3
29	Poland	50.6	0.0
30	Portugal	50.4	-1.6
31	Canada	50.0	4.0
32	Israel	48.2	1.9
33	South Korea	46.9	1.8
34	Chile	46.7	6.8
35	Mexico	45.5	12.4
36	Turkey	26.3	-0.5

Table 2-10. Environmental Health peer group rankings, scores, and ten-year changes in scores.

Association of Southeast Asian Nations

Rank	Country	Score	10-Yr Change
1	Singapore	77.0	4.5
2	Brunei Darussalam	68.1	0.9
3	Malaysia	48.0	4.3
4	Thailand	43.8	5.1
5	Viet Nam	35.1	4.1
6	Philippines	31.1	4.6
7	Cambodia	27.6	3.5
8	Indonesia	25.3	4.0
9	Laos	24.2	5.0
10	Myanmar	21.6	5.7

OPEC Countries

Rank	Country	Score	10-Yr Change
1	Kuwait	51.5	6.3
2	United Arab Emirates	49.4	2.6
3	Venezuela	42.9	3.3
4	Saudi Arabia	42.4	6.7
5	Algeria	42.0	5.4
6	Iran	41.9	6.8
7	Iraq	35.0	9.0
8	Equatorial Guinea	29.5	2.9
9	Gabon	29.4	6.0
10	Angola	20.5	1.6
11	Republic of Congo	19.7	2.4
12	Nigeria	15.2	0.2

La Francophonie

Rank	Country	Score	10-Yr Change
1	Switzerland	88.4	5.6
2	Luxembourg	86.7	7.3
3	Canada	85.9	4.6
4	France	83.9	7.7
5	Belgium	77.9	7.2
6	Greece	71.5	6.1
7	Mauritius	57.6	6.3
8	Seychelles	54.2	2.9
9	Saint Lucia	47.3	2.2
10	Lebanon	46.3	7.0
11	Dominica	46.2	1.4
12	Romania	45.2	6.3
13	Bulgaria	43.2	4.6
14	Tunisia	43.2	5.7
15	Moldova	42.0	9.1
16	Armenia	40.7	5.2
17	Albania	40.0	3.8
18	North Macedonia	36.5	5.0
19	Viet Nam	35.1	4.1
19	Cabo Verde	32.6	-1.6
21	Egypt	31.5	6.2
22	Comoros	31.1	1.3
23	Vanuatu	30.4	0.2
24	Sao Tome and Principe	30.1	1.7
25	Equatorial Guinea	29.5	2.9
26	Gabon	29.4	6.0
27	Morocco	28.6	4.7
28	Cambodia	27.6	3.5
28	Madagascar	24.4	0.8
30	Laos	24.2	5.0
30	Mauritania	24.0	3.0
32	Rwanda	22.7	1.2
33	Benin	22.2	-0.6
34	Burundi	22.0	0.6
34	Djibouti	21.6	2.2
36	Senegal	21.3	1.1
37	Dem. Rep. Congo	21.1	0.7
38	Haiti	21.1	0.3
39	Burkina Faso	20.9	-1.0
40	Mali	20.4	0.4
41	Cote d'Ivoire	19.8	1.1
42	Republic of Congo	19.7	2.4
43	Guinea	19.5	0.8
44	Niger	18.8	-0.7
45	Togo	18.2	0.5
45	Chad	16.7	-0.9
47	Guinea-Bissau	16.6	1.9
48	Cameroon	14.3	0.8
49	Central African Republic	13.1	-0.1

Arab League

Rank	Country	Score	10-Yr Change
1	Jordan	52.2	7.4
2	Qatar	51.7	2.3
3	Kuwait	51.5	6.3
4	United Arab Emirates	49.4	2.6
5	Lebanon	46.3	7.0
6	Bahrain	45.3	6.1
7	Tunisia	43.2	5.7
8	Saudi Arabia	42.4	6.7
9	Algeria	42.0	5.4
10	Oman	39.0	5.6
11	Iraq	35.0	9.0
12	Egypt	31.5	6.2
13	Comoros	31.1	1.3
14	Morocco	28.6	4.7
15	Mauritania	24.0	3.0
16	Djibouti	21.6	2.2
17	Sudan	17.6	1.3

European Union - 27

Rank	Country	Score	10-Yr Change
1	Finland	93.4	5.3
2	Sweden	93.1	4.6
3	Ireland	88.3	8.8
4	Luxembourg	86.7	7.3
5	Denmark	85.5	7.1
6	France	83.9	7.7
7	Netherlands	83.3	5.3
8	Germany	82.0	4.9
9	Austria	81.7	6.4
10	Spain	78.1	6.5
11	Belgium	77.9	7.2
12	Italy	76.9	6.1
13	Portugal	76.6	9.1
14	Malta	76.5	7.6
15	Cyprus	73.8	6.9
16	Estonia	71.8	11.8
17	Greece	71.5	6.1
18	Slovenia	64.4	5.0
19	Czech Republic	63.5	5.0
19	Lithuania	61.8	9.4
21	Slovakia	59.0	6.6
22	Latvia	56.9	8.6
23	Croatia	55.7	6.1
24	Poland	53.0	6.5
25	Hungary	47.6	5.2
26	Romania	45.2	6.3
27	Bulgaria	43.2	4.6

Emerging Markets

Rank	Country	Score	10-Yr Change
1	South Korea	73.3	3.8
2	Greece	71.5	6.1
3	Czech Republic	63.5	5.0
4	Chile	58.0	3.9
5	Taiwan	56.7	3.8
6	Argentina	56.3	3.7
7	Poland	53.0	6.5
8	Qatar	51.7	2.3
9	Kuwait	51.5	6.3
10	Russia	50.6	9.1
11	Colombia	50.3	6.7
12	United Arab Emirates	49.4	2.6
13	Malaysia	48.0	4.3
14	Turkey	47.8	7.1
15	Hungary	47.6	5.2
16	Brazil	46.0	7.2
17	Thailand	43.8	5.1
18	Peru	43.1	3.2
19	Saudi Arabia	42.4	6.7
19	Mexico	40.9	2.8
21	China	32.8	5.8
22	Egypt	31.5	6.2
23	Philippines	31.1	4.6
24	South Africa	28.1	6.9
25	Indonesia	25.3	4.0
26	India	12.5	2.9
27	Pakistan	11.4	1.5

Least Developed Countries

Rank	Country	Score	10-Yr Change
1	Comoros	31.1	1.3
2	Vanuatu	30.4	0.2
3	Sao Tome and Principe	30.1	1.7
4	Timor-Leste	29.6	-1.2
5	Mozambique	28.3	0.7
6	Tanzania	28.2	1.3
7	Cambodia	27.6	3.5
8	Bhutan	27.2	1.7
9	Kiribati	27.2	0.7
10	Malawi	26.7	2.3
11	Ethiopia	25.3	1.2
12	Uganda	24.9	0.1
13	Madagascar	24.4	0.8
14	Laos	24.2	5.0
15	Mauritania	24.0	3.0
16	Liberia	22.9	0.6
17	Solomon Islands	22.8	-0.7
18	Rwanda	22.7	1.2
19	Benin	22.2	-0.6
19	Burundi	22.0	0.6
21	Djibouti	21.6	2.2
22	Myanmar	21.6	5.7
23	Senegal	21.3	1.1
24	Gambia	21.3	-0.3
25	Zambia	21.2	2.1
26	Dem. Rep. Congo	21.1	0.7
27	Haiti	21.1	0.3
28	Burkina Faso	20.9	-1.0
28	Angola	20.5	1.6
30	Mali	20.4	0.4
30	Sierra Leone	19.7	1.1
32	Guinea	19.5	0.8
33	Niger	18.8	-0.7
34	Togo	18.2	0.5
34	Bangladesh	18.1	2.6
36	Sudan	17.6	1.3
37	Eritrea	17.5	1.1
38	Nepal	17.1	1.3
39	Chad	16.7	-0.9
40	Guinea-Bissau	16.6	1.9
41	Afghanistan	16.0	-0.2
42	Central African Republic	13.1	-0.1
43	Lesotho	10.9	1.6

Landlocked Developing Countries

Rank	Country	Score	10-Yr Change
1	Paraguay	44.9	3.7
2	Turkmenistan	42.3	6.1
3	Moldova	42.0	9.1
4	Armenia	40.7	5.2
5	Kazakhstan	37.5	5.9
6	North Macedonia	36.5	5.0
7	Bolivia	35.8	3.5
8	Azerbaijan	30.7	3.7
9	Kyrgyzstan	29.1	5.5
10	Bhutan	27.2	1.7
11	Malawi	26.7	2.3
12	Uzbekistan	26.5	3.2
13	Ethiopia	25.3	1.2
14	Uganda	24.9	0.1
15	Laos	24.2	5.0
16	Mongolia	23.8	3.3
17	Rwanda	22.7	1.2
18	Burundi	22.0	0.6
19	Zimbabwe	21.9	3.6
19	Botswana	21.3	4.0
21	Zambia	21.2	2.1
22	Burkina Faso	20.9	-1.0
23	Mali	20.4	0.4
24	Niger	18.8	-0.7
25	Eswatini	17.9	3.9
26	Nepal	17.1	1.3
27	Chad	16.7	-0.9
28	Tajikistan	16.6	1.9
28	Afghanistan	16.0	-0.2
30	Central African Republic	13.1	-0.1
30	Lesotho	10.9	1.6

Table 2-10. Environmental Health peer group rankings, scores, and ten-year changes in scores.

Organization of Islamic Cooperation

Rank	Country	Score	10-Yr Change
1	Brunei Darussalam	68.1	0.9
2	Jordan	52.2	7.4
3	Qatar	51.7	2.3
4	Kuwait	51.5	6.3
5	United Arab Emirates	49.4	2.6
6	Maldives	48.5	5.5
7	Malaysia	48.0	4.3
7	Turkey	47.8	7.1
9	Lebanon	46.3	7.0
10	Bahrain	45.3	6.1
11	Tunisia	43.2	5.7
12	Saudi Arabia	42.4	6.7
13	Turkmenistan	42.3	6.1
14	Algeria	42.0	5.4
15	Iran	41.9	6.8
16	Albania	40.0	3.8
17	Oman	39.0	5.6
18	Kazakhstan	37.5	5.9
19	Suriname	36.0	2.9
20	Iraq	35.0	9.0
21	Guyana	32.3	4.8
22	Egypt	31.5	6.2
23	Comoros	31.1	1.3
24	Azerbaijan	30.7	3.7
25	Gabon	29.4	6.0
26	Kyrgyzstan	29.1	5.5
26	Morocco	28.6	4.7
28	Mozambique	28.3	0.7
29	Uzbekistan	26.5	3.2
30	Indonesia	25.3	4.0
31	Uganda	24.9	0.1
32	Mauritania	24.0	3.0
33	Benin	22.2	-0.6
34	Djibouti	21.6	2.2
35	Senegal	21.3	1.1
36	Gambia	21.3	-0.3
37	Burkina Faso	20.9	-1.0
38	Mali	20.4	0.4
39	Cote d'Ivoire	19.8	1.1
40	Sierra Leone	19.7	1.1
40	Guinea	19.5	0.8
42	Niger	18.8	-0.7
43	Togo	18.2	0.5
44	Bangladesh	18.1	2.6
45	Sudan	17.6	1.3
46	Chad	16.7	-0.9
46	Tajikistan	16.6	1.9
48	Guinea-Bissau	16.6	1.9
49	Afghanistan	16.0	-0.2
50	Nigeria	15.2	0.2
51	Cameroon	14.3	0.8
52	Pakistan	11.4	1.5

G-20

Rank	Country	Score	10-Yr Change
1	Australia	86.4	4.1
2	Canada	85.9	4.6
3	France	83.9	7.7
4	United Kingdom	83.9	5.2
5	Japan	82.5	1.2
6	Germany	82.0	4.9
7	Italy	76.9	6.1
8	United States of America	76.8	6.6
9	South Korea	73.3	3.8
10	Argentina	56.3	3.7
11	Russia	50.6	9.1
12	Turkey	47.8	7.1
13	Brazil	46.0	7.2
14	Saudi Arabia	42.4	6.7
15	Mexico	40.9	2.8
16	China	32.8	5.8
17	South Africa	28.1	6.9
18	Indonesia	25.3	4.0
19	India	12.5	2.9

Commonwealth of Nations

Rank	Country	Score	10-Yr Change
1	Australia	86.4	4.1
2	Canada	85.9	4.6
3	New Zealand	84.9	3.6
4	United Kingdom	83.9	5.2
5	Singapore	77.0	4.5
6	Malta	76.5	7.6
7	Cyprus	73.8	6.9
7	Brunei Darussalam	68.1	0.9
9	Barbados	61.8	1.8
10	Mauritius	57.6	6.3
11	Antigua and Barbuda	55.8	2.9
12	Seychelles	54.2	2.9
13	Bahamas	54.0	2.8
14	Trinidad and Tobago	52.7	3.2
15	Maldives	48.5	5.5
16	Malaysia	48.0	4.3
17	Saint Lucia	47.3	2.2
18	Dominica	46.2	1.4
19	Tonga	45.6	1.4
20	Grenada	45.0	2.4
21	Samoa	44.0	1.2
22	Saint Vincent & Grenadines	42.5	1.4
23	Jamaica	41.8	2.2
24	Belize	39.0	1.2
25	Sri Lanka	39.0	4.1
26	Fiji	36.3	1.8
26	Guyana	32.3	4.8
28	Vanuatu	30.4	0.2
29	Papua New Guinea	29.9	1.4
30	Mozambique	28.3	0.7
31	Tanzania	28.2	1.3
32	South Africa	28.1	6.9
33	Kiribati	27.2	0.7
34	Malawi	26.7	2.3
35	Kenya	26.2	2.7
36	Uganda	24.9	0.1
37	Namibia	24.2	3.3
38	Solomon Islands	22.8	-0.7
39	Rwanda	22.7	1.2
40	Gambia	21.3	-0.3
40	Botswana	21.3	4.0
42	Zambia	21.2	2.1
43	Ghana	20.5	1.1
44	Sierra Leone	19.7	1.1
45	Bangladesh	18.1	2.6
46	Eswatini	17.9	3.9
46	Nigeria	15.2	0.2
48	Cameroon	14.3	0.8
49	India	12.5	2.9
50	Pakistan	11.4	1.5
51	Lesotho	10.9	1.6

Organization of Ibero-American States

Rank	Country	Score	10-Yr Change
1	Spain	78.1	6.5
2	Portugal	76.6	9.1
3	Uruguay	62.7	4.3
4	Chile	58.0	3.9
5	Argentina	56.3	3.7
6	Costa Rica	55.4	2.2
7	Colombia	50.3	6.7
7	Panama	49.0	5.6
9	Cuba	47.9	3.1
10	Ecuador	46.9	5.1
11	Brazil	46.0	7.2
12	Paraguay	44.9	3.7
13	Peru	43.1	3.2
14	Venezuela	42.9	3.3
15	Mexico	40.9	2.8
16	El Salvador	39.3	3.0
17	Nicaragua	37.1	2.8
18	Bolivia	35.8	3.5
19	Dominican Republic	33.0	0.6
20	Honduras	30.0	0.7
21	Equatorial Guinea	29.5	2.9
22	Guatemala	28.1	2.6

Small Island Developing States

Rank	Country	Score	10-Yr Change
1	Singapore	77.0	4.5
2	Barbados	61.8	1.8
3	Mauritius	57.6	6.3
4	Antigua and Barbuda	55.8	2.9
5	Seychelles	54.2	2.9
6	Bahamas	54.0	2.8
7	Trinidad and Tobago	52.7	3.2
7	Maldives	48.5	5.5
9	Cuba	47.9	3.1
10	Saint Lucia	47.3	2.2
11	Dominica	46.2	1.4
12	Tonga	45.6	1.4
13	Bahrain	45.3	6.1
14	Grenada	45.0	2.4
15	Samoa	44.0	1.2
16	Saint Vincent & Grenadines	42.5	1.4
17	Jamaica	41.8	2.2
18	Belize	39.0	1.2
19	Fiji	36.3	1.8
20	Suriname	36.0	2.9
21	Marshall Islands	35.8	2.7
22	Dominican Republic	33.0	0.6
23	Cabo Verde	32.6	-1.6
24	Guyana	32.3	4.8
25	Micronesia	31.9	1.0
26	Comoros	31.1	1.3
26	Vanuatu	30.4	0.2
28	Sao Tome and Principe	30.1	1.7
29	Papua New Guinea	29.9	1.4
30	Timor-Leste	29.6	-1.2
31	Kiribati	27.2	0.7
32	Solomon Islands	22.8	-0.7
33	Haiti	21.1	0.3
34	Guinea-Bissau	16.6	1.9

OECD Countries

Rank	Country	Score	10-Yr Change
1	Iceland	94.7	2.7
2	Finland	93.4	5.3
3	Sweden	93.1	4.6
4	Norway	92.2	6.3
5	Switzerland	88.4	5.6
6	Ireland	88.3	8.8
7	Luxembourg	86.7	7.3
7	Australia	86.4	4.1
9	Canada	85.9	4.6
10	Denmark	85.5	7.1
11	New Zealand	84.9	3.6
12	United Kingdom	83.9	5.2
13	France	83.9	7.7
14	Netherlands	83.3	5.3
15	Japan	82.5	1.2
16	Germany	82.0	4.9
17	Austria	81.7	6.4
18	Spain	78.1	6.5
19	Belgium	77.9	7.2
20	Italy	76.9	6.1
21	United States of America	76.8	6.6
22	Portugal	76.6	9.1
23	Israel	76.0	5.4
24	South Korea	73.3	3.8
25	Estonia	71.8	11.8
26	Greece	71.5	6.1
26	Slovenia	64.4	5.0
28	Czech Republic	63.5	5.0
29	Lithuania	61.8	9.4
30	Slovakia	59.0	6.6
31	Chile	58.0	3.9
32	Latvia	56.9	8.6
33	Poland	53.0	6.5
34	Turkey	47.8	7.1
35	Hungary	47.6	5.2
36	Mexico	40.9	2.8

Table 2-11. Ecosystem Vitality peer group rankings, scores, and ten-year changes in scores.

Association of Southeast Asian Nations

Rank	Country	Score	10-Yr Change
1	Laos	46.9	4.5
2	Singapore	42.5	-1.7
3	Brunei Darussalam	38.6	5.1
4	Philippines	38.6	-0.4
5	Cambodia	37.5	5.1
6	Thailand	37.3	1.4
7	Malaysia	36.0	8.2
8	Indonesia	34.1	3.7
9	Viet Nam	22.1	-2.8
10	Myanmar	20.2	-4.5

OPEC Countries

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	70.4	20.4
2	Gabon	53.3	13.4
3	Venezuela	52.0	3.8
4	Saudi Arabia	47.7	3.6
5	Kuwait	47.1	22.7
6	Republic of Congo	45.6	11.0
7	Equatorial Guinea	44.1	5.1
8	Iraq	41.6	10.4
9	Iran	40.6	6.2
10	Nigeria	33.3	-3.0
11	Algeria	31.6	-0.6
12	Angola	28.6	3.0

La Francophonie

Rank	Country	Score	10-Yr Change
1	Luxembourg	70.0	1.3
2	Romania	65.4	5.9
3	Niger	64.7	16.4
4	France	64.0	1.1
5	Switzerland	60.2	5.2
6	Armenia	58.1	6.3
7	Bulgaria	58.0	6.3
8	Belgium	57.9	9.6
9	Seychelles	57.8	14.3
10	Central African Republic	55.9	-0.1
11	Sao Tome and Principe	54.5	2.6
12	Greece	53.9	0.1
13	Gabon	53.3	13.4
14	Canada	52.5	10.2
15	Guinea-Bissau	51.2	10.6
16	Burkina Faso	49.6	2.8
17	Comoros	49.1	6.8
18	North Macedonia	48.7	6.1
19	Laos	46.9	4.5
19	Dem. Rep. Congo	46.1	-0.2
21	Cote d'Ivoire	46.0	-3.0
22	Republic of Congo	45.6	11.0
23	Albania	45.5	7.3
24	Equatorial Guinea	44.1	5.1
25	Egypt	43.7	4.2
26	Moldova	42.9	-3.1
27	Chad	42.3	2.0
28	Togo	41.1	2.3
28	Senegal	40.2	-0.5
30	Guinea	38.7	1.5
30	Mali	38.4	2.0
32	Cabo Verde	37.9	2.1
33	Rwanda	37.7	0.1
34	Dominica	37.6	0.9
34	Cambodia	37.5	5.1
36	Mauritius	37.2	17.0
37	Saint Lucia	36.4	3.1
38	Benin	36.2	0.6
39	Djibouti	36.2	9.5
40	Burundi	35.5	2.4
41	Cameroon	33.0	3.8
42	Tunisia	32.7	3.1
43	Mauritania	30.2	-1.0
44	Madagascar	29.5	0.9
45	Vanuatu	28.0	-6.3
45	Morocco	27.2	-0.1
47	Haiti	26.9	1.8
48	Viet Nam	22.1	-2.8
49	Lebanon	20.4	-4.5

Arab League

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	70.4	20.4
2	Comoros	49.1	6.8
3	Saudi Arabia	47.7	3.6
4	Kuwait	47.1	22.7
5	Egypt	43.7	4.2
6	Bahrain	42.3	2.6
7	Iraq	41.6	10.4
8	Jordan	40.3	1.2
9	Djibouti	36.2	9.5
10	Qatar	34.5	-11.9
11	Sudan	34.5	-2.1
12	Oman	33.5	2.6
13	Tunisia	32.7	3.1
14	Algeria	31.6	-0.6
15	Mauritania	30.2	-1.0
16	Morocco	27.2	-0.1
17	Lebanon	20.4	-4.5

European Union - 27

Rank	Country	Score	10-Yr Change
1	Austria	73.9	3.3
2	Slovenia	72.7	2.6
3	Luxembourg	70.0	1.3
4	Malta	68.2	24.5
5	Germany	66.8	-1.5
6	Slovakia	66.3	-0.9
7	Croatia	65.6	22.2
8	Romania	65.4	5.9
9	Latvia	65.4	1.1
10	Estonia	65.0	-1.5
11	Hungary	65.0	3.8
12	Czech Republic	64.5	-0.7
13	France	64.0	1.1
14	Finland	62.0	4.8
15	Denmark	61.3	-1.2
16	Lithuania	61.0	0.6
17	Sweden	60.6	7.5
18	Spain	60.3	4.7
19	Netherlands	60.0	2.0
19	Poland	60.0	-0.1
21	Bulgaria	58.0	6.3
22	Belgium	57.9	9.6
23	Italy	57.2	3.2
24	Cyprus	54.2	1.5
25	Greece	53.9	0.1
26	Ireland	50.9	-0.3
27	Portugal	49.6	1.8

Emerging Markets

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	70.4	20.4
2	Hungary	65.0	3.8
3	Czech Republic	64.5	-0.7
4	Poland	60.0	-0.1
5	Brazil	55.2	7.0
6	Greece	53.9	0.1
7	Mexico	53.7	13.1
8	Chile	51.2	13.4
9	Colombia	49.6	1.1
10	South Korea	48.8	0.1
11	Saudi Arabia	47.7	3.6
12	Kuwait	47.1	22.7
13	Taiwan	46.4	0.2
14	Peru	45.2	0.4
15	South Africa	44.2	12.7
16	Egypt	43.7	4.2
17	Russia	39.0	0.4
18	Argentina	38.9	7.4
19	Philippines	38.6	-0.4
19	Pakistan	37.8	3.5
21	Thailand	37.3	1.4
22	Malaysia	36.0	8.2
23	Qatar	34.5	-11.9
24	Indonesia	34.1	3.7
25	China	24.5	4.5
26	Turkey	20.3	-1.7
27	India	19.3	-2.1

Least Developed Countries

Rank	Country	Score	10-Yr Change
1	Niger	64.7	16.4
2	Zambia	58.2	-4.5
3	Central African Republic	55.9	-0.1
4	Bhutan	54.9	-2.3
5	Sao Tome and Principe	54.5	2.6
6	Malawi	54.1	-1.7
7	Kiribati	52.7	2.1
8	Guinea-Bissau	51.2	10.6
9	Burkina Faso	49.6	2.8
10	Uganda	49.2	2.5
11	Comoros	49.1	6.8
12	Laos	46.9	4.5
13	Dem. Rep. Congo	46.1	-0.2
14	Ethiopia	45.6	4.4
15	Tanzania	45.2	2.0
16	Mozambique	44.5	5.7
17	Chad	42.3	2.0
18	Togo	41.1	2.3
19	Senegal	40.2	-0.5
19	Timor-Leste	39.9	8.6
21	Guinea	38.7	1.5
22	Mali	38.4	2.0
23	Rwanda	37.7	0.1
24	Cambodia	37.5	5.1
25	Nepal	37.5	-5.0
26	Afghanistan	36.9	16.7
27	Sierra Leone	36.4	8.6
28	Djibouti	36.2	9.5
28	Benin	36.2	0.6
30	Burundi	35.5	2.4
30	Gambia	34.6	9.7
32	Sudan	34.5	-2.1
33	Eritrea	30.6	-1.1
34	Mauritania	30.2	-1.0
34	Madagascar	29.5	0.9
36	Bangladesh	29.4	-4.4
37	Angola	28.6	3.0
38	Vanuatu	28.0	-6.3
39	Haiti	26.9	1.8
40	Lesotho	23.5	2.0
41	Liberia	20.9	-2.8
42	Myanmar	20.2	-4.5
43	Solomon Islands	14.6	-10.4

Landlocked Developing Countries

Rank	Country	Score	10-Yr Change
1	Niger	64.7	16.4
2	Zimbabwe	61.7	3.7
3	Botswana	61.4	3.3
4	Zambia	58.2	-4.5
5	Armenia	58.1	6.3
6	Central African Republic	55.9	-0.1
7	Tajikistan	55.7	9.5
8	Bhutan	54.9	-2.3
9	Malawi	54.1	-1.7
10	Bolivia	52.9	-1.1
11	Burkina Faso	49.6	2.8
12	Uganda	49.2	2.5
13	Paraguay	48.9	-3.6
14	North Macedonia	48.7	6.1
15	Kazakhstan	48.1	2.0
16	Laos	46.9	4.5
17	Mongolia	45.9	0.5
18	Ethiopia	45.6	4.4
19	Azerbaijan	44.4	-4.5
19	Moldova	42.9	-3.1
21	Chad	42.3	2.0
22	Uzbekistan	41.0	1.5
23	Turkmenistan	40.7	8.5
24	Kyrgyzstan	40.4	7.3
25	Mali	38.4	2.0
26	Rwanda	37.7	0.1
27	Nepal	37.5	-5.0
28	Eswatini	37.0	3.9
28	Afghanistan	36.9	16.7
30	Burundi	35.5	2.4
30	Lesotho	23.5	2.0

Table 2-11. Ecosystem Vitality peer group rankings, scores, and ten-year changes in scores.

Organization of Islamic Cooperation

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	70.4	20.4
2	Niger	64.7	16.4
3	Tajikistan	55.7	9.5
4	Gabon	53.3	13.4
5	Guinea-Bissau	51.2	10.6
6	Burkina Faso	49.6	2.8
7	Uganda	49.2	2.5
7	Comoros	49.1	6.8
9	Kazakhstan	48.1	2.0
10	Saudi Arabia	47.7	3.6
11	Kuwait	47.1	22.7
12	Suriname	46.6	-1.9
13	Cote d'Ivoire	46.0	-3.0
14	Albania	45.5	7.3
15	Mozambique	44.5	5.7
16	Azerbaijan	44.4	-4.5
17	Egypt	43.7	4.2
18	Chad	42.3	2.0
19	Bahrain	42.3	2.6
20	Iraq	41.6	10.4
21	Togo	41.1	2.3
22	Uzbekistan	41.0	1.5
23	Turkmenistan	40.7	8.5
24	Iran	40.6	6.2
25	Kyrgyzstan	40.4	7.3
26	Jordan	40.3	1.2
26	Senegal	40.2	-0.5
28	Guyana	40.2	3.4
29	Guinea	38.7	1.5
30	Brunei Darussalam	38.6	5.1
31	Mali	38.4	2.0
32	Pakistan	37.8	3.5
33	Afghanistan	36.9	16.7
34	Sierra Leone	36.4	8.6
35	Djibouti	36.2	9.5
36	Benin	36.2	0.6
37	Malaysia	36.0	8.2
38	Maldives	35.7	16.3
39	Gambia	34.6	9.7
40	Sudan	34.5	-2.1
40	Qatar	34.5	-11.9
42	Indonesia	34.1	3.7
43	Oman	33.5	2.6
44	Nigeria	33.3	-3.0
45	Cameroon	33.0	3.8
46	Tunisia	32.7	3.1
46	Algeria	31.6	-0.6
48	Mauritania	30.2	-1.0
49	Bangladesh	29.4	-4.4
50	Morocco	27.2	-0.1
51	Lebanon	20.4	-4.5
52	Turkey	20.3	-1.7

G-20

Rank	Country	Score	10-Yr Change
1	Germany	66.8	-1.5
2	France	64.0	1.1
3	Australia	62.3	14.1
4	United Kingdom	62.3	9.7
5	Japan	59.6	1.5
6	Italy	57.2	3.2
7	Brazil	55.2	7.0
8	Mexico	53.7	13.1
9	Canada	52.5	10.2
10	United States of America	51.4	1.1
11	South Korea	48.8	0.1
12	Saudi Arabia	47.7	3.6
13	South Africa	44.2	12.7
14	Russia	39.0	0.4
15	Argentina	38.9	7.4
16	Indonesia	34.1	3.7
17	China	24.5	4.5
18	Turkey	20.3	-1.7
19	India	19.3	-2.1

Commonwealth of Nations

Rank	Country	Score	10-Yr Change
1	Malta	68.2	24.5
2	Australia	62.3	14.1
3	United Kingdom	62.3	9.7
4	Botswana	61.4	3.3
5	Zambia	58.2	-4.5
6	New Zealand	57.9	-0.2
7	Seychelles	57.8	14.3
7	Belize	57.8	-0.5
9	Cyprus	54.2	1.5
10	Malawi	54.1	-1.7
11	Kiribati	52.7	2.1
12	Canada	52.5	10.2
13	Bahamas	52.1	20.4
14	Namibia	51.3	10.9
15	Saint Vincent & Grenadines	51.1	7.6
16	Uganda	49.2	2.5
17	Tanzania	45.2	2.0
18	Mozambique	44.5	5.7
19	South Africa	44.2	12.7
20	Trinidad and Tobago	44.0	9.1
21	Antigua and Barbuda	43.6	10.3
22	Singapore	42.5	-1.7
23	Tonga	40.9	4.5
24	Guyana	40.2	3.4
25	Sri Lanka	40.1	-1.6
26	Jamaica	39.8	-2.0
26	Brunei Darussalam	38.6	5.1
28	Pakistan	37.8	3.5
29	Rwanda	37.7	0.1
30	Dominica	37.6	0.9
31	Mauritius	37.2	17.0
32	Eswatini	37.0	3.9
33	Sierra Leone	36.4	8.6
34	Saint Lucia	36.4	3.1
35	Malaysia	36.0	8.2
36	Maldives	35.7	16.3
37	Ghana	34.7	1.1
38	Gambia	34.6	9.7
39	Kenya	34.6	3.2
40	Nigeria	33.3	-3.0
40	Grenada	33.1	8.6
42	Cameroon	33.0	3.8
43	Bangladesh	29.4	-4.4
44	Vanuatu	28.0	-6.3
45	Samoa	25.6	-4.9
46	Barbados	24.9	6.4
46	Lesotho	23.5	2.0
48	Papua New Guinea	21.9	-0.8
49	Fiji	21.0	-4.2
50	India	19.3	-2.1
51	Solomon Islands	14.6	-10.4

Organization of Ibero-American States

Rank	Country	Score	10-Yr Change
1	Spain	60.3	4.7
2	Panama	57.5	18.8
3	Brazil	55.2	7.0
4	Mexico	53.7	13.1
5	Bolivia	52.9	-1.1
6	Venezuela	52.0	3.8
7	Dominican Republic	51.8	-0.9
7	Chile	51.2	13.4
9	Colombia	49.6	1.1
10	Portugal	49.6	1.8
11	Ecuador	49.2	5.4
12	Paraguay	48.9	-3.6
13	Costa Rica	46.4	5.7
14	Peru	45.2	0.4
15	Equatorial Guinea	44.1	5.1
16	Honduras	40.9	8.6
17	Nicaragua	40.9	-0.5
18	Argentina	38.9	7.4
19	Cuba	35.1	2.3
20	El Salvador	33.0	10.6
21	Guatemala	29.0	-4.2
22	Uruguay	25.8	7.3

Small Island Developing States

Rank	Country	Score	10-Yr Change
1	Seychelles	57.8	14.3
2	Belize	57.8	-0.5
3	Sao Tome and Principe	54.5	2.6
4	Kiribati	52.7	2.1
5	Bahamas	52.1	20.4
6	Dominican Republic	51.8	-0.9
7	Guinea-Bissau	51.2	10.6
7	Saint Vincent & Grenadines	51.1	7.6
9	Comoros	49.1	6.8
10	Suriname	46.6	-1.9
11	Trinidad and Tobago	44.0	9.1
12	Antigua and Barbuda	43.6	10.3
13	Singapore	42.5	-1.7
14	Bahrain	42.3	2.6
15	Tonga	40.9	4.5
16	Guyana	40.2	3.4
17	Timor-Leste	39.9	8.6
18	Jamaica	39.8	-2.0
19	Cabo Verde	37.9	2.1
20	Dominica	37.6	0.9
21	Mauritius	37.2	17.0
22	Saint Lucia	36.4	3.1
23	Maldives	35.7	16.3
24	Cuba	35.1	2.3
25	Grenada	33.1	8.6
26	Micronesia	29.4	4.6
26	Vanuatu	28.0	-6.3
28	Haiti	26.9	1.8
29	Samoa	25.6	-4.9
30	Barbados	24.9	6.4
31	Papua New Guinea	21.9	-0.8
32	Fiji	21.0	-4.2
33	Marshall Islands	18.7	-1.5
34	Solomon Islands	14.6	-10.4

OECD Countries

Rank	Country	Score	10-Yr Change
1	Austria	73.9	3.3
2	Slovenia	72.7	2.6
3	Luxembourg	70.0	1.3
4	Germany	66.8	-1.5
5	Slovakia	66.3	-0.9
6	Latvia	65.4	1.1
7	Hungary	65.0	3.8
7	Estonia	65.0	-1.5
9	Czech Republic	64.5	-0.7
10	France	64.0	1.1
11	Australia	62.3	14.1
12	United Kingdom	62.3	9.7
13	Finland	62.0	4.8
14	Denmark	61.3	-1.2
15	Lithuania	61.0	0.6
16	Sweden	60.6	7.5
17	Spain	60.3	4.7
18	Switzerland	60.2	5.2
19	Poland	60.0	-0.1
20	Netherlands	60.0	2.0
21	Japan	59.6	1.5
22	New Zealand	57.9	-0.2
23	Belgium	57.9	9.6
24	Norway	57.6	5.6
25	Italy	57.2	3.2
26	Greece	53.9	0.1
26	Mexico	53.7	13.1
28	Iceland	53.4	-0.9
29	Canada	52.5	10.2
30	United States of America	51.4	1.1
31	Chile	51.2	13.4
32	Ireland	50.9	-0.3
33	Portugal	49.6	1.8
34	South Korea	48.8	0.1
35	Israel	42.5	-2.2
36	Turkey	20.3	-1.7

Table 2-12. Climate Change peer group rankings, scores, and ten-year changes in scores.

Association of Southeast Asian Nations

Rank	Country	Score	10-Yr Change
1	Singapore	46.5	9.3
2	Brunei Darussalam	41.7	13.3
3	Thailand	36.0	14.8
4	Malaysia	27.2	16.1
5	Cambodia	23.3	-2.2
6	Indonesia	23.2	4.5
7	Myanmar	17.3	-8.1
8	Philippines	16.9	-21.9
9	Laos	16.2	-11.1
10	Viet Nam	10.1	-0.7

OPEC Countries

Rank	Country	Score	10-Yr Change
1	United Arab Emirates	70.4	20.4
2	Gabon	53.3	13.4
3	Venezuela	52.0	3.8
4	Saudi Arabia	47.7	3.6
5	Kuwait	47.1	22.7
6	Republic of Congo	45.6	11.0
7	Equatorial Guinea	44.1	5.1
8	Iraq	41.6	10.4
9	Iran	40.6	6.2
10	Nigeria	33.3	-3.0
11	Algeria	31.6	-0.6
12	Angola	28.6	3.0

La Francophonie

Rank	Country	Score	10-Yr Change
1	Djibouti	73.7	22.3
2	North Macedonia	69.8	0.0
3	Dominica	68.8	25.0
4	Luxembourg	67.4	30.4
5	Saint Lucia	64.8	-3.8
6	Sao Tome and Principe	63.2	14.8
7	Switzerland	60.5	12.9
8	Gabon	56.3	-19.0
9	Seychelles	53.9	1.1
10	Equatorial Guinea	53.6	33.2
11	Albania	52.5	15.8
12	Cabo Verde	51.4	11.3
13	Romania	51.3	4.2
14	Greece	50.8	8.2
15	Vanuatu	50.1	-17.3
16	Bulgaria	49.8	2.9
17	Central African Republic	49.5	-1.6
18	France	49.5	11.5
19	Tunisia	48.3	14.9
19	Belgium	48.1	1.7
21	Mauritius	46.4	4.2
22	Republic of Congo	44.9	3.1
23	Moldova	42.9	-13.9
24	Armenia	41.4	3.0
25	Comoros	41.2	-5.5
26	Guinea-Bissau	40.5	-3.6
27	Lebanon	37.9	-11.1
28	Cameroon	35.4	-9.9
28	Dem. Rep. Congo	35.1	-0.5
30	Togo	34.4	-9.2
30	Senegal	33.6	-2.4
32	Rwanda	32.6	-11.9
33	Guinea	30.0	-1.7
34	Morocco	29.5	4.3
34	Burundi	29.4	-37.3
36	Egypt	28.5	9.0
37	Madagascar	28.4	-15.3
38	Canada	28.2	-3.3
39	Haiti	27.9	4.1
40	Mauritania	27.8	-9.3
41	Burkina Faso	27.6	2.8
42	Benin	26.2	-4.5
43	Cote d'Ivoire	25.1	-18.7
44	Cambodia	23.3	-2.2
45	Mali	21.9	-7.2
45	Chad	18.5	-1.6
47	Niger	17.9	-25.0
48	Laos	16.2	-11.1
49	Viet Nam	10.1	-0.7

Arab League

Rank	Country	Score	10-Yr Change
1	Djibouti	73.7	22.3
2	Tunisia	48.3	14.9
3	Jordan	42.8	15.4
4	Comoros	41.2	-5.5
5	Bahrain	39.9	8.8
6	Lebanon	37.9	-11.1
7	United Arab Emirates	34.0	17.9
8	Kuwait	32.3	11.6
9	Morocco	29.5	4.3
10	Egypt	28.5	9.0
11	Mauritania	27.8	-9.3
12	Sudan	25.1	5.9
13	Saudi Arabia	24.8	17.6
14	Oman	23.2	11.1
15	Qatar	21.5	5.8
16	Algeria	20.9	-12.8
17	Iraq	8.8	-30.1

European Union - 27

Rank	Country	Score	10-Yr Change
1	Denmark	92.4	37.0
2	Finland	83.6	47.2
3	Malta	82.3	35.7
4	Sweden	75.4	30.9
5	Luxembourg	67.4	30.4
6	Slovenia	62.9	17.1
7	Latvia	58.6	15.8
8	Croatia	56.6	17.6
9	Netherlands	54.5	10.6
10	Cyprus	53.8	10.4
11	Slovakia	53.5	6.0
12	Czech Republic	52.8	11.8
13	Estonia	52.0	11.5
14	Romania	51.3	4.2
15	Greece	50.8	8.2
16	Austria	50.3	11.9
17	Bulgaria	49.8	2.9
18	France	49.5	11.5
19	Ireland	48.2	2.0
19	Italy	48.2	9.0
21	Belgium	48.1	1.7
22	Hungary	48.1	-1.7
23	Germany	47.2	4.9
24	Lithuania	47.1	2.9
25	Spain	41.3	10.7
26	Poland	38.8	-3.6
27	Portugal	37.6	-10.9

Emerging Markets

Rank	Country	Score	10-Yr Change
1	Czech Republic	52.8	11.8
2	Greece	50.8	8.2
3	Hungary	48.1	-1.7
4	Mexico	38.9	16.7
5	Poland	38.8	-3.6
6	Taiwan	38.1	16.3
7	Thailand	36.0	14.8
8	Chile	35.8	1.0
9	Argentina	35.5	10.4
10	South Africa	34.1	8.8
11	United Arab Emirates	34.0	17.9
12	Kuwait	32.3	11.6
13	Peru	32.2	-3.2
14	South Korea	30.9	2.5
15	China	30.4	21.9
16	Colombia	30.2	-6.2
17	Brazil	29.6	2.6
18	Russia	29.1	-0.9
19	Egypt	28.5	9.0
19	Malaysia	27.2	16.1
21	Saudi Arabia	24.8	17.6
22	Indonesia	23.2	4.5
23	India	21.7	-0.9
24	Qatar	21.5	5.8
25	Turkey	21.5	-3.2
26	Philippines	16.9	-21.9
27	Pakistan	16.9	-0.9

Least Developed Countries

Rank	Country	Score	10-Yr Change
1	Djibouti	73.7	22.3
2	Afghanistan	65.6	44.6
3	Solomon Islands	63.9	13.9
4	Sao Tome and Principe	63.2	14.8
5	Kiribati	56.3	9.8
6	Lesotho	53.3	0.7
7	Vanuatu	50.1	-17.3
8	Central African Republic	49.5	-1.6
9	Gambia	46.5	4.5
10	Comoros	41.2	-5.5
11	Guinea-Bissau	40.5	-3.6
12	Eritrea	40.4	-13.7
13	Angola	37.7	-3.8
14	Bhutan	36.8	-19.1
15	Sierra Leone	35.5	8.9
16	Dem. Rep. Congo	35.1	-0.5
17	Togo	34.4	-9.2
18	Senegal	33.6	-2.4
19	Malawi	33.1	-11.1
19	Timor-Leste	32.8	-9.5
21	Rwanda	32.6	-11.9
22	Liberia	30.5	-7.6
23	Guinea	30.0	-1.7
24	Burundi	29.4	-37.3
25	Madagascar	28.4	-15.3
26	Haiti	27.9	4.1
27	Mauritania	27.8	-9.3
28	Burkina Faso	27.6	2.8
28	Uganda	26.8	5.6
30	Benin	26.2	-4.5
30	Zambia	25.6	-14.3
32	Tanzania	25.3	6.1
33	Sudan	25.1	5.9
34	Nepal	24.1	-22.3
34	Cambodia	23.3	-2.2
36	Mali	21.9	-7.2
37	Ethiopia	19.9	3.8
38	Mozambique	19.3	-5.2
39	Bangladesh	18.8	-1.6
40	Chad	18.5	-1.6
41	Niger	17.9	-25.0
42	Myanmar	17.3	-8.1
43	Laos	16.2	-11.1

Landlocked Developing Countries

Rank	Country	Score	10-Yr Change
1	North Macedonia	69.8	0.0
2	Eswatini	67.9	-2.4
3	Afghanistan	65.6	44.6
4	Botswana	63.1	15.8
5	Lesotho	53.3	0.7
6	Central African Republic	49.5	-1.6
7	Moldova	42.9	-13.9
8	Zimbabwe	41.9	-7.7
9	Armenia	41.4	3.0
10	Uzbekistan	41.3	1.7
11	Bhutan	36.8	-19.1
12	Azerbaijan	36.4	-0.4
13	Kazakhstan	34.9	26.0
14	Kyrgyzstan	34.0	-7.6
15	Malawi	33.1	-11.1
16	Rwanda	32.6	-11.9
17	Turkmenistan	30.2	11.0
18	Paraguay	30.1	-13.6
19	Burundi	29.4	-37.3
19	Bolivia	28.3	1.0
21	Burkina Faso	27.6	2.8
22	Tajikistan	27.3	-15.8
23	Uganda	26.8	5.6
24	Zambia	25.6	-14.3
25	Nepal	24.1	-22.3
26	Mali	21.9	-7.2
27	Ethiopia	19.9	3.8
28	Chad	18.5	-1.6
28	Niger	17.9	-25.0
30	Laos	16.2	-11.1
30	Mongolia	14.6	-16.1

Table 2-12. Climate Change peer group rankings, scores, and ten-year changes in scores.

Organization of Islamic Cooperation

Rank	Country	Score	10-Yr Change
1	Djibouti	73.7	22.3
2	Afghanistan	65.6	44.6
3	Gabon	56.3	-19.0
4	Albania	52.5	15.8
5	Suriname	50.3	-20.5
6	Tunisia	48.3	14.9
7	Gambia	46.5	4.5
7	Jordan	42.8	15.4
9	Brunei Darussalam	41.7	13.3
10	Uzbekistan	41.3	1.7
11	Comoros	41.2	-5.5
12	Guinea-Bissau	40.5	-3.6
13	Guyana	40.0	-22.2
14	Bahrain	39.9	8.8
15	Lebanon	37.9	-11.1
16	Azerbaijan	36.4	-0.4
17	Sierra Leone	35.5	8.9
18	Cameroon	35.4	-9.9
19	Kazakhstan	34.9	26.0
20	Togo	34.4	-9.2
21	Kyrgyzstan	34.0	-7.6
22	United Arab Emirates	34.0	17.9
23	Senegal	33.6	-2.4
24	Maldives	33.5	2.9
25	Kuwait	32.3	11.6
26	Turkmenistan	30.2	11.0
26	Guinea	30.0	-1.7
28	Nigeria	29.6	-12.9
29	Morocco	29.5	4.3
30	Egypt	28.5	9.0
31	Mauritania	27.8	-9.3
32	Burkina Faso	27.6	2.8
33	Tajikistan	27.3	-15.8
34	Malaysia	27.2	16.1
35	Uganda	26.8	5.6
36	Benin	26.2	-4.5
37	Sudan	25.1	5.9
38	Cote d'Ivoire	25.1	-18.7
39	Saudi Arabia	24.8	17.6
40	Iran	24.0	7.8
40	Indonesia	23.2	4.5
42	Oman	23.2	11.1
43	Mali	21.9	-7.2
44	Qatar	21.5	5.8
45	Turkey	21.5	-3.2
46	Algeria	20.9	-12.8
46	Mozambique	19.3	-5.2
48	Bangladesh	18.8	-1.6
49	Chad	18.5	-1.6
50	Niger	17.9	-25.0
51	Pakistan	16.9	-0.9
52	Iraq	8.8	-30.1

G-20

Rank	Country	Score	10-Yr Change
1	United Kingdom	91.5	47.1
2	France	49.5	11.5
3	Italy	48.2	9.0
4	Germany	47.2	4.9
5	Australia	43.8	9.4
6	Japan	41.2	6.1
7	Mexico	38.9	16.7
8	United States of America	37.2	4.0
9	Argentina	35.5	10.4
10	South Africa	34.1	8.8
11	South Korea	30.9	2.5
12	China	30.4	21.9
13	Brazil	29.6	2.6
14	Russia	29.1	-0.9
15	Canada	28.2	-3.3
16	Saudi Arabia	24.8	17.6
17	Indonesia	23.2	4.5
18	India	21.7	-0.9
19	Turkey	21.5	-3.2

Commonwealth of Nations

Rank	Country	Score	10-Yr Change
1	United Kingdom	91.5	47.1
2	Malta	82.3	35.7
3	Barbados	79.9	25.2
4	Dominica	68.8	25.0
5	Eswatini	67.9	-2.4
6	Grenada	65.7	7.8
7	Saint Lucia	64.8	-3.8
7	Namibia	64.6	29.5
9	Solomon Islands	63.9	13.9
10	Botswana	63.1	15.8
11	Bahamas	61.8	1.8
12	Saint Vincent & Grenadines	61.0	14.2
13	Antigua and Barbuda	60.2	12.5
14	Kiribati	56.3	9.8
15	Jamaica	54.1	-4.1
16	Seychelles	53.9	1.1
17	Cyprus	53.8	10.4
18	Lesotho	53.3	0.7
19	Vanuatu	50.1	-17.3
20	Trinidad and Tobago	49.3	38.2
21	Belize	47.1	-5.6
22	Gambia	46.5	4.5
23	Singapore	46.5	9.3
24	Mauritius	46.4	4.2
25	Tonga	46.0	-13.7
26	Samoa	44.2	-14.8
26	Australia	43.8	9.4
28	Brunei Darussalam	41.7	13.3
29	New Zealand	40.4	-3.0
30	Guyana	40.0	-22.2
31	Fiji	40.0	-6.2
32	Sierra Leone	35.5	8.9
33	Cameroon	35.4	-9.9
34	South Africa	34.1	8.8
35	Maldives	33.5	2.9
36	Malawi	33.1	-11.1
37	Rwanda	32.6	-11.9
38	Nigeria	29.6	-12.9
39	Kenya	29.0	-9.8
40	Canada	28.2	-3.3
40	Malaysia	27.2	16.1
42	Uganda	26.8	5.6
43	Sri Lanka	26.4	-7.3
44	Zambia	25.6	-14.3
45	Papua New Guinea	25.4	0.9
46	Tanzania	25.3	6.1
46	Ghana	23.8	-17.7
48	India	21.7	-0.9
49	Mozambique	19.3	-5.2
50	Bangladesh	18.8	-1.6
51	Pakistan	16.9	-0.9

Organization of Ibero-American States

Rank	Country	Score	10-Yr Change
1	Cuba	61.1	13.8
2	Equatorial Guinea	53.6	33.2
3	El Salvador	50.2	6.7
4	Panama	43.5	2.4
5	Ecuador	43.2	15.3
6	Venezuela	42.1	-5.4
7	Costa Rica	41.5	3.2
7	Spain	41.3	10.7
9	Mexico	38.9	16.7
10	Portugal	37.6	-10.9
11	Uruguay	37.0	-1.7
12	Dominican Republic	36.5	-7.3
13	Chile	35.8	1.0
14	Argentina	35.5	10.4
15	Honduras	35.0	9.1
16	Nicaragua	34.5	-3.2
17	Peru	32.2	-3.2
18	Colombia	30.2	-6.2
19	Paraguay	30.1	-13.6
20	Brazil	29.6	2.6
21	Bolivia	28.3	1.0
22	Guatemala	26.7	-4.6

Small Island Developing States

Rank	Country	Score	10-Yr Change
1	Barbados	79.9	25.2
2	Dominica	68.8	25.0
3	Grenada	65.7	7.8
4	Saint Lucia	64.8	-3.8
5	Solomon Islands	63.9	13.9
6	Sao Tome and Principe	63.2	14.8
7	Bahamas	61.8	1.8
7	Cuba	61.1	13.8
9	Saint Vincent & Grenadines	61.0	14.2
10	Antigua and Barbuda	60.2	12.5
11	Kiribati	56.3	9.8
12	Marshall Islands	55.8	2.2
13	Jamaica	54.1	-4.1
14	Seychelles	53.9	1.1
15	Cabo Verde	51.4	11.3
16	Suriname	50.3	-20.5
17	Vanuatu	50.1	-17.3
18	Trinidad and Tobago	49.3	38.2
19	Micronesia	49.2	-21.1
20	Belize	47.1	-5.6
21	Singapore	46.5	9.3
22	Mauritius	46.4	4.2
23	Tonga	46.0	-13.7
24	Samoa	44.2	-14.8
25	Comoros	41.2	-5.5
26	Guinea-Bissau	40.5	-3.6
26	Guyana	40.0	-22.2
28	Fiji	40.0	-6.2
29	Bahrain	39.9	8.8
30	Dominican Republic	36.5	-7.3
31	Maldives	33.5	2.9
32	Timor-Leste	32.8	-9.5
33	Haiti	27.9	4.1
34	Papua New Guinea	25.4	0.9

OECD Countries

Rank	Country	Score	10-Yr Change
1	Denmark	92.4	37.0
2	United Kingdom	91.5	47.1
3	Finland	83.6	47.2
4	Sweden	75.4	30.9
5	Luxembourg	67.4	30.4
6	Slovenia	62.9	17.1
7	Switzerland	60.5	12.9
7	Latvia	58.6	15.8
9	Iceland	56.4	11.1
10	Netherlands	54.5	10.6
11	Slovakia	53.5	6.0
12	Czech Republic	52.8	11.8
13	Estonia	52.0	11.5
14	Greece	50.8	8.2
15	Austria	50.3	11.9
16	France	49.5	11.5
17	Italy	48.2	9.0
18	Ireland	48.2	2.0
19	Hungary	48.1	-1.7
20	Belgium	48.1	1.7
21	Germany	47.2	4.9
22	Lithuania	47.1	2.9
23	Norway	43.9	5.7
24	Australia	43.8	9.4
25	Spain	41.3	10.7
26	Japan	41.2	6.1
26	New Zealand	40.4	-3.0
28	Israel	39.8	4.6
29	Mexico	38.9	16.7
30	Poland	38.8	-3.6
31	Portugal	37.6	-10.9
32	United States of America	37.2	4.0
33	Chile	35.8	1.0
34	South Korea	30.9	2.5
35	Canada	28.2	-3.3
36	Turkey	21.5	-3.2

Chapter 3. Drivers of Good Environmental Performance

1. Introduction

Clarity on the drivers of good environmental performance can help policymakers reform programs, maximize returns on sustainability investments, and achieve real-world progress toward enhancing environmental health and ecosystem vitality. This chapter identifies the determinants of environmental success by exploring how economic, governmental, and social factors affect sustainability performance.

Providing an analytically rigorous explanation of why certain countries outperform their peers in meeting environmental challenges while other countries fall behind, the 2022 EPI helps policymakers to strengthen their country's performance. These insights guide decision-makers to the right policy levers to engage as they seek to improve environmental conditions.

The 2022 EPI explores factors of environmental success in three categories: (1) economic, (2) governance, and (3) social. It then explores how these factors enable drivers of sustainability, illustrating why certain countries environmentally outperform their peers. Decades of research has produced a wide range of insights into the drivers of environmental degradation and conservation, allowing decision-makers to better understand the policy pathways before them. Policymakers must take care, however, to distinguish between correlates and the drivers of success in sustainability.

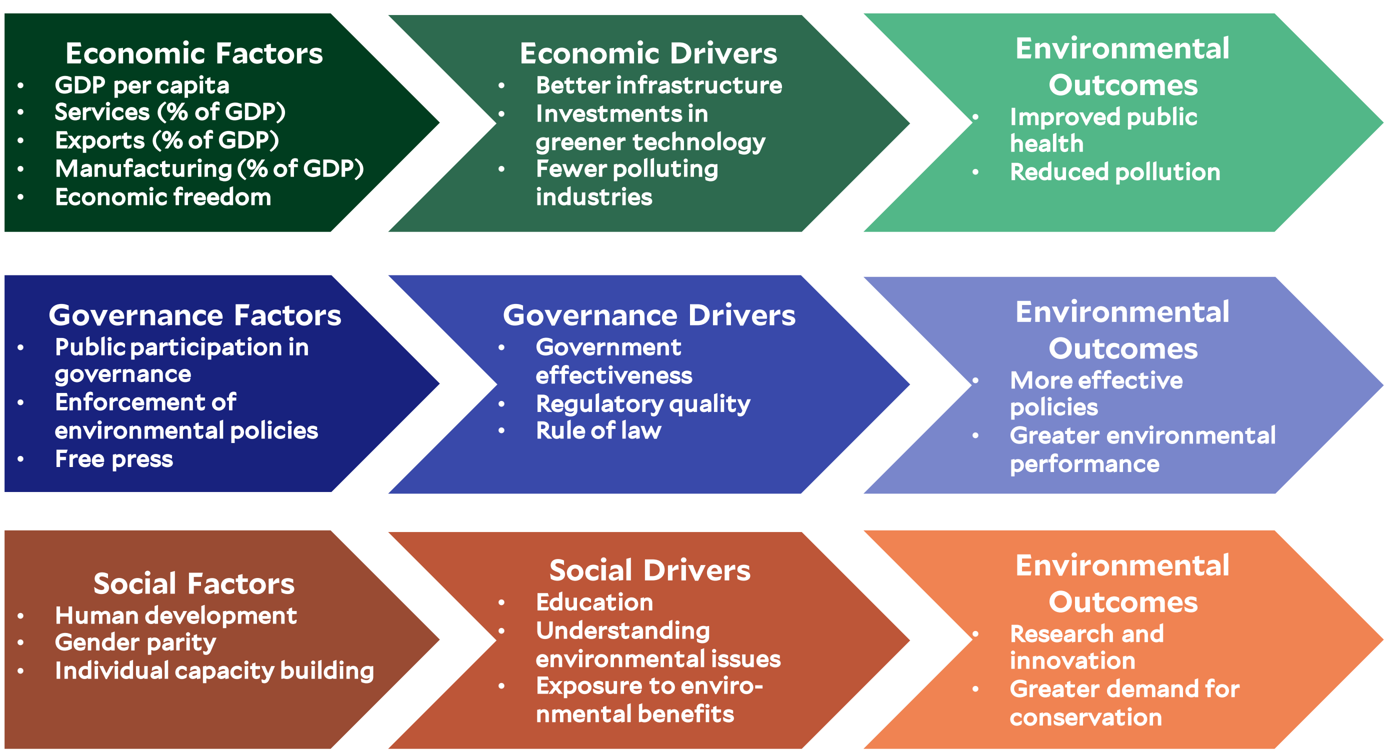
Figure 3-1 illustrates the framework of this drivers analysis. Although strong economies, good governance, and human development do not inherently elevate environmental performance, they are foundations on which good policies can be built.

Strong economies generate financial resources that enable investments in environmental protection. Wealthy countries can afford better civil infrastructure (such as drinking water systems and waste water treatment), pollution control technologies, and greener energy sources. Investments in these factors in turn drives improved public health and thus strong sustainability performance.

Good governance results in more effective sustainability policies, reduces corruption and skirting of regulations, supports public debate reinforced by a free press, and encourages citizens to push their lawmakers for greater environmental protections. These features of effective governance drive good environmental performance by ensuring environmental laws are uniformly enforced and responsive to new information.

Societal development leads to a more highly educated, civically engaged, and healthy public. Well-informed and healthy societies better understand critical environmental issues, know firsthand the benefits of regulations, and demand further action from leaders.

Figure 3-1. The framework of the 2022 EPI drivers analysis. Economic, governance, and social factors enable drivers of favorable environmental outcomes.



2. Drivers Analysis

Environmental policymaking benefits from understanding the determinants of sustainability. Research has long demonstrated a link between wealth and environmental performance, but this finding obscures several nuances that policymakers must understand to achieve more sustainable economies and societies. Figure 3-2 illustrates that country wealth does not fully account for environmental performance. At any wealth level, some countries outperform their financial peers. Wealthy democracies tend to perform better than wealthy autocracies, suggesting that governance structures join financial resources as an important determinant of sustainability trajectories. Intuitively, countries that prioritize sustainability likewise outperform those with less of a policy focus on environmental success.

This chapter leverages statistical analyses to examine the link between environmental performance and key economic, governance, and social factors. Relationships between these factors and scores in the overall EPI, three policy objectives, and 11 issue categories highlight the correlates of policy success, which can help to pinpoint specific drivers of sustainability.

Although a significant body of work examines the relationship between EPI scores and socioeconomic variables, the 2022 EPI team consolidates analyses to focus on 11 factors, presenting a concise but comprehensive overview of the determinants of successful environmental performance. These 11 factors are rooted in an extensive literature review — detailed in the Research Context section of this chapter — and fall into three categories: economic, governance, and social factors.

Economic Factors

We use five indicators to gauge country-scale economic activity, development, and market structure:

- **Per capita GDP**: national GDP normalized by population
- **Services, value added (% of GDP)**: total value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services (World Bank, 2020c)
- **Exports of goods and services (% of GDP)**: total value of all goods and other market services provided to the rest of the world (World Bank, 2020a)

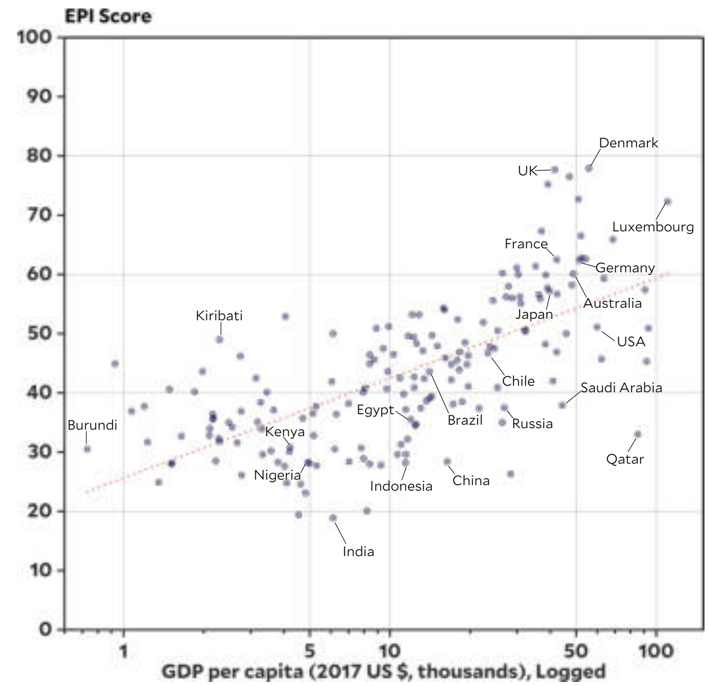


Figure 3-2. The relationship between 2022 Environmental Performance Index scores and GDP per capita is positive and strong (r = 0.70), although many countries out- or underperform their economic peers.

- **Manufacturing, value added (% of GDP)**: total value stemming from industries belonging to manufacturing, namely those falling under the International Standard Industrial Classification (ISIC) divisions 15-37 (World Bank, 2020b)
- **Index of Economic Freedom**: a measure of 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 (Miller et al., 2022).

The World Bank provides data on services, manufacturing, and exports as a percentage of GDP, and the IMF supplies data on GDP per capita. The Heritage Foundation produces the Index of Economic Freedom (IEF) report, which provides an indicator of open markets and property rights. Note that this measure of market liberalism relies on underlying datasets that overlap to some extent with the governance indicators used in this analysis (see the next section for details).

Focusing on these variables, EPI researchers explore the connection between income, sectoral composition, economic policy, and environmental quality across 180 countries. This connection — sometimes called the Environmental Kuznets Curve (EKC) — provides an empirical pattern which suggests that environmental degradation first rises with country wealth but then falls as countries dedicate more resources toward environmental protection (Grossman and Krueger, 1991; Stern, 2018). Since the EKC's conception, policymakers and researchers have heavily debated its existence. The 2022 EPI advances this discussion by providing detailed information on specific correlations between per capita GDP, sectoral composition, and the EPI's issue areas.

Governance Factors

The 2022 EPI drivers analysis also explores three elements of governance with well-established theoretical links to policy outcomes. The data underlying this analysis come from the World Bank's Worldwide Governance Indicators (WGIs) (Kaufmann et al., 2010):

- **Government Effectiveness**: "Effectiveness captures 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**: "Regulatory quality captures 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**: "Rule of law captures 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."

Using hundreds of variables reflecting differing dimensions of governance perceptions reported by surveys of households and firms, commercial business information providers, non-governmental organizations, and public sector organizations, the WGIs capture aspects of a country's governance and political institutions. The three factors tracked here measure a country's ability to fulfill its promises to its citizens, enact sensible policies, and hold itself accountable to its own rules.

Studies comparing governance factors and environmental performance consistently identify a strong correlation between good governance and environmental performance (Esty and Porter, 2005; Hsu et al., 2013; Srebotnjak and Esty, 2005; Wendling et al., 2020)As detailed below, these results are consistent with the findings of the 2022 EPI, which finds a robust correlation between country WGI scores and environmental performance, particularly in the EPI's Environmental Health policy objective.

Social Factors

The drivers analysis further investigates the hypothesis that investments in human development and individual capacity (including education, health, skills, and equal opportunity) provide enabling conditions that support improved environmental outcomes. We use three social metrics:

- **Gender Development Index (GDI)**: "measures gender gaps in human development achievements by accounting for disparities between women and men in three basic dimensions of human development—health, knowledge and living standards (UNDP, 2020a)."

- **Human Development Index (HDI)**: "a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living. (UNDP, 2020b)"

- **World Happiness Report (WHR)**: uses Gallup World Poll survey data from 2019–2021 to rank countries' felt happiness. Six sub-factors — wealth, life expectancy, generosity, social support, freedom, and corruption — determine a country's overall happiness score (Helliwell et al., 2022).

Groundbreaking analyses have suggested a positive correlation between country sustainability and human development (Dietz et al., 2009; De Neve and Sachs, 2020). The 2022 EPI analyses build on this prior work by examining the association between a country's social investments and environmental performance. Two of the drivers in this category are provided by the United Nations Development Programme, with the third produced by the United Nations Sustainable Development Solutions Network. Both the GDI and HDI use the same underlying data set, although the GDI scores countries based on gender-adjusted performance on three dimensions of human development using gaps between women and men in the HDI. The WHR incorporates metrics reflected in both the governance indicator category and the HDI to quantify a country's happiness. All three indicators make use of per-capita GDP or overall GDP in their calculations.

3. Statistical Techniques

The 2022 EPI drivers analysis is based on statistical relationships derived from Spearman's correlations, which quantify the strength and direction of an association between two indicators. The closer a correlation coefficient (*r*) is to -1 or +1, the stronger the association between indicators. A positive coefficient indicates that scores in both indicators tend to rise or fall together, whereas a negative coefficient indicates that countries scoring highly in one indicator tend to get low scores in another. Where data is missing for a country, we omit that country from the correlation analysis. We note that a strong correlation between two variables does not imply causation. Proving that specific economic, governance, or social factors translate into good environmental performance would require additional data and time series of EPI scores, which are unavailable due to incomplete underlying datasets.

4. Results

Several striking conclusions emerge from the 2022 EPI drivers analysis (Figure 3-3). Most notably, good governance emerges as fundamental to good policy outcomes. Economic development, moreover, correlates strongly with environmental health. This relationship provides support for the suggestion that economic success creates financial capacity that can be (and often is) invested in projects and programs that protect air and water resources — thus advancing public health.

Weak relationships emerge between climate change, ecosystem services, fisheries, and the factors analyzed. This result suggests that for some sustainability challenges, financial resources, good governance, and social health do not enable drivers to reverse environmental harm. If true, countries need to carefully manage their performance in these critical environmental issues,

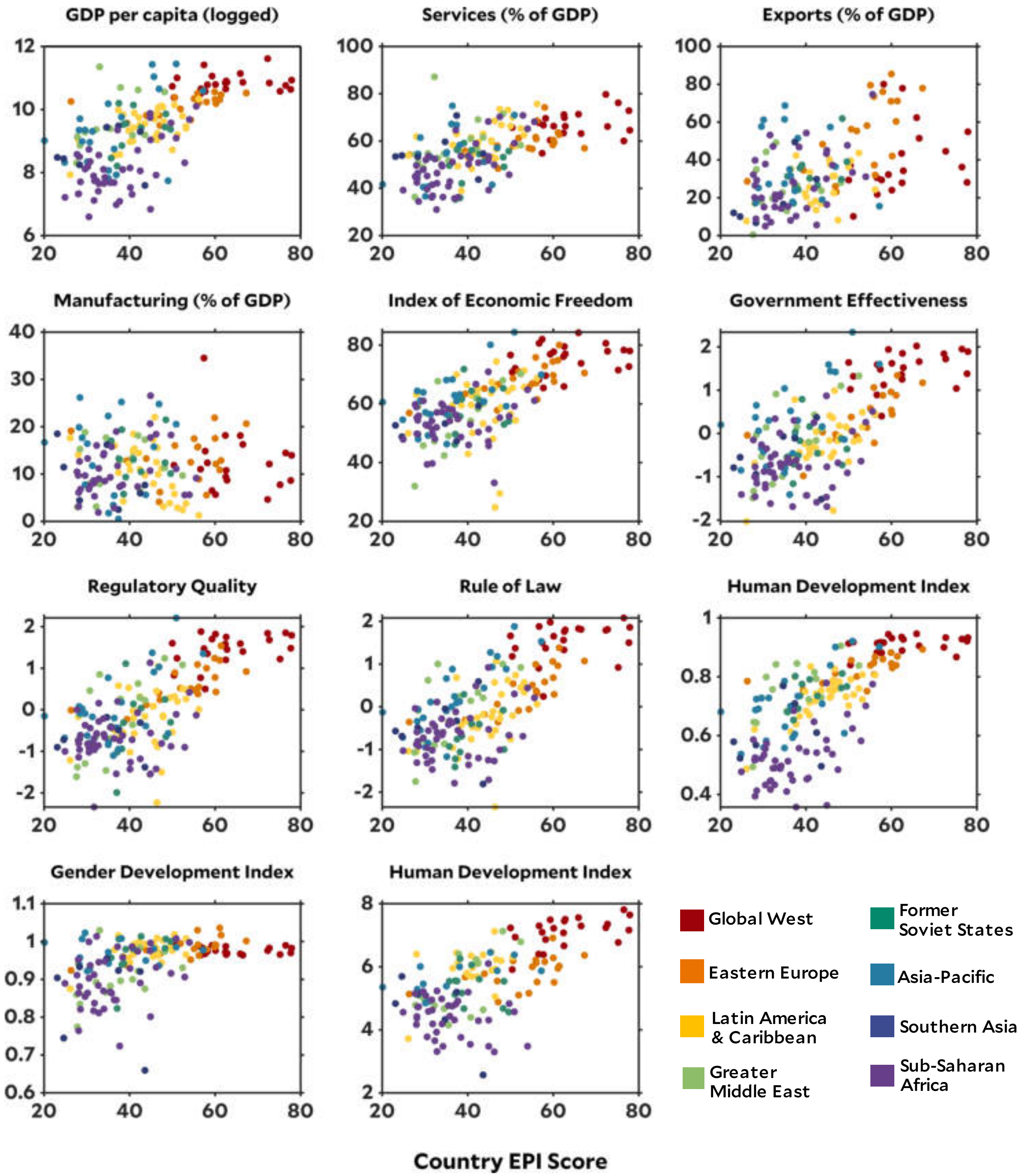
Figure 3-3. Correlations (Spearman's *r*) between EPI scores and explanatory factors. Insignificant results in grey.

	EPI	Env. Health	Ecosystem Vitality	Climate Change	Air Quality	Sanitation & Drinking Water	Heavy Metals	Waste Mgmt.	Biodiversity & Habitat	Ecosystem Services	Fisheries	Acid Rain	Agriculture	Water Resources
GDP *per capita*	0.70	0.89	0.47	0.41	0.76	0.91	0.77	0.86	0.29	0.03	-0.18	0.67	0.25	0.73
Services (% of GDP)	0.64	0.70	0.29	0.60	0.65	0.64	0.59	0.66	0.15	0.17	0.02	0.48	-0.07	0.60
Exports (% of GDP)	0.48	0.41	0.35	0.44	0.31	0.44	0.39	0.48	0.28	-0.04	-0.03	0.38	0.12	0.34
Manufacturing (% of GDP)	0.01	0.07	0.06	-0.08	0.01	0.16	0.07	0.10	0.04	-0.25	-0.07	0.19	0.32	0.14
Index of Economic Freedom	0.65	0.72	0.46	0.45	0.62	0.71	0.70	0.72	0.36	-0.04	-0.09	0.53	0.13	0.58
Government Effectiveness	0.63	0.79	0.42	0.34	0.68	0.80	0.76	0.76	0.29	-0.06	-0.13	0.57	0.18	0.65
Regulatory Quality	0.64	0.78	0.45	0.35	0.67	0.79	0.74	0.76	0.34	-0.08	-0.09	0.59	0.18	0.68
Rule of Law	0.65	0.76	0.40	0.44	0.68	0.73	0.73	0.74	0.27	-0.05	-0.07	0.57	0.10	0.64
Human Development Index	0.73	0.93	0.50	0.42	0.82	0.96	0.79	0.85	0.32	0.03	-0.13	0.67	0.26	0.77
Gender Development Index	0.52	0.55	0.33	0.43	0.50	0.49	0.54	0.45	0.32	-0.13	0.00	0.45	0.11	0.39
World Happiness Report	0.63	0.79	0.49	0.38	0.71	0.79	0.68	0.79	0.32	0.04	-0.09	0.55	0.21	0.61

Correlation Coefficients

-1 0 +1

Figure 3-4. Scatterplots between EPI scores and the various explanatory factors.



designing and implementing regulations or other policies to improve their performance. This section explores these findings in greater detail, illuminating how policymakers and researchers can use data-driven insights to identify pathways to a more sustainable future.

Economic Factors and Environmental Outcomes

Several economic factors exhibit strong associations with EPI scores, particularly with issue categories under Environmental Health (Figure 3-3). GDP per capita is very highly correlated with Air Quality (r = 0.76), Sanitation & Drinking Water (r = 0.91), Heavy Metals (r = 0.77), and Waste Management (r = 0.86). These results suggest that country wealth enables investments in public health, and that these investments successfully drive improvements in environmental performance. Financial resources are critical to mitigating environmental harm for several reasons. First, countries need substantial investments to implement existing technologies, such as scrubbers on smokestacks or renewable energy sources (Hartman et al., 1997; Kim et al., 2017). Additional investments are needed for research and development of next-generation technologies that reduce pollution or more effectively protect public health (Yang et al., 2018).

Correlations between Environmental Health and services as a percent of national GDP (r = 0.70), and between Environmental Health and the Index of Economic Freedom (IEF) (r = 0.72) are somewhat weaker. The IEF has a positive correlation with good performance on Air Quality, Drinking Water & Sanitation, Heavy Metals, and Waste Management. These results offer some support for the hypothesis that economic liberalism and open markets are associated with improvements in environmental quality. Economic liberalism may enable better environmental performance by fostering technological innovation and spurring companies to undertake voluntary sustainability commitments (Ambec et al., 2013), although other research underscores the environmental costs of poorly-regulated industries (Elliott and Esty, 2021).

The lack of strong association between Environmental Health scores and manufacturing as a percent of national GDP suggests that production need not result in poor environmental outcomes. If production-based economies generated greater pollution that worsened environmental health, analyses should reveal a negative correlation between manufacturing and Environmental Health. The results instead imply that industrializing countries do not have to sacrifice public health to drive economic development. The data further suggests that sustainable development – where economic progress and environmental gains occur simultaneously – is possible, although not yet attained by most industrializing countries.

Climate Change performance is most strongly correlated with the percent of national GDP from services. Service-oriented economies, such as those based on education, retail, information technology, and financial industries, consume fewer natural resources and generate significantly less GHG emissions than manufacturing-based economies (Salzman, 2000), which translates into better climate scores. Service-based economies are also wealthier, however, meaning this positive correlation may be confounded by the increased investments in carbon-free technologies made by wealthy countries. Climate Change is uncorrelated with manufacturing as a percentage of GDP, suggesting that the world's largest producers of goods are not inherently the largest contributors to climate change.

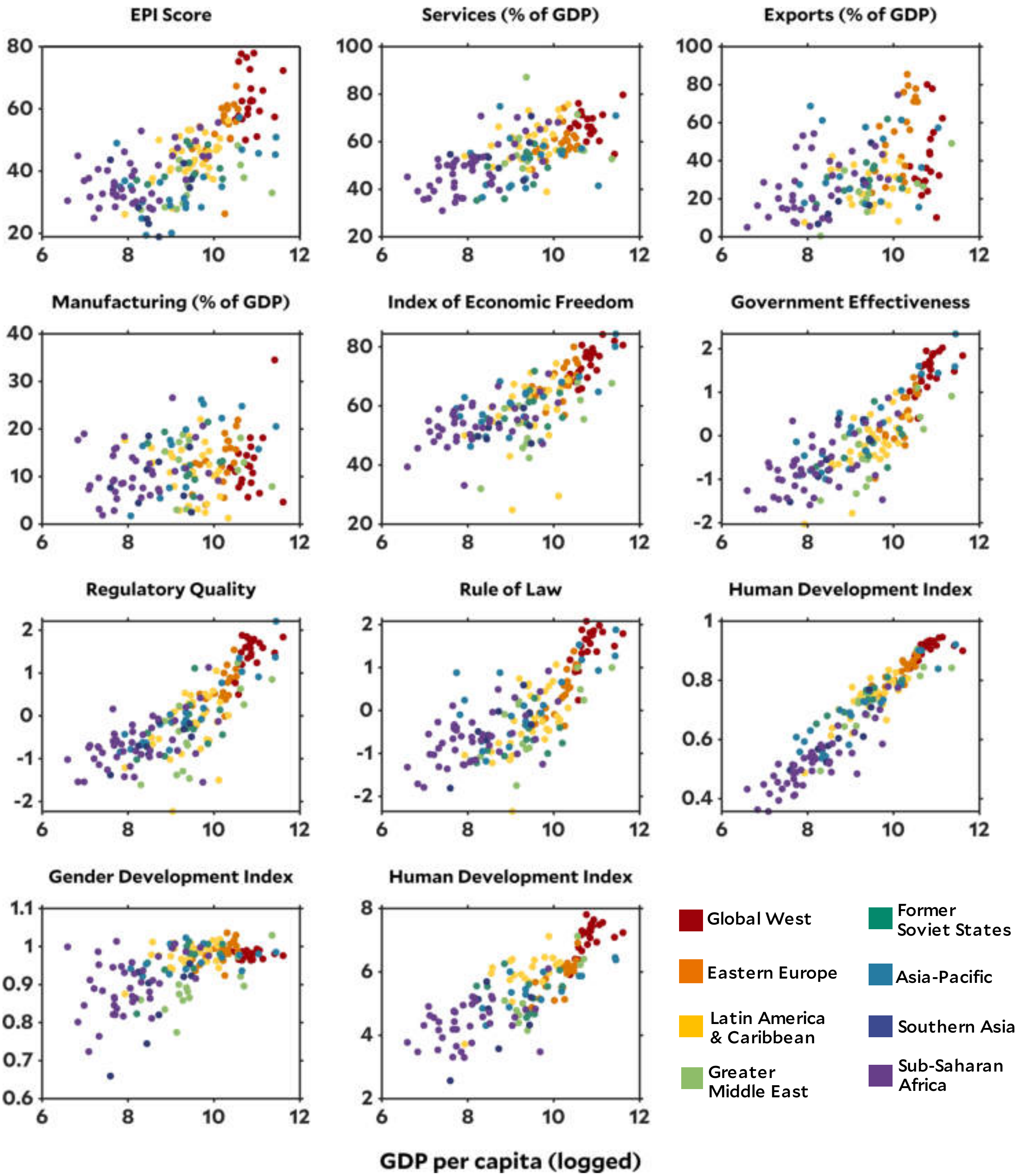
Ecosystem Vitality displays far fewer clear-cut correlations with the economic factors explored in these analyses, suggesting that increased country wealth, environmental deregulation, or transitions from manufacturing to service-based economies does not necessarily produce gains in Biodiversity & Habitat, Ecosystem Services, Fisheries, and Agriculture. To achieve progress in these critical issues, leaders must actively mitigate habitat destruction, regulate natural resource consumption, and implement policies that fill gaps where drivers fall short in achieving environmental success.

Governance Factors and Environmental Outcomes

Good governance enables public participation in policymaking, reduces corruption, and encourages debate that pushes leaders to enact more effective environmental solutions. Each of these drivers in turn propels countries down a more sustainable path. Strong associations between the three Worldwide Governance Indicators (WGIs) and Environmental Health support the principle that governance matters for achieving better environmental outcomes. A wealth of literature demonstrates the importance of governance in sustainable development (Gallego-Álvarez and Fernández-Gómez, 2016; Hsu et al., 2013; Wendling et al., 2020), and the 2022 EPI reaffirms this finding.

Government Effectiveness is robustly correlated with Air Quality (r = 0.68), Sanitation & Drinking Water (r = 0.80), Heavy Metals (r = 0.76), and Waste Management (r = 0.76). High scores in Government Effectiveness indicate quality public services and their independence from political pressures. These results suggest that countries whose civil services are well-funded, adequately staffed, and free from undue political influence produce positive public health outcomes. Each of the Environmental Health issue categories is also strongly correlated with Regulatory Quality and Rule of Law. Countries scoring highly in these governance factors demonstrate policies and regulations that both promote private sector

Figure 3-4. Scatterplots between explanatory factors and GDP *per capita*.



development and are evenly enforced. Clear and fair expectations for environmental compliance drives innovation and industrial growth without sacrificing the health of the environment.

Good governance is also linked to high performance in some of the EPI's Ecosystem Vitality issue categories. The correlation coefficients between Government Effectiveness and Acid Rain, Regulatory Quality and Acid Rain, and Rule of Law and Acid Rain are 0.57, 0.59, and 0.57. While not as compelling as the relationship between the WGIs and the Environmental Health issue category indicators, the relationship is strong enough to demonstrate that governance does matter to some Ecosystem Vitality issue categories. The strong correlations between governance indicators and Acid Rain may stem from this issue's tangible impact on quality of life and the fact that governments can claim policy wins with relatively simple and cheap technological fixes, like installing sulfur dioxide and nitrogen oxide scrubbers on smokestacks. The same analysis holds for Water Resources.

Climate Change scores are positively, but weakly, correlated with Government Effectiveness, Regulatory Quality, and Rule of Law. Although greenhouse gas emitters may be complying with climate regulations, these regulations may not be stringent enough to put countries on track to successfully mitigate climate change. Only 64 countries or states currently have a carbon pricing scheme in place, accounting for just 21 percent of greenhouse gas emissions (World Bank, 2022a). The weak correlations between Climate Change performance and the WGIs suggests that governance drivers — such as public participation in policymaking — are not pushing the world to act quickly enough on mitigating climate change. One possible failure in the driver model includes public misinformation on climate change (West and Bergstrom, 2021).

Social Factors and Environmental Outcomes

Social vitality — including human development, gender parity, and public happiness — both impacts and is impacted by environmental quality. Healthy societies enable greater investments in human development and individual capacity, enabling drivers that support improved environmental outcomes.

The association between Environmental Health and the Human Development Index (HDI) is the strongest association ($r = 0.93$) seen between any of the factors and the EPI's policy objectives. An even stronger correlation exists between the HDI and Sanitation and Drinking Water ($r = 0.96$). These robust associations show that standards of living appear tightly coupled to public health – as would be expected. The HDI is further robustly correlated with the other issue categories under Environmental Health. For Air Quality, Heavy Metals, and Waste Management, the relationship has an r of 0.82, 0.79, and 0.85, the highest correlation for any of these issue categories bar one. (The Waste Management indicator has an r of 0.86 with GDP per-capita.) High collinearity between the HDI and Environmental Health suggests that policymakers may concurrently achieve improvements to both Environmental Health and human development. For instance, programs to provide cleaner residential cookstoves produce human health and environmental cobenefits by reducing air pollutant emissions (Abdo et al., 2021; Grieshop et al., 2011).

The Gender Development Index is less strongly correlated with better environmental performance in the EPI's data. A growing body of research is defining a link between gender parity and environmental outcomes (MacGregor, 2017). Women spend more time indoors than men in many countries around the world, and may be more highly impacted by household air pollution (Ali et al., 2021). Understanding gender differences in environmental health should continue to play a critical role in developing more sustainable policies (WHO, 2010b).

Social happiness may lead to better environmental outcomes by enabling a stronger identity with and connection to nature (Zidanšek, 2007), although the reverse may also be true. Country scores on Environmental Health policy objective, and Water Resources and Acid Rain issue categories under the Ecosystem Vitality policy objective, are positively correlated with scores in the World Happiness Report (WHR). The 2022 EPI's drivers analysis supports recent arguments that environmental performance and well-being are connected (Van Doesum et al., 2021), paving the way for further investigation of the significance and extent of this relationship.

4. Insights for Environmental Policymaking

The 2022 EPI presents this drivers analysis to help decision-makers better understand how their sustainability policies fit into their country's broader economic, governance, and social currents.

Two primary takeaways emerge from the 2022 EPI data analysis: wealth and good governance matter. Wealth, which enables investments in environmental protection, leads to higher EPI scores by allowing countries to upgrade environment-related infrastructure and adopt better pollution-control technologies. These investments improve public health and lead to better environmental outcomes.

Financial resources, however, are not fully predictive of environmental performance. Comparing the performance of Germany and Estonia illustrates these points. Despite a $20,000 gap in per-capita GDP, Estonia and Germany rank side-by-side (14th and 15th) in the 2022 EPI. The range of EPI scores expands with higher country wealth, especially at GDP per capita levels greater than $30,000. The comparatively low score of the United States (51.1), despite having a large GDP per capita (nearly $60,000), is another example of how country wealth does not invariably lead to strong environmental performance. Above a certain economic threshold, the drivers analysis suggests that good governance may be more determinative than wealth for reaching environmental targets.

Countries at all stages of economic development can elevate their environmental performance by improving government effectiveness, rule of law, and regulatory quality. Environmental drivers enabled by good governance include more robust public debate, officials being held accountable for ineffective policies, and better enforcement of environmental protections. A significant and growing body of research shows that voice and accountability — the extent to which citizens express opinions and participate in selecting their government — is highly correlated with environmental performance (Wendling et al., 2020).

Considering the strong association between EPI and Index of Economic Freedom (IEF) scores, the 2022 EPI drivers analysis suggests that democratically-elected governments and free markets are best positioned to respond to environmental challenges and adopt policy preferences that drive countries toward a more sustainable future. Weaker state capacity for legislation and policymaking also explains why wealthy autocracies tend to underperform their democratic peers on the EPI (Iwińska et al., 2019). In the case of developing country democracies, a focus on good governance may enhance environmental gains as economic growth accelerates.

Policymakers striving to maintain economic growth while simultaneously improving environmental performance should note that some countries with high rates of manufacturing and services still achieve top EPI scores. These results show that, while some countries are growing at the expense of environmental health and ecosystem vitality, all countries can make conscious policy choices to protect the environment and thereby achieve more sustainable development.

5. Research Context and Discussion

The 2022 EPI drivers analysis provides further insight with regard to the Environmental Kuznets Curve, (EKC), which hypothesizes an association between environmental problems — such as emissions and pollution — and per capita GDP (Grossman and Krueger, 1991; Stern, 2018). Under the standard Kuznets Curve hypothesis, inequality rises, then falls, with economic growth. The EKC likewise suggests that early in the process of economic development, environmental degradation increases as the economy expands. Then, at some higher threshold of per capita income, environmental degradation decreases as rising per capita incomes translates into greater environmental commitment and investments.

Since its proposal, the existence of the EKC has been heavily debated (Perman and Stern, 2003). A number of studies have found evidence for the existence of the curve across environmental issue categories and indicators (Bradshaw et al., 2010; Dinda, 2004; Grossman and Krueger, 1995; Mukherjee and Chakraborty, 2013). But other analyses suggest this relationship holds more strongly for some environmental issues and less so with regard to other challenges, such as GHG emissions (Esty and Dua, 1997). Earlier editions of the EPI and other research provided some quantitative support for the suggestion that the EKC holds for certain issues, such as air pollution (Esty and Porter, 2005; Jessberger, 2011). While some studies have found a positive relationship between income and environmental performance in aggregate (Hsu et al., 2013; Wendling et al., 2020), the highly variable performance of wealthy countries on the EPI suggests that income cannot alone explain country-to-country variations in environmental performance.

The 2022 EPI's drivers analysis advances the EKC debate by indicating whether country wealth is determinative of environmental performance in specific issues. One relevant finding is the stronger relationship between Environmental Health's issue categories and GDP per capita than between Ecosystem Vitality and GDP per capita. While Environmental Health scores tend to rise with per capita GDP — for instance, the correlation between GDP per capita and Sanitation & Drinking Water is the strongest observed in the 2022 drivers analysis — Ecosystem Vitality scores display weaker or even negative correlations to per capita GDP.

Economic indicators selected for the 2022 EPI driver's analysis, which reflect the sectoral composition of a country's economies as well as their level of market liberalism, are intended to further understand the relationship between economic structure and environmental performance. Information about economic structure and policy through the IEF helps deepen policymakers' understanding of whether economic liberalism and open markets are beneficial or harmful to environmental performance, and what tradeoffs may exist between market reforms and environmental issues. Data on the relationship between economic growth and environmental performance is mixed, but some research indicates freer economic markets yield positive environmental returns (Dkhili, 2019; Esty and Porter, 2001; Pimonenko et al., 2018). In contrast, other studies suggest a negative correlation or no correlation between environmental performance and economic liberalism (Bernauer and Böhmelt, 2013; Chowdhury and Islam, 2017; Shum, 2009). Considering the disparate nature of prior findings, the 2022 EPI's results may provide clarity on whether economic liberalism does in fact influence environmental performance, and to further policymakers' understanding of the explanatory value of such an association.

Researchers have also demonstrated the importance of good governance in implementing successful sustainability policies. One causal mechanism is that greater freedoms in democracies allows their citizens to counter environmental degradation and hold politicians accountable for policies that result in environmental degradation (Drosdowski, 2006). Several other studies note a positive correlation between democratic governance and environmental performance, especially over the long-term (Farzin and Bond, 2006; Gallagher and Thacker, 2008). More nuanced studies have noted that governance indicators are not universally strong predictors of environmental performance. Some research finds that government effectiveness is positively correlated with environmental quality in democracies, but is uncorrelated in autocracies (Iwińska et al., 2019). Others have found that government effectiveness and rule of law are both statistically significant and positively correlated with environmental performance using past EPI data, reaffirming the conclusion in this report that governance is a strong positive contributor to EPI scores (Pourali et al., 2019). The EPI team calls for further research on the impact of regulatory quality on environmental performance.

Analysis on the relationship between well-being and sustainability indicates a link between the two factors. Several studies have found that happiness is correlated with exposure to nature (Frumkin et al., 2017; MacKerron and Mourato, 2013). In direct relation to the EPI, the 2020 World Happiness Report finds that populations exposed to more pollution and warmer climates report being less happy. The negative association between air pollution and well-being is particularly well-documented in Chinese urban regions (Xu et al., 2022). As the relationship between mental health and environmental health becomes better characterized, policymakers may realize societal and economic benefits from protecting their country's ecosystems and broadening access to parkland (Buckley, 2020).

The 2022 EPI's drivers analysis provides an empirical basis for definitively dismissing the outdated assumption that economic progress comes at the expense of sustainability. To the contrary, the EPI data provide powerful support for the theory of sustainable development and the policy logic for advancing economic and environmental goals in tandem. Good environmental performance is highly correlated with country wealth, but the 2022 EPI's drivers analysis demonstrates that this relationship is not determinative of a country's environmental performance. A more comprehensive analytic framework — taking into account economic, governance, and social policy levers — suggests that countries constrained with regard to some factors may still be able to achieve high levels of sustainability by engaging other policy drivers. Most notably, a number of middle-income nations deliver solid environmental outcomes by enhancing good governance and committing to sustainability as a policy priority.

Chapter 4. Climate Change Mitigation

1. Introduction

Climate change endangers our health and safety. Hotter temperatures, rising sea levels, and stronger storms jeopardize human lives and livelihoods, harm ecosystem vitality, and destabilize the global economy. The 2022 EPI provides decision-makers with policy insights and toolkits to mitigate climate change by reducing greenhouse gas (GHG) emissions.

A warming planet risks degrading ecosystems and endangering human health. Scientists predict the planet will experience more frequent and intense heat waves, hurricanes, forest fires, and other extreme weather events (Ranasinghe et al., 2021), resulting in unprecedented biodiversity and ecosystem loss (Pivello et al., 2021). Melting ice and the ocean's thermal expansion have now caused sea levels to rise by 0.20 meters, inundating coastal habitats and communities (Fox-Kemper et al., 2021). Hotter temperatures and extreme weather exacerbate malnutrition by reducing the yields of many major crops (Watts et al., 2021). These phenomena further worsen heat-related death, dehydration, the spread of disease, and other health problems (Atwoli et al., 2021). Climate change could soon force 216 million people to migrate in search of safer homes and better opportunities (Clement et al., 2021).

In addition to compromising ecosystem vitality and human health, policymakers and researchers predict that climate change will also threaten global economic stability (Battiston et al., 2021; Kiley, 2021). By 2050, the world is projected to lose around 10% of total economic value due to climate harms (Swiss Re Institute, 2021) — nearly three times the devastating economic loss in 2020 during the COVID-19 pandemic (Levy Yeyati and Filippini, 2021). These harms will not affect countries equally. Several advanced economies located in the northern hemisphere are better resourced to adapt to adverse weather and health effects (Swiss Re Institute, 2021). Wealthy countries, which have historically emitted the majority of GHGs, will suffer less from climate change's negative effects (Althor et al., 2016). Forecasts suggest that the burden of climate change will instead disproportionately fall on populations already experiencing poverty and malnutrition, intensifying existing disparities in global public health (Cuomo, 2011; Nielsen et al., 2021).

Human action directly causes the Earth to warm. According to the Intergovernmental Panel on Climate Change, "it is unequivocal that human influence has warmed the atmosphere, ocean, and land" (IPCC, 2021). By burning fossil fuels, altering landscapes, and more, humans emit GHGs and black carbon into the atmosphere. Atmospheric carbon dioxide concentrations are now higher than they have been for at least 2 million years (Gulev et al., 2021). Even if the world were to completely stop emitting GHGs today, temperatures will continue to rise as the world reaches a new equilibrium. In effect, additional harm from climate change is already "locked-in." The more quickly global emissions abate, the lower the future maximum temperature and climate harms will be.

Ever-rising greenhouse gas emissions hinder the world's ability to meet the Sustainable Development Goals and amplify the environmental threats discussed in other chapters of this report. Recent international efforts — such as the Paris Agreement of 2015 and the 2021 Glasgow Climate Pact — demonstrate a heightened interest in uniting the world behind more ambitious climate mitigation policies. The Glasgow Pact outlines a goal to reach net-zero greenhouse gas emissions by mid-century, limiting warming to 1.5 °C and avoiding the most devastating effects of climate change (IPCC, 2021). The world is running out of time to meet this goal. Global temperature has already risen by about 1.1 °C since the pre-industrial age.

Despite recent policy commitments, most countries' actions fall far short of what is needed. To minimize the environmental, health, and economic damages caused by climate change, the world must strive to more rapidly reduce greenhouse gas emissions. The 2022 EPI's Climate Change indicators provide powerful insights that policymakers, the media, business leaders, non-governmental organizations, and the public can leverage to gauge the adequacy of national policies, spotlight the largest contributors to climate change, and identify policies to improve the emissions trajectories of lagging countries.

Focus 4.1

Climate Change — A New Policy Objective in the 2022 EPI

Climate change is linked to, and worsens, many of the other sustainability issues discussed in this report, including those under Environmental Health and Ecosystem Vitality. Reflecting a paradigm shift in scientific and political discussions, the 2022 EPI introduces Climate Change as a coequal policy objective, underscoring climate action as one of today's paramount environmental issues. This methodological innovation paves the way for additional progress on mitigation and adaptation policy, which are both crucial to protecting human and environmental health. Monitoring the policy commitments made by 197 nations in the Glasgow Climate Pact, we introduce an innovative indicator that tracks country performance on net-zero greenhouse gas emissions commitments. We welcome feedback from the global sustainability community on this new framework.

2. Indicators

Adjusted Emission Growth Rates (53% of issue category)
This set of indicators tracks trends in countries' emissions of climate pollutants: four greenhouse gases and black carbon. Together, these five indicators account for 53% of the weight in the Climate Change issue category:

- carbon dioxide (CO_2) (36.2% of issue category),
- methane (CH_4) (8.7% of issue category),
- fluorinated gases (F-gases) (3.7% of issue category),
- nitrous oxide (N_2O) (1.8% of issue category), and
- black carbon (2.6% of issue category).

For each climate pollutant, we calculate the average rate of increase or decrease in emissions over ten years (2010–2019). We adjust these rates for economic trends to capture change related to policy, rather than general economic behaviors.

Projected Emissions Levels in 2050 (36% of issue category)
This indicator captures whether countries are on track to reach zero emissions of four greenhouse gases by 2050. These greenhouse gases are carbon dioxide, methane, fluorinated gases, and nitrous oxide. We calculate the average rate of increase or decrease in emissions over ten years (2010–2019) and extrapolate this trend to 2050, projecting the level of emissions in that same year. Extrapolation is an appropriate way to gauge which countries have begun adequately reducing emissions and highlight which countries are not on track to meet the 2050 climate target. Projected 2050 emissions equal to or below zero receive the maximum score. These trends are best used to identify whether a country's current policies are sufficient to meet the 2050 target. Some nations currently not on track are working to adopt policies that shift their trajectories. Likewise, some countries that have significantly reduced emissions in the past decade may find it difficult to find additional solutions to maintain their current trend. Future EPI reports will closely monitor the continued steps that countries are taking to achieve steady emissions reductions.

CO_2 Emissions from Land Cover Change (4% of issue category)
This indicator measures the rates of increase or decrease in CO_2 emissions caused by shifts in land types. We measure average annual growth rates in emissions over a ten-year period from 2008 to 2017.

Greenhouse Gas (GHG) Intensity Growth Rate (4% of issue category)
This indicator estimates the growth rates of greenhouse gas emissions per unit of GDP. We measure average annual growth rates in greenhouse gas intensity over a ten-year period from 2010 to 2019.

Greenhouse Gas Emissions per Capita (3% of issue category)
This indicator measures average greenhouse gas emissions per person in each country in the year 2019.

Map 4-1. Global rankings on overall Climate Change Mitigation performance.

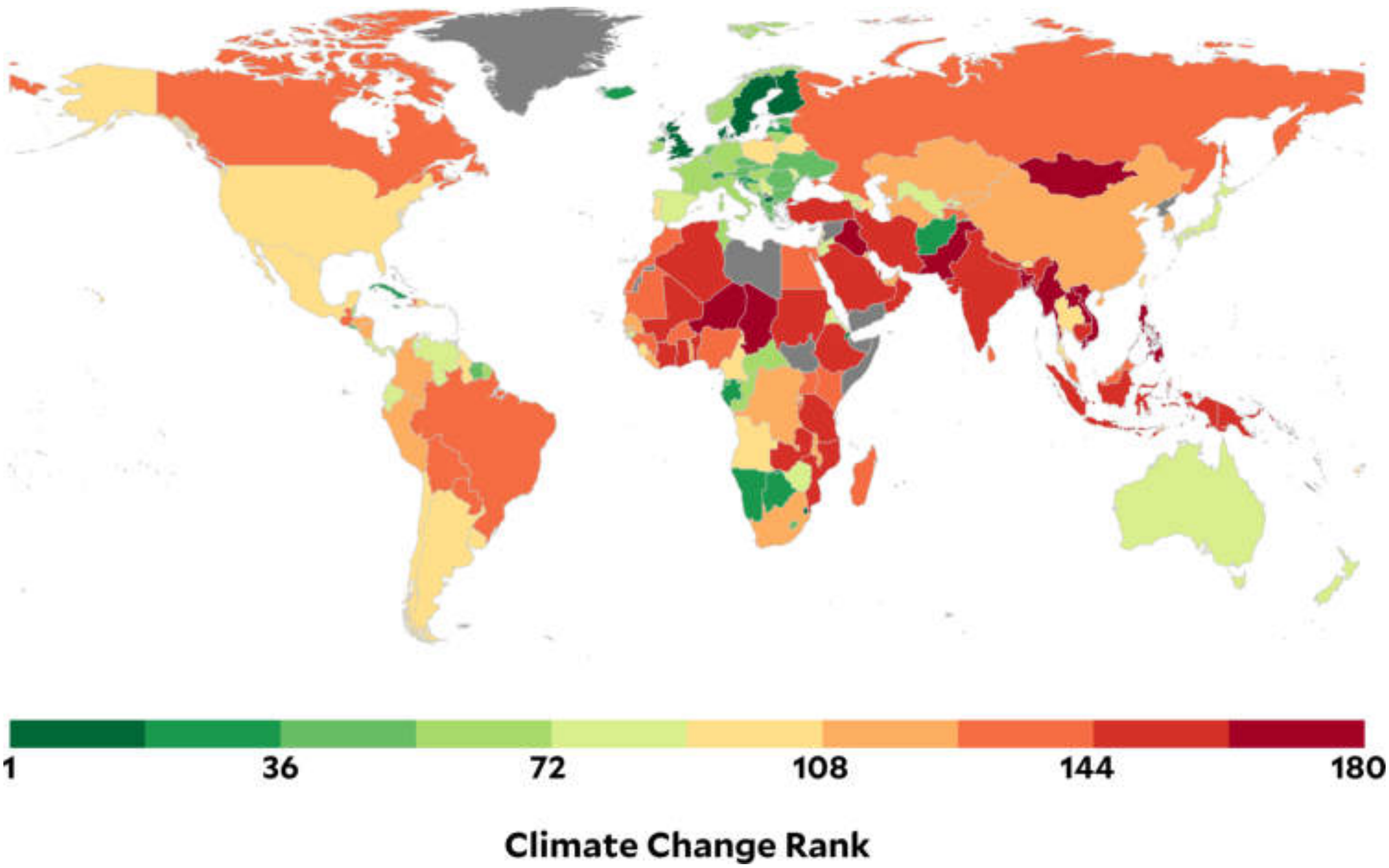


Table 4-1. Global rankings, scores, and regional rankings (REG) on Climate Change Mitigation.

RANK	COUNTRY	SCORE	REG
1	Denmark	92.4	1
2	United Kingdom	91.5	2
3	Finland	83.6	3
4	Malta	82.3	4
5	Barbados	79.9	1
6	Sweden	75.4	5
7	Djibouti	73.7	1
8	North Macedonia	69.8	1
9	Dominica	68.8	2
10	Eswatini	67.9	2
11	Luxembourg	67.4	6
12	Grenada	65.7	3
13	Afghanistan	65.6	1
14	Saint Lucia	64.8	4
15	Namibia	64.6	3
16	Solomon Islands	63.9	1
17	São Tomé and Príncpe	63.2	4
18	Botswana	63.1	5
19	Slovenia	62.9	2
20	Bahamas	61.8	5
21	Cuba	61.1	6
22	St. Vincent and Grenadines	61.0	7
23	Switzerland	60.5	7
24	Antigua and Barbuda	60.2	8
25	Latvia	58.6	3
26	Croatia	56.6	4
27	Iceland	56.4	8
28	Gabon	56.3	6
28	Kiribati	56.3	2
30	Marshall Islands	55.8	3
31	Ukraine	54.7	1
32	Netherlands	54.5	9
33	Jamaica	54.1	9
34	Seychelles	53.9	7
35	Cyprus	53.8	5
36	Equatorial Guinea	53.6	8
37	Slovakia	53.5	6
38	Lesotho	53.3	9
39	Czech Republic	52.8	7
40	Albania	52.5	8
41	Montenegro	52.3	9
42	Estonia	52.0	10
43	Cabo Verde	51.4	10
44	Romania	51.3	11
45	Greece	50.8	12
46	Suriname	50.3	10
46	Austria	50.3	10
48	El Salvador	50.2	11
49	Vanuatu	50.1	4
50	Bulgaria	49.8	13
51	Central African Republic	49.5	11
51	France	49.5	11
53	Trinidad and Tobago	49.3	12
54	Micronesia	49.2	5
55	Tunisia	48.3	1
56	Ireland	48.2	12
56	Italy	48.2	12
58	Belgium	48.1	14
58	Hungary	48.1	14
60	Germany	47.2	15
61	Belize	47.1	13
61	Lithuania	47.1	15
63	Gambia	46.5	12
63	Singapore	46.5	6
65	Mauritius	46.4	13
66	Tonga	46.0	7
67	Bosnia and Herzegovina	45.1	16
68	Republic of Congo	44.9	14
69	Samoa	44.2	8
70	Norway	43.9	16
71	Australia	43.8	17
72	Georgia	43.6	2
73	Panama	43.5	14
74	Ecuador	43.2	15
75	Moldova	42.9	3
76	Jordan	42.8	2
77	Venezuela	42.1	16
78	Zimbabwe	41.9	15
79	Serbia	41.7	17
79	Brunei Darussalam	41.7	9
81	Costa Rica	41.5	17
82	Armenia	41.4	4
83	Spain	41.3	18
83	Uzbekistan	41.3	5
85	Comoros	41.2	16
85	Japan	41.2	10
87	Guinea-Bissau	40.5	17
88	Eritrea	40.4	18
88	New Zealand	40.4	19
90	Guyana	40.0	18
90	Fiji	40.0	11
92	Bahrain	39.9	3
93	Israel	39.8	4
94	Belarus	39.6	6
95	Mexico	38.9	19
96	Poland	38.8	18
97	Taiwan	38.1	12
98	Lebanon	37.9	5
99	Angola	37.7	19
100	Portugal	37.6	20
101	United States of America	37.2	21
102	Uruguay	37.0	20
103	Bhutan	36.8	2
104	Dominican Republic	36.5	21
105	Azerbaijan	36.4	7
106	Thailand	36.0	13
107	Chile	35.8	22
108	Sierra Leone	35.5	20
108	Argentina	35.5	23
110	Cameroon	35.4	21
111	Dem. Rep. Congo	35.1	22
112	Honduras	35.0	24
113	Kazakhstan	34.9	8
114	Nicaragua	34.5	25
115	Togo	34.4	23
116	South Africa	34.1	24
117	United Arab Emirates	34.0	6
117	Kyrgyzstan	34.0	9
119	Senegal	33.6	25
120	Maldives	33.5	3
121	Malawi	33.1	26
122	Timor-Leste	32.8	14
123	Rwanda	32.6	27
124	Kuwait	32.3	7
125	Peru	32.2	26
126	South Korea	30.9	15
127	Liberia	30.5	28
128	China	30.4	16
129	Colombia	30.2	27
129	Turkmenistan	30.2	10
131	Paraguay	30.1	28
132	Guinea	30.0	29
133	Nigeria	29.6	30
133	Brazil	29.6	29
135	Morocco	29.5	8
136	Burundi	29.4	31
137	Russia	29.1	11
138	Kenya	29.0	32
139	Egypt	28.5	9
140	Madagascar	28.4	33
141	Bolivia	28.3	30
142	Canada	28.2	22
143	Haiti	27.9	31
144	Mauritania	27.8	34
145	Burkina Faso	27.6	35
146	Tajikistan	27.3	12
147	Malaysia	27.2	17
148	Uganda	26.8	36
149	Guatemala	26.7	32
150	Sri Lanka	26.4	4
151	Benin	26.2	37
152	Zambia	25.6	38
153	Papua New Guinea	25.4	18
154	Tanzania	25.3	39
155	Côte d'Ivoire	25.1	40
155	Sudan	25.1	10
157	Saudi Arabia	24.8	11
158	Nepal	24.1	5
159	Iran	24.0	12
160	Ghana	23.8	41
161	Cambodia	23.3	19
162	Oman	23.2	13
162	Indonesia	23.2	20
164	Mali	21.9	42
165	India	21.7	6
166	Qatar	21.5	14
166	Turkey	21.5	19
168	Algeria	20.9	15
169	Ethiopia	19.9	43
170	Mozambique	19.3	44
171	Bangladesh	18.8	7
172	Chad	18.5	45
173	Niger	17.9	46
174	Myanmar	17.3	21
175	Pakistan	16.9	8
175	Philippines	16.9	22
177	Laos	16.2	23
178	Mongolia	14.6	24
179	Viet Nam	10.1	25
180	Iraq	8.8	16

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 and scores on Climate Change Mitigation.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Barbados	79.9	1
Dominica	68.8	2
Grenada	65.7	3
Saint Lucia	64.8	4
Bahamas	61.8	5
Cuba	61.1	6
St. Vincent and Grenadines	61.0	7
Antigua and Barbuda	60.2	8
Jamaica	54.1	9
Suriname	50.3	10
El Salvador	50.2	11
Trinidad and Tobago	49.3	12
Belize	47.1	13
Panama	43.5	14
Ecuador	43.2	15
Venezuela	42.1	16
Costa Rica	41.5	17
Guyana	40.0	18
Mexico	38.9	19
Uruguay	37.0	20
Dominican Republic	36.5	21
Chile	35.8	22
Argentina	35.5	23
Honduras	35.0	24
Nicaragua	34.5	25
Peru	32.2	26
Colombia	30.2	27
Paraguay	30.1	28
Brazil	29.6	29
Bolivia	28.3	30
Haiti	27.9	31
Guatemala	26.7	32

EASTERN EUROPE

Country	Score	Reg. Rank
North Macedonia	69.8	1
Slovenia	62.9	2
Latvia	58.6	3
Croatia	56.6	4
Cyprus	53.8	5
Slovakia	53.5	6
Czech Republic	52.8	7
Albania	52.5	8
Montenegro	52.3	9
Estonia	52.0	10
Romania	51.3	11
Greece	50.8	12
Bulgaria	49.8	13
Hungary	48.1	14
Lithuania	47.1	15
Bosnia and Herzegovina	45.1	16
Serbia	41.7	17
Poland	38.8	18
Turkey	21.5	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Afghanistan	65.6	1
Bhutan	36.8	2
Maldives	33.5	3
Sri Lanka	26.4	4
Nepal	24.1	5
India	21.7	6
Bangladesh	18.8	7
Pakistan	16.9	8

GLOBAL WEST

Country	Score	Reg. Rank
Denmark	92.4	1
United Kingdom	91.5	2
Finland	83.6	3
Malta	82.3	4
Sweden	75.4	5
Luxembourg	67.4	6
Switzerland	60.5	7
Iceland	56.4	8
Netherlands	54.5	9
Austria	50.3	10
France	49.5	11
Ireland	48.2	12
Italy	48.2	12
Belgium	48.1	14
Germany	47.2	15
Norway	43.9	16
Australia	43.8	17
Spain	41.3	18
New Zealand	40.4	19
Portugal	37.6	20
United States of America	37.2	21
Canada	28.2	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Ukraine	54.7	1
Georgia	43.6	2
Moldova	42.9	3
Armenia	41.4	4
Uzbekistan	41.3	5
Belarus	39.6	6
Azerbaijan	36.4	7
Kazakhstan	34.9	8
Kyrgyzstan	34.0	9
Turkmenistan	30.2	10
Russia	29.1	11
Tajikistan	27.3	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Solomon Islands	63.9	1
Kiribati	56.3	2
Marshall Islands	55.8	3
Vanuatu	50.1	4
Micronesia	49.2	5
Singapore	46.5	6
Tonga	46.0	7
Samoa	44.2	8
Brunei Darussalam	41.7	9
Japan	41.2	10
Fiji	40.0	11
Taiwan	38.1	12
Thailand	36.0	13
Timor-Leste	32.8	14
South Korea	30.9	15
China	30.4	16
Malaysia	27.2	17
Papua New Guinea	25.4	18
Cambodia	23.3	19
Indonesia	23.2	20
Myanmar	17.3	21
Philippines	16.9	22
Laos	16.2	23
Mongolia	14.6	24
Viet Nam	10.1	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Angola	37.7	19
Benin	26.2	37
Botswana	63.1	5
Burkina Faso	27.6	35
Burundi	29.4	31
Cabo Verde	51.4	10
Cameroon	35.4	21
Central African Republic	49.5	11
Chad	18.5	45
Comoros	41.2	16
Côte d'Ivoire	25.1	40
Dem. Rep. Congo	35.1	22
Djibouti	73.7	1
Equatorial Guinea	53.6	8
Eritrea	40.4	18
Eswatini	67.9	2
Ethiopia	19.9	43
Gabon	56.3	6
Gambia	46.5	12
Ghana	23.8	41
Guinea	30.0	29
Guinea-Bissau	40.5	17
Kenya	29.0	32
Lesotho	53.3	9
Liberia	30.5	28
Madagascar	28.4	33
Malawi	33.1	26
Mali	21.9	42
Mauritania	27.8	34
Mauritius	46.4	13
Mozambique	19.3	44
Namibia	64.6	3
Niger	17.9	46
Nigeria	29.6	30
Republic of Congo	44.9	14
Rwanda	32.6	27
São Tomé and Príncpe	63.2	4
Senegal	33.6	25
Seychelles	53.9	7
Sierra Leone	35.5	20
South Africa	34.1	24
Tanzania	25.3	39
Togo	34.4	23
Uganda	26.8	36
Zambia	25.6	38
Zimbabwe	41.9	15

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Tunisia	48.3	1
Jordan	42.8	2
Bahrain	39.9	3
Israel	39.8	4
Lebanon	37.9	5
United Arab Emirates	34.0	6
Kuwait	32.3	7
Morocco	29.5	8
Egypt	28.5	9
Sudan	25.1	10
Saudi Arabia	24.8	11
Iran	24.0	12
Oman	23.2	13
Qatar	21.5	14
Algeria	20.9	15
Iraq	8.8	16

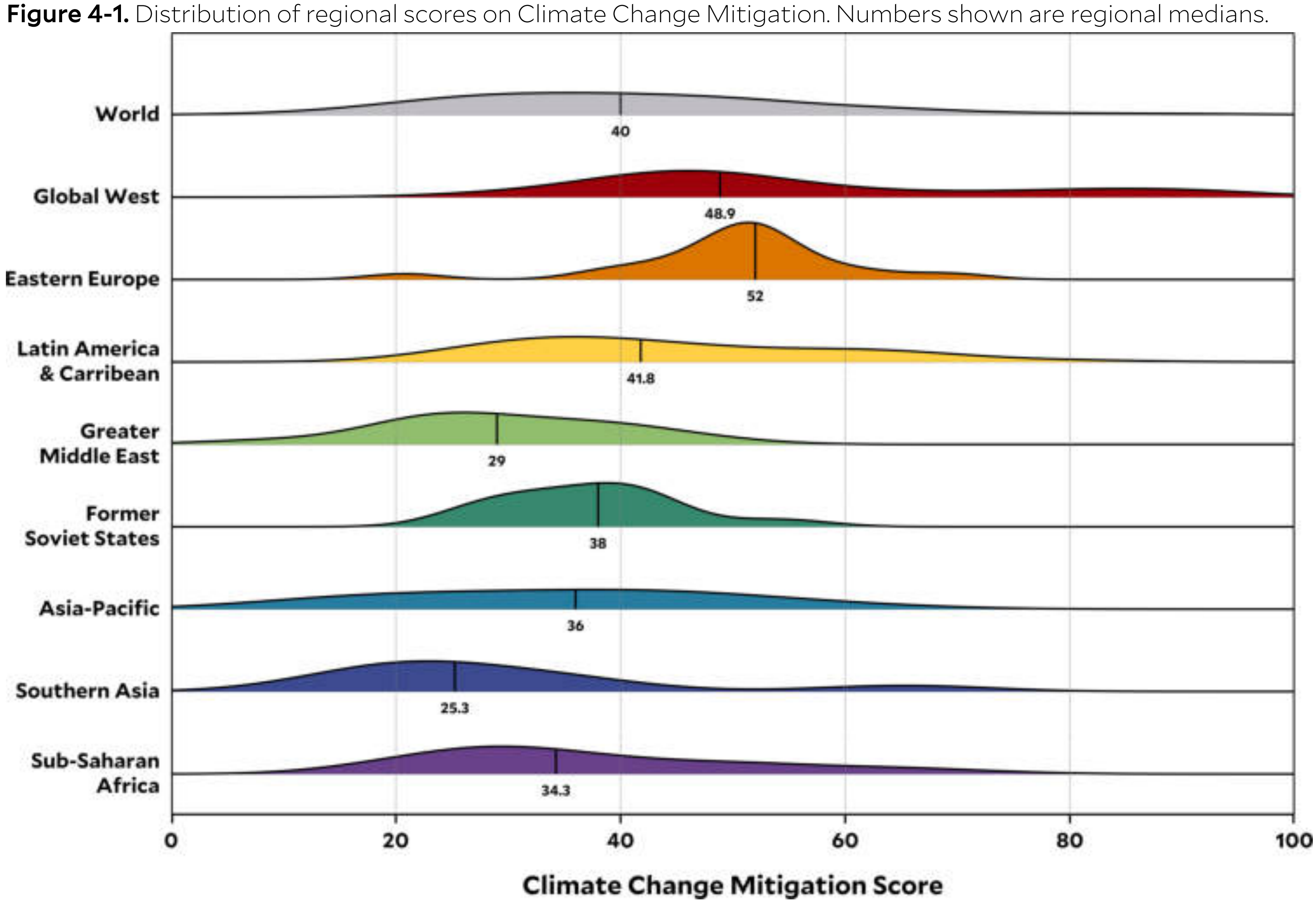
2. Global Trends

Progress toward mitigating climate change remains insufficient. Despite brief declines due to the COVID-19 shutdown, greenhouse gas (GHG) emissions have surpassed previous highs in many nations and across the planet as a whole. The Intergovernmental Panel on Climate Change (IPCC) estimates that human activity has already warmed the planet 1.1ºC above pre-industrial levels (IPCC, 2021). The last decade was the warmest on record, contributing to an increase in severity and frequency of extreme weather events (WMO, 2021). From 2010 to 2019, these events displaced over 23 million people every year (WMO, 2021).

Despite their destructive effects, carbon dioxide, methane, nitrous oxide, fluorinated gas, and black carbon emissions continue to increase globally. Only a few regions have seen decreasing emissions of some gases. In the past decade, the Global West has decreased carbon dioxide, methane, and nitrous oxide emissions. Latin America & the Caribbean and the Former Soviet States have also decreased their carbon dioxide emissions, although to a lesser degree. These emissions reductions are offset by gains elsewhere, especially in Southern Asia and Asian-Pacific countries. Rising emissions globally continue to drive climate change and push temperatures upward.

To prevent climate change consequences from worsening, every country must establish far-reaching policy commitments to reduce greenhouse gas emissions. Nearly 200 countries have signed the Paris Agreement, ratifying a goal to limit warming to well below 2 ˚C and ideally 1.5 ˚C. Under the Agreement, countries submit Nationally Determined Contributions (NDCs) that outline their emissions reduction goals every five years. Nearly 160 countries have abided by this schedule, with 93 nations submitting more ambitious second NDCs (Climate Watch, 2021). If fully implemented, these current pledges would limit warming to between 2 ˚C and 2.4 ˚C (Meinshausen et al., 2022; UNEP, 2021). The Paris Agreement's 1.5 ˚C goal remains attainable — but becomes

Figure 4-1. Distribution of regional scores on Climate Change Mitigation. Numbers shown are regional medians.



increasingly unlikely with each passing year. Several of the largest emitters have defined 2030 targets that would make it difficult to reach net-zero emissions by mid-century (UNEP, 2022a). This "credibility gap" demonstrates that simply committing to reduce emissions is not enough. Countries must enact policies that live up to their climate commitments.

Carbon dioxide represents the most important GHG in terms of climatic impact, making up 71% of the world's emissions in 2019 when normalized by each gas's global warming potential (Figure 4-2). As shown in Figure 4-3, each individual region follows this trend other than Sub-Saharan Africa, a high methane emitter. Carbon dioxide emissions are increasing by nearly 300 megatons per year, the fastest of any greenhouse gas. Even though an individual molecule of carbon dioxide warms the planet less than the other GHGs, the sheer amount of carbon dioxide emissions means this gas is a primary driver of climate change. Carbon dioxide also increases ocean acidity, harming marine life (Doney et al., 2009).

Fluorinated gases (F-gases), including SF_6 and other industrial gases used as refrigerants, account for only 3.3% of global greenhouse emissions but remain the proportionally fastest-growing source of climate pollutants (Sovacool et al., 2021). A single ton of F-gases can warm the planet hundreds to thousands of times more than a ton of carbon dioxide (Forster et al., 2021), making F-gas emissions an important driver of climate change. Despite their potency — and the availability of technological alternatives (Wolf et al., 2020) — climate policies have not kept sufficient pace to adequately mitigate F-gas use and emissions.

Nitrous oxide and methane emissions present a unique threat to Earth's climate system. While sources of carbon dioxide and fluorinated gases have well-researched and sustainable replacements, there are no concrete pathways to fully eliminate agricultural emissions of methane and nitrous oxide. The Global West is the only region decreasing both methane and nitrous oxide, but emissions in other regions outweigh this progress. Despite these trends, it is still possible to reach net-zero total greenhouse gas emissions. Once the world has lowered methane and nitrous oxide emissions as much as possible, it can use carbon capture and sequestration methods to draw carbon dioxide out of the atmosphere, compensating for emissions of other gases. Carbon removal technologies remain in their infancy and require further investments to be scaled up and improved (NASEM, 2019).

Economic growth remains strongly correlated with national greenhouse gas emissions (Figure 4-4). As a country gains wealth, it typically uses more energy, which

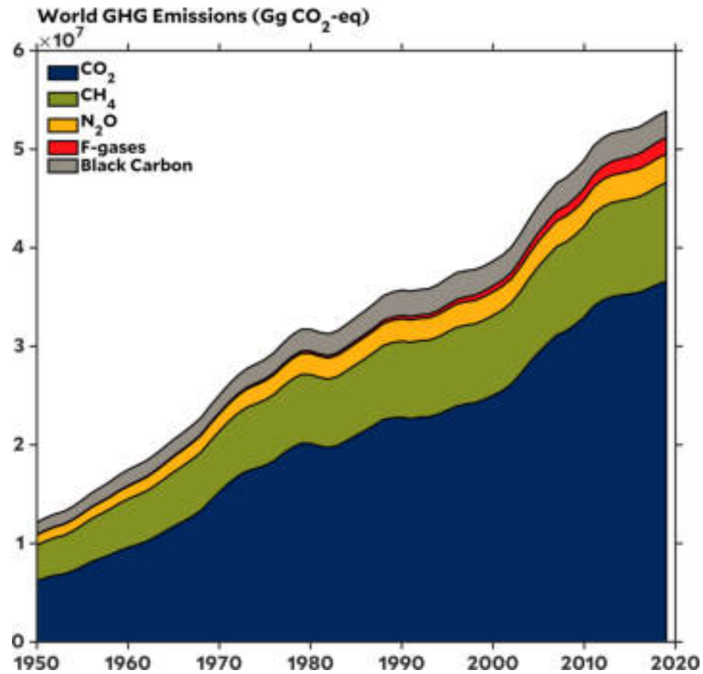


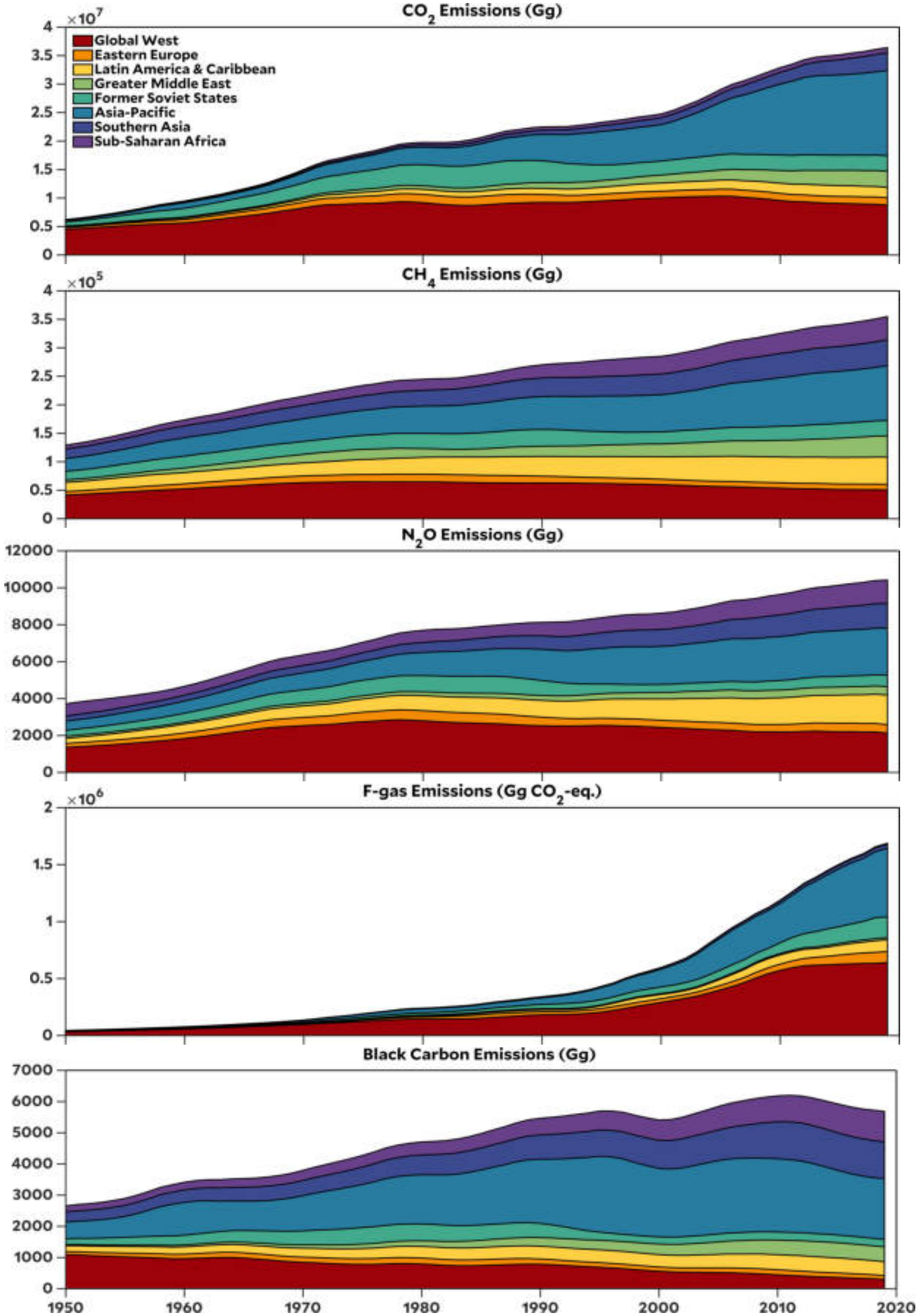
Figure 4-2. Global climate pollutant emissions. Source: Potsdam Institute (PIK).

has historically come from fossil fuels. However, wealthy countries also have resources to expand renewable energy sources or transition to less-polluting service-based economies. Many higher-income countries, like Denmark and the United Kingdom, have begun to decouple economic growth from greenhouse gas emissions (Figure 4-5). The global score in the *greenhouse gas intensity growth rate* indicator increased from 42 to 54 over the past 10 years, reflecting this trend. Decoupling emissions from GDP plays a crucial role in the climate crisis, as it allows nations to sustainably develop and improve their citizens' quality of life without relying on fossil fuels.

Many richer countries are turning to low-carbon energy sources to fuel growth. These alternatives have become increasingly accessible as prices continue to fall. For instance, onshore wind and solar photovoltaic energy are reliably cheaper than coal (Lazard, 2021). However, while many high-income nations are now switching to cleaner energy sources, their economies were built on fossil fuels. Cumulatively, they are responsible for the majority of historical emissions (Thwaites and Bos, 2021).

Developing countries cannot rely on fossil fuels if the world is to successfully mitigate climate change. The world recognized this inequality in the Paris Climate Agreement. When every country committed to more aggressive climate action, developed nations agreed to collectively dedicate $100 billion USD annually by 2020 to help developing countries adopt greener technologies.

Figure 4-3. Regional climate pollutant emissions Source: PIK.



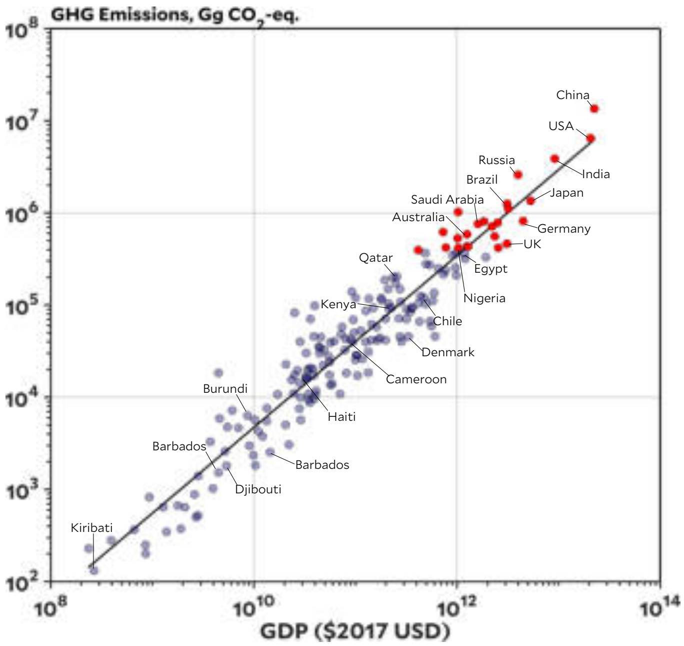


Figure 4-4. Relationship between countries' greenhouse gas emissions and GDP (PPP, constant 2017 international $) for 2019 data. Red points show the 25 largest emitting countries. Sources: greenhouse gas emissions from PIK, GDP from World Bank Databank and IMF.

Several of the world's wealthiest countries, including the United States and Canada, provided less than half of this target (Thwaites and Bos, 2021). To limit warming to 1.5 °C, countries must increase annual climate change financing by at least 590% (CPI, 2021). The Glasgow Climate Pact of 2021 emphasized the importance of climate change financing, outlining an equal distribution between adaptation and mitigation. Since funds have historically focused on mitigation efforts, this goal marks an important step toward protecting vulnerable countries from warming that has already occurred.

3. Leaders and Laggards

Denmark leads the world in mitigating climate change, having reduced greenhouse gas emissions by 50% in the past few decades while also doubling the size of its economy. The Danish Climate Act commits the country to slashing emissions even further, making 70% emissions reductions by 2030 a legally binding target. Denmark, along with Costa Rica, also heads the Beyond Oil & Gas Alliance, an international consortium aiming to phase out oil and gas use. Copenhagen, Denmark's capital city, strives to be a frontrunner in this effort, aiming to be net carbon neutral in 2025 by encouraging renewable energy growth and building infrastructure for greener public transport (Cathcart-Keays, 2016; Sovacool et al., 2018; Taylor, 2018). In late 2021, Denmark derived 67% of its electricity supply from clean sources (USDOC, 2021). In the last decade, Denmark's largest energy company, Ørsted, transformed from one of the most coal-intensive energy producers in Europe to a leader in renewable energy (Skov et al., 2021). The company plans to end the use of coal by 2023 and has set a target to make its operations and energy production completely carbon neutral by 2025. While Denmark is a small nation, and it cannot significantly reduce worldwide emissions, it serves as an important model for how countries can combat climate change while maintaining economic growth and a high standard of living.

The United Kingdom emerges as another top climate performer in the 2022 EPI. By 2020, the country had slashed emissions almost 50% below 1990 levels (UK Climate Change Committee, 2021), driven in part by a massive reduction of coal and shift toward natural gas and renewables. Once the dominant source of energy, coal now only powers 2% of the country and is scheduled to be completely phased out by 2024 (UK, 2021). To wean itself off coal, the country instituted a carbon price floor and invested heavily in solar and wind energy, which are expected to comprise over 50% of the UK power sector by 2030 (IEA, 2019). As one of the founders of the Powering Past Coal Alliance, the United Kingdom is also working to encourage the reduction of coal production outside its borders (PPCA, 2022). The United Kingdom boasts a strong legal framework for reducing greenhouse gas emissions. In 2008, policymakers instituted the Climate Change Act, which committed the country to reaching 80% emissions reductions by 2050. The Act has since been strengthened to mandate net-zero emissions by 2050. The government must set a legally binding carbon budget every five years, creating tangible short-term goals to help the country stay on track.

The Climate Change Act also set up a Committee on Climate Change to serve as an independent body to monitor the nation's progress toward reaching its climate goals (Fankhauser et al., 2018). As a cross-check on the government, the Committee has offered important words of caution that the United Kingdom's significant progress in reducing emissions over the past decade may become more difficult to sustain now that most of the country's coal plants have been replaced (UK Climate Change Committee, 2021).

Iraq's climate performance has deteriorated in recent years, earning the country the lowest score in the Climate Change Mitigation issue category. Carbon dioxide emissions have increased nearly 300% since 1990, due to the expanded use of emissions-intensive energy sources like crude petroleum and fuel oil (Hashim et al., 2020). Iraq contributes to nearly 10% of global methane emissions from the oil and gas sector, driven largely by a 75%

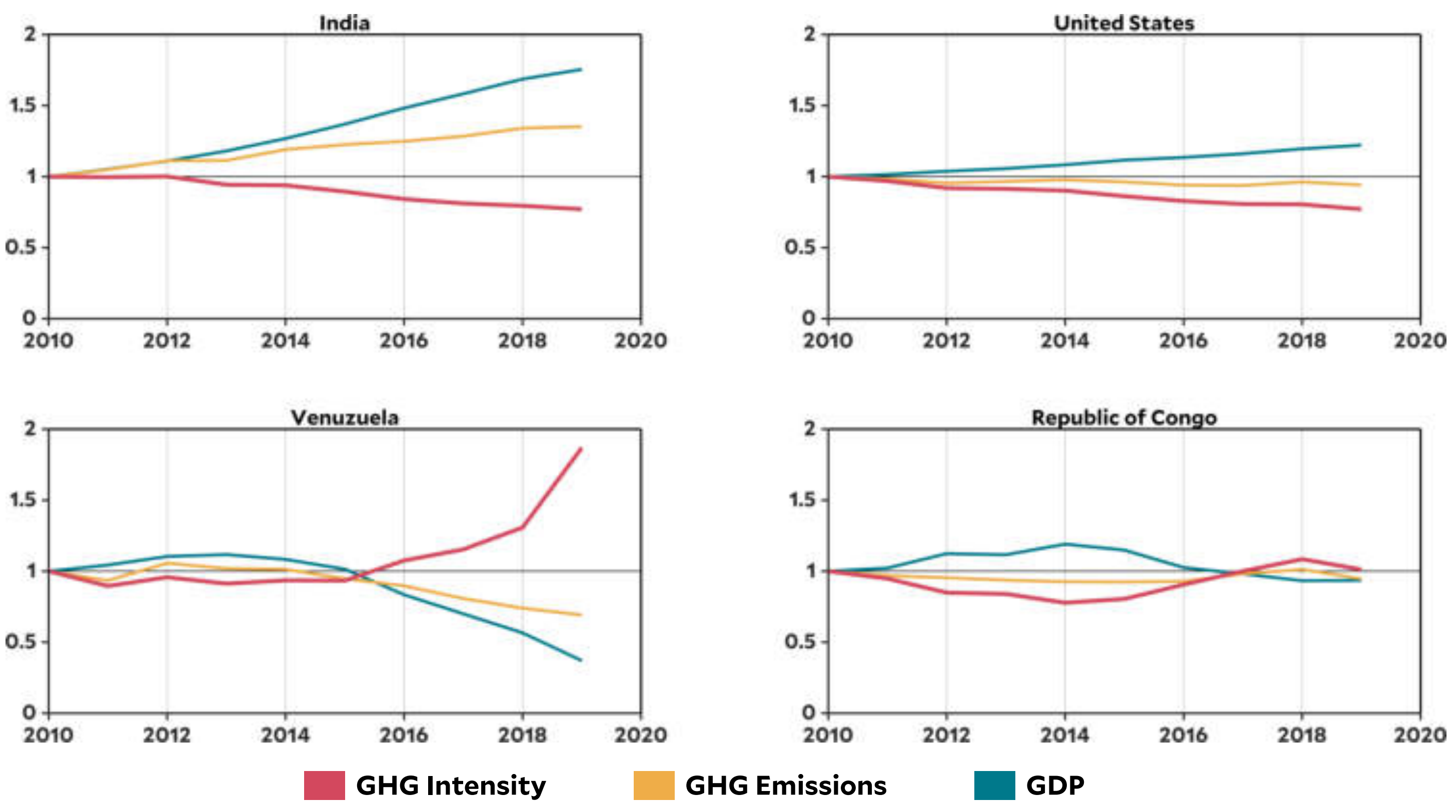
increase in natural gas production since 2010 (IEA, 2021). Political instability has caused further emissions, with oil fields and petroleum stocks being set ablaze during periods of conflict (Bulmer, 2018). As climate change worsens due to global emissions of greenhouse gases, the Iraqi climate is warming at rates twice as fast as the worldwide average (Ranasinghe et al., 2021). Warming threatens to dry out Iraqi marshlands, a water source that many towns rely on for both sustenance and economic activity (Al Ameri et al., 2019; Foltyn, 2022).

Iraq's economy heavily relies on oil, with revenues accounting for 42% of its GDP (World Bank, 2021). During oil production, Iraq engages in gas flaring, a wasteful process that releases carbon dioxide and methane into the atmosphere. As with other oil-dependent nations, Iraq faces difficult choices on the road to a more sustainable future. It may adopt best practices from other Gulf countries for diversifying its economy and expanding renewable energy generation (Hilmi et al., 2020; Lilliestam and Patt, 2015).

Out of the 180 countries evaluated in the EPI, only four are on track to reach net-zero emissions by 2050: Denmark, the United Kingdom, Namibia, and Botswana. Of these four, only Denmark and the United Kingdom have demonstrated a consistently declining trend in greenhouse gas emissions. This striking result demonstrates that these are the only two countries that have been able to maintain economic growth while decreasing emissions in line with the Glasgow Climate Pact. Both countries have passed legislation indicating their intention to reach net-zero emissions by 2050. As discussed above, the Danish Climate Act and the United Kingdom's Climate Change Act require these countries to reach net-zero by 2050. While the United Kingdom has achieved rapid emissions reductions in recent years, some experts attribute this to the replacement of coal with natural gas-fueled power plants. According to the government's own analysis, the trend may become less steep following this transition (UK Climate Change Committee, 2021).

Current projections suggest that just four major emitters will account for over 50% of the world's residual greenhouse gas emissions by 2050: China, India, the United States, and Russia (Figure 4-6). China, India, and Russia are all currently increasing their emissions, indicating the obstacles they must overcome to reach net-zero emissions. Although emissions have declined in the United States over the last decade, they are not falling fast enough to reach net-zero emissions by 2050, given the very high level of current emissions (Figure 4-7). Perhaps of more

Figure 4-5. Representative countries showing trends in greenhouse gas emissions, GDP, and greenhouse gas intensity (defined as emissions per unit GDP). Data are normalized to the base year of 2010. Sources: greenhouse gas emissions from PIK, GDP from World Bank Databank and IMF.



concern to those worried about these findings, the U.S. emissions trend flattened in recent years, reflecting the rollback of several climate policies under the Trump Administration between 2016 and 2020. In particular, the withdrawal of the United States from the Paris Climate Agreement, relaxed methane emissions regulations, and weaker fuel efficiency standards meant the nation lost precious time while its peers in the Global West enacted significant policies to reduce their greenhouse gas emissions.

Removal of carbon dioxide from the atmosphere, or "carbon drawdown", will play an important role in reaching net zero targets (Frischmann, 2021). Some sectors' greenhouse gas emissions — particularly agriculture and air travel — will be difficult to completely eliminate (Fellmann et al., 2018; Hasan et al., 2021; Schäfer et al., 2016), and countries will need to deploy carbon capture and sequestration methods to offset these emissions (Prussi et al., 2021). The *carbon dioxide emissions from land cover change* indicator monitors progress toward leveraging nature-based solutions to mitigate climate change. The global average EPI score for this metric decreased by nearly 26 points over the last decade, suggesting that deforestation is limiting countries' ability to sequester carbon from the atmosphere. This trend could be reversed through reforestation and afforestation policies, although nature-based solutions are not wholly sufficient to mitigate climate change (NASEM, 2019; Royal Society, 2017). It is therefore critical that countries strive to reduce greenhouse gas emissions and invest in new carbon removal techniques to avoid the worst effects of climate change.

Figure 4-6. Projected residual greenhouse gas emissions by country in 2050. Source: PIK, with analysis by EPI.

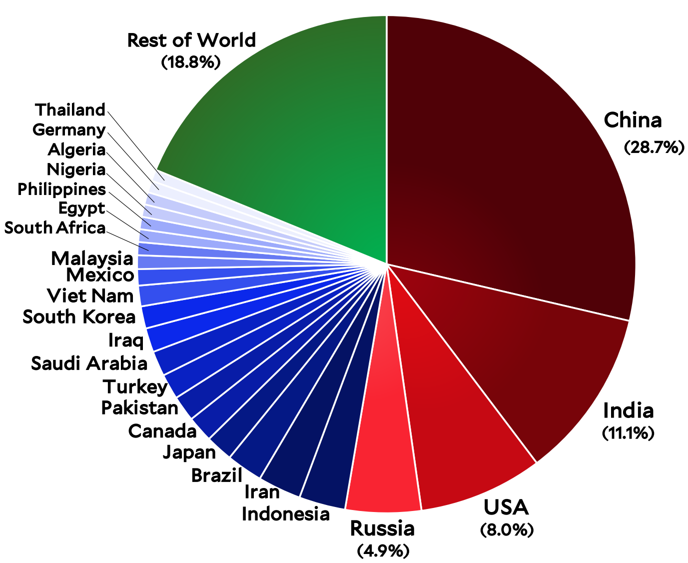
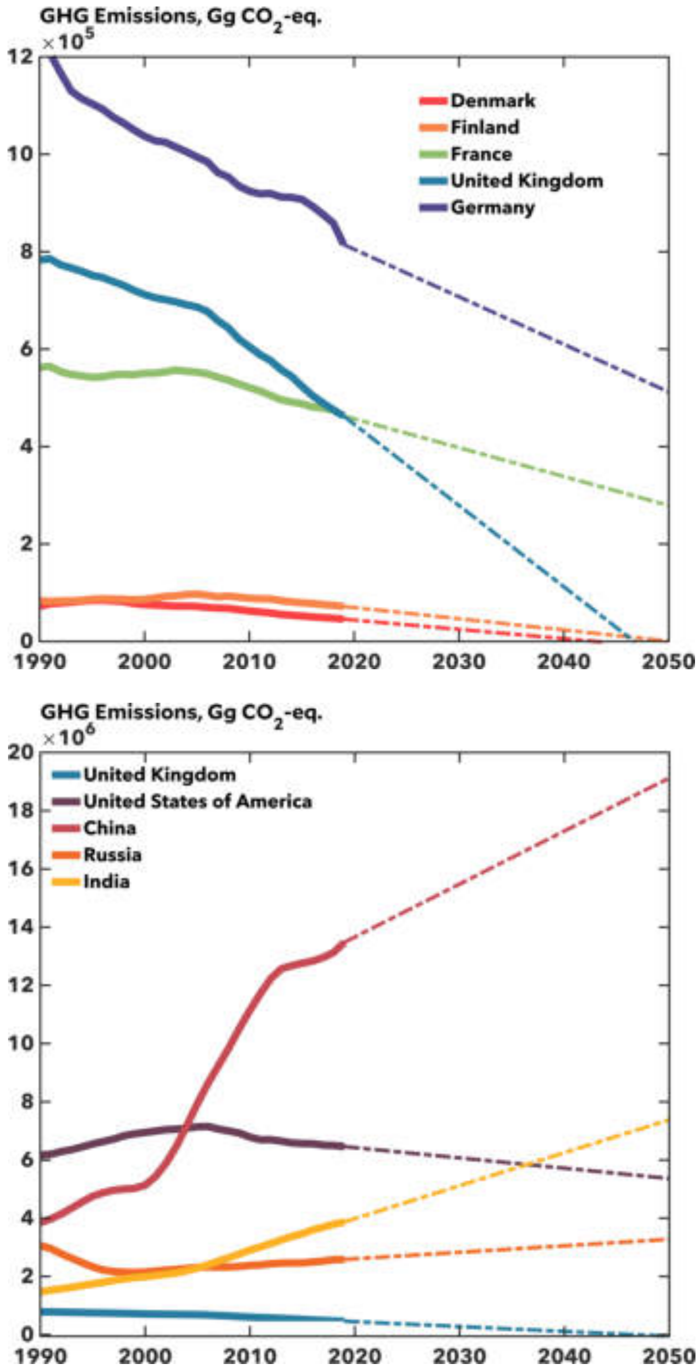


Figure 4-7. Greenhouse gas emissions trajectories and projections to 2050. Source: PIK, with analysis by EPI.



Focus 4.2

Denmark's bilateral energy partnerships

Over the last four decades, Denmark has transformed its energy portfolio from a fossil fuel-based system to one where renewable energy makes up 40 percent of generation — all while maintaining energy reliability as well as a growing economy. However, greenhouse gas emissions reductions are necessary in all sectors to combat climate change, which is also the reason why the Danish government has set a target of reducing national emissions by 70% by 2030, compared with 1990 levels.

Denmark's greatest climatic leadership may lie in its engagement beyond its borders. The country aims to share its experiences, technical capacity, and insights with global energy partners. Specifically, Denmark collaborates with 19 countries on a national, regional and/or local authority level. The 19 bilateral energy partnership countries are China, Egypt, Ethiopia, France, Germany, India, Indonesia, Japan, Kenya, Mexico, the Netherlands, Poland, South Africa, South Korea, Turkey, Ukraine, the United Kingdom, the United States, and Vietnam. Together, these countries account for more than 60% of global CO_2 emissions. By collaborating with some of the world's biggest countries and fastest-growing economies, Denmark puts its expertise to use where it holds the greatest impact. The efforts are focused on Danish core competencies within energy transitions, namely:

- Long-term energy modeling;
- Integration of renewables into the energy system;
- Wind power, offshore and onshore;
- Energy efficiency, industry and buildings;
- District heating.

A prerequisite for a green transition is a flexible regulatory and policy framework. As a world leader in sustainability policy, Denmark shares best practices for creating a competitive business environment, fostering innovation, reducing consumer prices and carbon emissions, and expanding global markets for clean energy technologies with its partners.

The following examples from the partnerships demonstrate Denmark's impact:

With over 1.4 billion inhabitants, China is the world's most populous country as well as the world's largest emitter of CO_2. However, China has announced ambitious climate goals and aims to be carbon-neutral by 2060. To help China achieve its CO_2 reduction targets, Denmark has been working closely with China for many years, helping to integrate more renewable energy into the energy system and increasing the flexibility of its power plants. Denmark has extensive experience with high wind power fluctuations, and has partnered to share this know-how to integrate more wind energy into Chinese electrical grids. This engagement has reduced China's CO_2 emissions by nearly 20 million tons in just a few years.

South Africa is the second-largest economy in Africa, with a growing population as well as an increasing demand for energy. Currently, coal makes up the largest share of the South African energy system, meeting around 70% of installed power generation capacity. However, South Africa has excellent natural resources enabling large-scale renewable energy production from solar and wind power. To unlock this potential, Denmark has been collaborating closely with South Africa on wind resource assessments. This has resulted in the creation of the Wind Atlas for South Africa (WASA), which is currently entering its fourth and final phase, helping to enable the planning of large-scale utilization of wind power in South Africa.

4. Methods

Adjusted Emission Growth Rates

The EPI's adjusted emissions growth rate indicators measure countries' progress toward reducing emissions of four major greenhouse gases and black carbon particulates. Each climate pollutant warms the climate to a different degree, and emissions can be compared by factoring in global warming potentials to convert data into equivalent emissions of carbon dioxide. The scientific consensus indicates that the world must restrict total net emissions after 2019 to 400 – 650 gigatons of carbon dioxide equivalents to limit warming to below 1.5 °C, reaching net-zero emissions by 2050 (IPCC, 2021). The adjusted emission growth rate indicators measure whether countries are making consistent strides toward achieving this goal.

Several pollutants are driving climate change. While carbon dioxide accounts for nearly 80% of warming (Forster et al., 2021) and remains the primary focus of climate policies, the world also needs deep reductions in other emissions to mitigate climate change. A recent emphasis on methane emissions demonstrates persistent and unanticipated challenges to meeting international climate goals (Fletcher and Schaefer, 2019). Methane emissions warm the planet 30 times as much as the same amount of carbon dioxide emissions over 100 years, but countries have only recently made serious efforts to combat methane emissions. Some climate pollutants also directly threaten human health in addition to warming the planet. Nitrous oxide emissions deplete stratospheric ozone and increase rates of skin cancer (Kanter et al., 2021). Exposure to black carbon also increases rates of cancer and cardiovascular disease (Grahame et al., 2014). Methane emissions exacerbate ground-level ozone concentrations, worsening respiratory illnesses. Clearly, countries can make progress toward reducing climate change and improving air quality by reducing emissions of climate pollutants.

Indicator Background

EPI researchers calculate the emissions growth rate for greenhouse gases and black carbon as the average annual rate of increase or decrease in raw emissions over the most recent ten years of data, 2010 – 2019. Most countries' greenhouse gas emissions have increased over the past ten years, although around 50 countries' emissions are declining. Downward trends may result from successful climate policies or from economic recession. To estimate which cause is driving a country's negative growth rate, the EPI team calculates the correlation between ten years of annual emissions and GDP. Negative growth rates are then adjusted to account for economic fluctuations according to the following formula:

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

where r is Spearman's correlation coefficient between ten years of GDP and emissions data. Countries where r is close to 1 will have their negative growth rate adjusted toward zero. This methodology explicitly gives less credit to countries that achieve emissions reductions through economic downturn. Where countries have decoupled economies from fossil fuel consumption, r will be close to -1. These countries will have their negative growth rates augmented for achieving sustainable economic growth. Most countries with declining emissions fall into this category (Figure 4-8).

Data Sources

Greenhouse gas emissions data for CO_2, CH_4, N_2O, and F-gases come from the Potsdam Institute for Climate Impact Research (PIK) and span from 2010 to 2019. We source these data from PIK's "Potsdam Realtime Integrated Model for probabilistic Assessment of emission Paths" (PRIMAP-hist) dataset. The PRIMAP-hist dataset compiles emissions data from multiple datasets and sources (Gütschow et al., 2016). It is freely available at: https://doi.org/10.5281/-zenodo.5494497

Data for black carbon emissions come from the Community Emissions Data System (CEDS) and span from 2010 to 2019. CEDS is managed by the Joint Global Change Research Institute and Pacific Northwest National Laboratory and is funded by the U.S. Department of Energy Office of Science. Emissions data is derived using fuel consumption, technology, and emissions control policies as inputs (McDuffie et al., 2020). Fuel combustion data are based on analyses from the International Energy Agency, whereas non-combustion data are sourced from the Emission Database for Global Atmospheric Research (EDGAR) database. The full CEDS dataset is publicly available for download from:
https://doi.org/10.5281/zenodo.4741285

Limitations

The 2022 EPI's adjusted emissions growth rate indicators are derived from existing GHG inventories that in turn are calculated using several assumptions. The CEDS and PRIMAP-hist inventories take a bottom-up approach, estimating emissions by multiplying fossil fuel use or anthropogenic activity by a corresponding emissions factor, accounting for the greenhouse gases released per unit of fuel use or activity. These emissions factors do not account for variation across sites, factories, and operations. For instance, agricultural emissions factors vary in ways too granular to be comprehensively represented in current national emissions inventories (Walling and Vaneeckhaute, 2020). Uncertainties are higher for non-CO_2 greenhouse gases.

Many developing countries lack the technical expertise and capacity to monitor greenhouse gas sources and sinks, making it difficult to compile accurate national emissions inventories (Tongwane and Moeletsi, 2018; Yona et al., 2020). Quantifying emissions from certain sectors, such as agriculture, can be difficult, meaning estimates are derived from regional data that can introduce uncertainties. The EPI team notes that the emissions trends are calculated using data between 2010 and 2019, and do not reflect emissions reductions during the COVID-19 pandemic.

Policymakers should not see the adjusted emissions growth rate indicators as incompatible with economic growth. Industrializing countries have a right to sustainably develop, expand their economies, and improve their populations' quality of life. This may require initial increases in greenhouse gas emissions from least-developed countries, although these nations may seize the opportunity to technologically leap-frog and preferentially adopt renewable energy sources over fossil fuel-based infrastructure.

Projected GHG Emissions Levels in 2050

After significant declines in greenhouse gas emissions during the initial stages of the COVID-19 pandemic, global emissions have again risen to pre-pandemic levels. This rebound demonstrates the world is not on track to mitigate climate change and reach net-zero emissions by mid-century. Although many signatories to the Glasgow Climate Pact committed to reaching that goal, several countries' current policies do not align with their pledged emissions reductions. The world thus faces a gap in credibility between climate action and climate commitment.

Reaching net-zero emissions by 2050 could limit warming to 1.5 °C (UNEP, 2021), but this goal grows further out of reach with each year of insufficient action. Recognizing the increased urgency of mitigating climate change, the 2021 Glasgow Climate Pact urges countries to revisit and strengthen their pledged emissions reductions targets for 2030 — thereby putting the world on a more transparent path to net-zero emissions by mid-century. For the first time, the Pact also addressed reaching net-zero greenhouse gas emissions by mid-century, as opposed to focusing solely on reducing carbon dioxide emissions. Countries must mitigate methane, nitrous oxide, and F-gas emissions to feasibly reach this target. This broader scope accompanies the recent Global Methane Pledge, in which 112 countries aim to reduce total methane emissions by 30% by 2030.

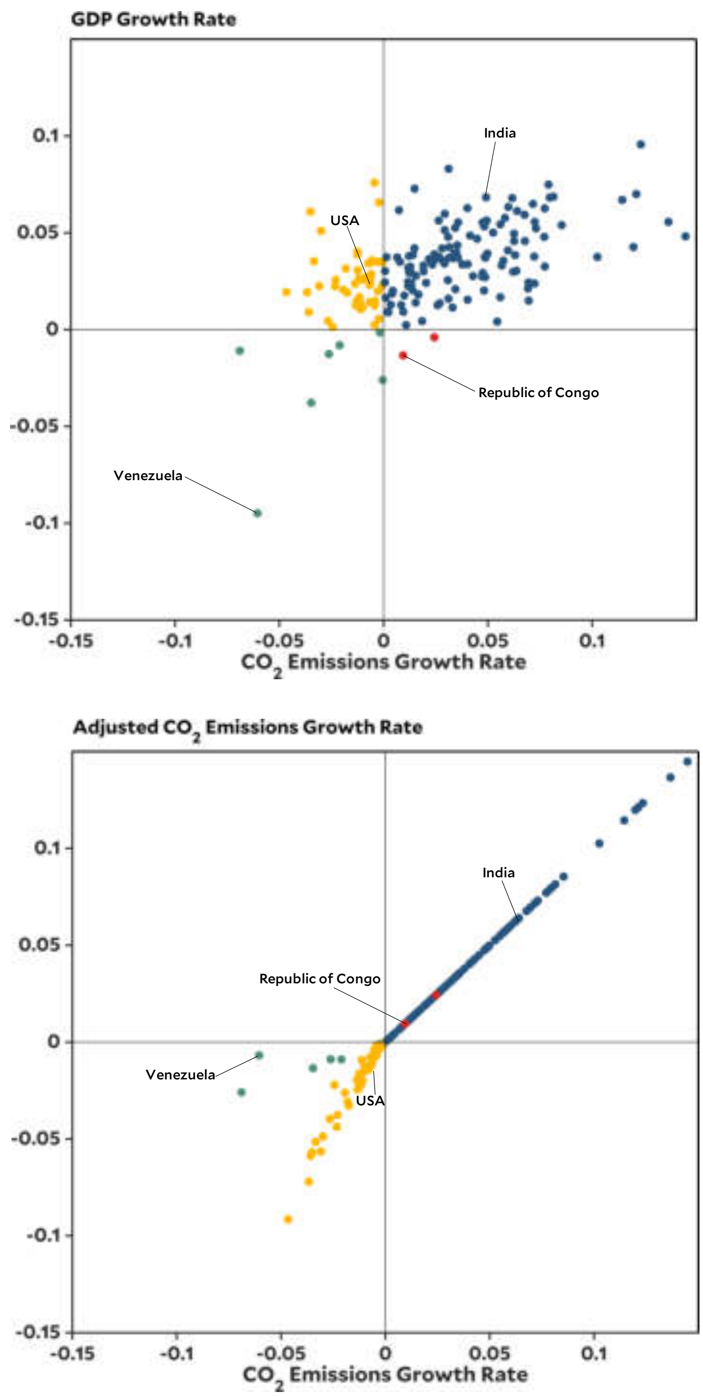


Figure 4-8. Adjusting declining greenhouse gas emission growth rates based on correlation with economic growth rates. Sources: CO_2 emissions from PIK, GDP from World Bank Databank and IMF.

Indicator Background

To facilitate policy discussions and highlight the countries on track to reach greenhouse gas neutrality by mid-century, the 2022 EPI introduces a new indicator on projected emissions levels in 2050. EPI researchers project each country's 2050 greenhouse gas emissions by summing carbon dioxide, methane, nitrous oxide, and F-gas emissions together using each gas's respective global warming potentials. Next, a linear regression on a ten-year trend between 2010 to 2019 gives an emissions slope. This slope is extrapolated from 2019 to 2050. Each country's score corresponds to the log of its projected emissions in 2050. Countries projected to reach zero emissions by or before 2050 receive a top score in this indicator.

Data Sources

Data for CO_2, CH_4, N_2O, and F-gas emissions come from the Potsdam Institute for Climate Impact Research (PIK). We source these data from PIK's "Potsdam Realtime Integrated Model for probabilistic Assessment of emission Paths" (PRIMAP-hist) dataset. The PRIMAP-hist dataset compiles emissions data from multiple datasets and sources (Gütschow et al., 2016). It is freely available at: https://doi.org/10.5281/-zenodo.5494497

Limitations

The 2022 EPI introduces the projected emissions levels in 2050 as a pilot indicator for gauging countries' climate progress, presenting it to the global scientific and policymaking community for review and commentary. The indicator is based on several important assumptions. First, the pilot indicator does not yet account for carbon dioxide removal. Current projections only account for decreasing emissions. Although the low rate of carbon dioxide removal from the atmosphere currently permits this assumption, the EPI team recognizes that carbon capture and sequestration efforts will become an increasingly important feature of national climate policy portfolios in the years to come. Promising strategies for carbon drawdown include both nature-based solutions and engineered technologies (NASEM, 2019; Royal Society, 2017). As research and datasets on carbon sequestration advance, subsequent iterations of the EPI's projected emissions indicator will incorporate negative emissions estimates into 2050 projections (Harris et al., 2021).

Second, the indicator's projections use trends that may improve or decline in the coming decades as countries enact new climate policies. The projected emissions levels in 2050 indicator is best used as a gauge as to whether current emissions trajectories are sufficient to meet the net-zero goal, rather than an estimate of the magnitude of net emissions in 2050. Subsequent refinements to the indicator may include more sophisticated methods of projecting emissions trajectories based on codified climate policies, renewable energy capacity, and other economic factors.

Growth Rate in Carbon Dioxide (CO_2) Emissions from Land Cover Change

Scientists increasingly recognize land cover change as an important driver, and symptom, of climate change (Friedlingstein et al., 2020; Song et al., 2018). 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 and availability related to 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 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 2022 EPI captures these estimates in the *growth rate in CO_2 emissions from land cover* indicator.

Indicator Background

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 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 ten years from 2008 to 2017.

Data Sources

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 (Buendia et al., 2019), 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/news/.

Limitations

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; regrowth is measured as a single value limited to the years 2000–2012. This measure does not account for regrowth after tree cover loss, as would typically occur post-natural disturbances, 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 actual 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 or significant levels of natural disturbance.

The 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 and analysis of outputs are discussed in more detail at flintpro.com/news/.

Greenhouse Gas Intensity Growth Rate

Countries can grow their economies sustainably by transitioning from fossil fuels to renewable energy sources. The EPI's *greenhouse gas (GHG) intensity growth rate* indicator measures countries' progress in decoupling emissions from economic growth. The metric underscores the need to wean economies off fossil fuels in countries at all wealth levels. While richer countries may be best-positioned to reduce emissions as they transition from industry to service-based economies (Creutzig et al., 2018), developing countries may be able to technologically leap-frog developed countries, adopting and expanding greener energy sources without first supporting growth with fossil fuels (Arndt et al., 2019).

Indicator Background

The 2022 EPI derives the GHG intensity growth rate as the average rate of increase or decrease in greenhouse gas emissions per unit of GDP. The growth rate is calculated as a slope over the years 2010 to 2019. This indicator includes carbon dioxide, methane, nitrous oxide, and F-gas emissions across all sectors of the economy, with each gas's annual emissions multiplied by its global warming potential.

Data Sources

Emission data for the GHG intensity growth rate indicator come from the Potsdam Institute for Climate Impact Research's PRIMAP-hist dataset, described above in greater detail. GDP data come from the World Bank and IMF.

Limitations

As with the adjusted emission growth rate indicators, the data undergirding the GHG intensity growth rate indicator are derived from emissions factors that introduce uncertainty into estimates. Emissions inventories are more accurate in developed countries than in developing ones. The PRIMAP-hist dataset reports emissions up to 2019, meaning indicator scores do not capture emissions reductions and economic fluctuations related to the COVID-19 pandemic.

Greenhouse Gas Emissions *per Capita*

Many developing countries still struggle to elevate the quality of life for their residents and reduce energy poverty. Recognizing that sustainable development may entail some degree of fossil-fuel reliance in these countries, the 2022 EPI includes the *greenhouse gas emissions per capita* indicator. Standardizing national greenhouse gas emissions by population allows for a fairer comparison of the climatic impact between different countries' typical residents.

Indicator Background
The *greenhouse gas emissions per capita* indicator considers emissions of carbon dioxide, methane, nitrous oxide, and F-gas emissions across all sectors of the economy, with each gas's 2019 emissions multiplied by its global warming potential.

Data Sources
Emission data for the indicator come from the Potsdam Institute for Climate Impact Research's PRIMAP-hist dataset, described in greater detail above. Population data come from the World Bank and IMF.

Limitations
The *greenhouse gas emissions per capita* indicator reflects country performance at a point in time rather than reflecting a trend. Thus, this indicator does not reflect whether countries' emissions profiles are headed in the right direction. However, calculating a trend and scoring countries based on whether emissions per capita are increasing or decreasing over time would obscure differences in the optimal emissions trajectories between countries. For example, least-developed countries' emissions may defensibly rise in the coming years to support an increased quality of life for residents there. The current *per capita* indicator construction provides policymakers with an understanding of how resource-intensive their economies and societies are.

Focus 4.3

Assessing the costs of nuclear phase-out: Germany case study

The politically charged discussions surrounding many nations' plans to phase out nuclear energy often obscure the economic and environmental costs of such plans. For there to be more productive and transparent policy discussions on the future of nuclear power in any government's energy policy or response to climate change, policymakers should conduct and debate cost-benefit analyses that study the often-overlooked costs that a transition away from nuclear power might entail, in addition to the benefits that alternative energy sources might provide.

Recent denuclearization campaigns, often led by green parties in Europe and anti-nuclear power groups including the Friends of the Earth, Greenpeace, Sortir du nucléaire and WISE, have highlighted the potential environmental and health risks that might arise from the mining and extraction of uranium, the continued operation of nuclear power plants near urban areas, and the eventual disposal of hazardous radioactive waste. Green party politicians in France and Germany have consistently rejected nuclear power as a viable source of renewable "green" energy.

The meltdown of the Japanese Fukushima Daiichi reactors caused by the Tōhoku earthquake and tsunami in 2011 galvanized the anti-nuclear platform of these environmental groups and Germany's "Greens" political party. In the state elections following the 2011 earthquake, the Greens obtained impressive results due to their long-time anti-nuclear politics. As a result, on May 30th of 2011, Chancellor Angela Merkel's coalition announced a plan to incrementally shut down Germany's 17 nuclear power stations by 2022, and a few months later, the German industrial engineering firm Siemens (which built all of Germany's plants) announced it would withdraw entirely from the nuclear industry. Just three of the original reactors are still online, indicating that the phase-out is proceeding according to the original schedule.

Remarkably, this policy reversal lacked much public participation in debating the tradeoffs between the health risks, taxpayer costs, and environmental benefits of nuclear energy. Germany's nuclear phase-out policy has significantly increased its dependence on fossil fuels to meet immediate energy demand in the years following 2011. Some analyses demonstrate that the shutdown of nuclear reactors was in-part compensated by increasing production from fossil fuel fired power stations — including many powered by Russian natural gas (Jarvis et al., 2020). Recent estimates suggest that the policy increased production from fossil-fuel power plants (+15%) and imports (+37%), increasing wholesale prices by 4%. The higher electricity prices for German consumers could amount to $1.6 billion per year.

Shutting down Germany's nuclear power plants may also have important public health implications, contributing to over 1,000 additional premature deaths due to increased air pollution emanating from fossil fuel power plants (Jarvis et al., 2020). The replacement of nuclear power production resulted in a notable increase in CO_2 (+13%), SO_2 (+11.7%), NO_x (+12.5%) and fine particle emissions (+12.2%). The additional carbon dioxide emissions amount to 36 million tons per year, close to 5% of Germany's total emissions in 2020, which, based on a social cost of carbon of $50/t$CO_2$, represents an additional cost of $1.8 billion per year.

Overall, results do indicate significant costs on an economic and environmental level associated with the closing of Germany's nuclear plants. Current debates over opening and closing nuclear plants persist in the French and German political arenas, with recent controversies over the Fessenheim and Bugey plants in France acting as a reminder of the continued need to understand and evaluate the costs associated with their closure.

Just as the Russian invasion of Ukraine has forced Europe to reassess its dependence on fossil fuel imports from Russia, now is the time for Germany and other EU countries to rethink their decisions to close their nuclear power plants. While the continued operation of these plants might well require significant investments to update the equipment and maintain top-tier safety standards, now is the time for such as reconsideration – in the face of net-zero GHG targets that will be hard to reach in many nations without nuclear power.

Chapter 5. Air Quality

1. Introduction

Poor air quality is one of the most critical public health issues around the world. Exposure to air pollutants causes over 6 million early deaths annually, with nearly 99% of the global population living in areas with unsafe concentrations of ambient air pollutants (Cohen et al., 2017; Health Effects Institute, 2020; World Health Organization, 2022). The health effects of air pollution extend beyond respiratory illnesses. Residents breathing polluted air have higher rates of heart disease, cancer, and diabetes (Bourdrel et al., 2017; Martoni, 2018; Turner et al., 2020). Recent evidence also indicates a link between chronic exposure to air pollutants and susceptibility to COVID-19 (Kim and Bell, 2021; Wu et al., 2020).

Although air quality is a global sustainability issue, its impacts and severity are highly variable both between and within countries. Complex feedbacks between different air pollutants create tradeoffs, where improvements in one area (e.g., nitrogen oxides) can exacerbate another (e.g., ozone) (Seinfeld and Pandis, 1998). The EPI's insights empower policymakers to track air quality trends within their borders, explore tradeoffs, and enact scientifically-grounded emissions control policies. Since greenhouse gases and air pollutants share many sources, efforts to improve air quality will also mitigate climate change.

The 2022 EPI introduces four innovative air quality indicators to more comprehensively track the public health outcomes of poor air quality. New indicators measure exposure to nitrogen oxides (NO_X), sulfur dioxide (SO_2), carbon monoxide (CO), and volatile organic compounds.

These join the existing indicators that quantify premature death from exposure to fine particulate matter ($PM_{2.5}$), ground-level ozone (O_3), and pollution from the combustion of household solid fuels.

The expanded Air Quality issue category therefore captures country performance in both ambient and indoor air quality.

2. Indicators

Particulate Matter ($PM_{2.5}$) Health Impacts (47% of issue category)
We measure the public health impacts of *exposure to $PM_{2.5}$* using the number of age-standardized disability-adjusted life-years (DALY rate) lost per 100,000 persons. $PM_{2.5}$ is fine airborne particulate matter smaller than 2.5 micrometers in diameter.

Household Solid Fuel Combustion Health Impacts (38% of issue category)
We measure the health impacts from the combustion of *household solid fuels* using the number of age-standardized disability-adjusted life-years (DALY rate) lost per 100,000 persons. Household solid fuel combustion is the primary cause of poor indoor air quality in many parts of the world.

Ozone (O_3) Health Impacts (4.5% of issue category)
We measure the public health impacts of *exposure to ground-level ozone* using the number of age-standardized disability-adjusted life-years (DALY rate) lost per 100,000 persons. Ground-level ozone is produced via reactions of other air pollutants.

Nitrogen Oxides (NO_X) Exposure (4.5% of issue category)
We measure *exposure to ground-level nitrogen oxides* (NO and NO_2) using a country's ambient ground-level concentration. The pollutant concentration is population-weighted to better capture the exposure levels in geographic areas with a higher human population density.

Sulfur Dioxide (SO_2) Exposure (2% of issue category)
We measure *exposure to ground-level sulfur dioxide* using a country's ambient ground-level concentration. The pollutant concentration is population-weighted to better capture the exposure levels in geographic areas with a higher human population density.

Carbon Monoxide (CO) Exposure (2% of issue category)
We measure *exposure to ground-level carbon monoxide* using a country's ambient ground-level concentration. The pollutant concentration is population-weighted to better capture the exposure levels in geographic areas with a higher human population density.

Volatile Organic Compounds (VOCs) Exposure (2% of issue category)
We measure exposure to *ground-level volatile organic compounds* using a country's ambient ground-level concentration. The pollutant concentration is population-weighted to better capture the exposure levels in geographic areas with a higher human population density.

Map 5-1. Global rankings on Air Quality.

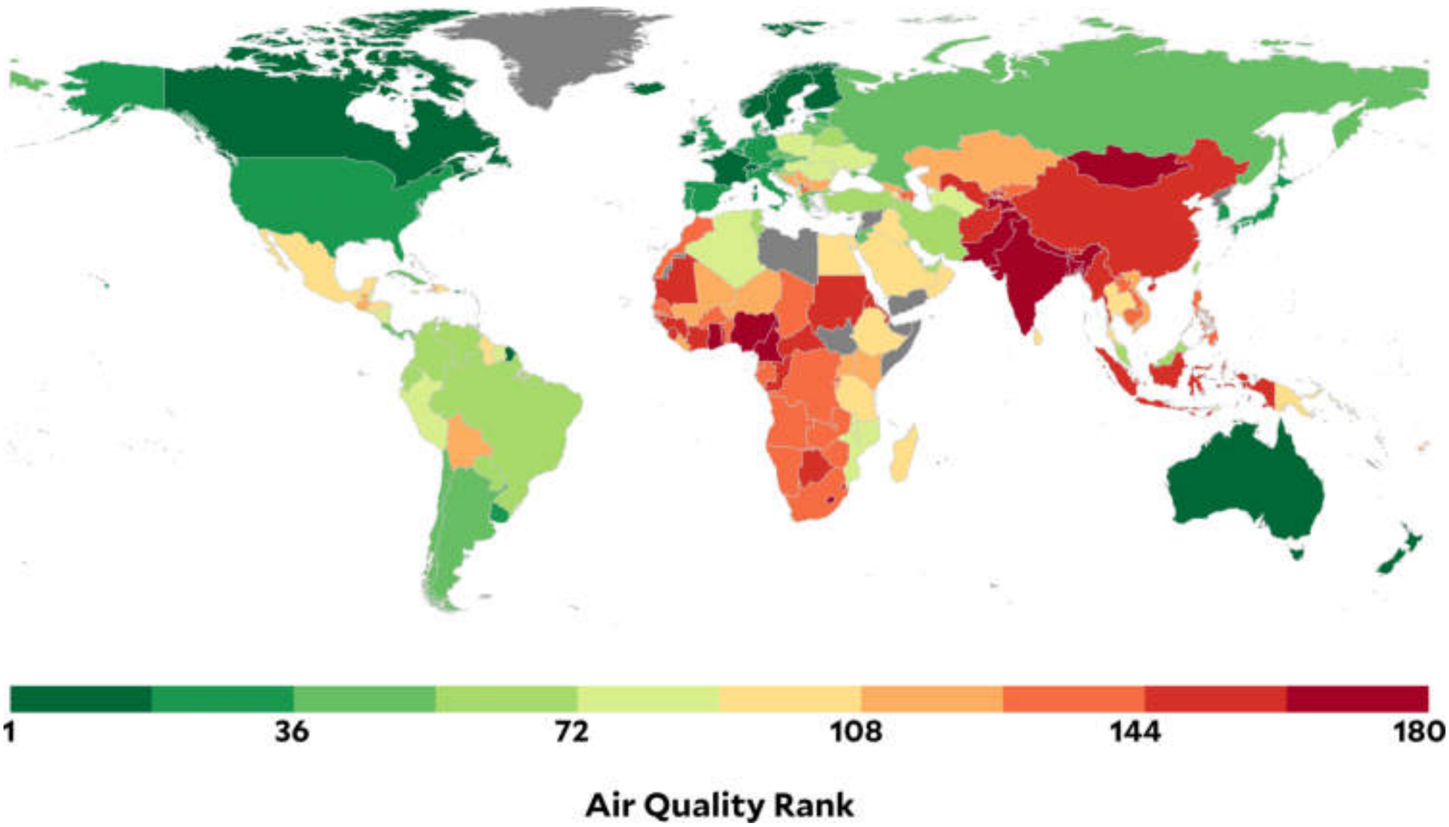


Table 5-1. Global rankings, scores, and regional rankings (REG) on Air Quality.

RANK	COUNTRY	SCORE	REG
1	Iceland	96.0	1
2	Sweden	94.0	2
3	Finland	93.5	3
4	New Zealand	93.2	4
5	Norway	92.4	5
6	Australia	91.1	6
7	Ireland	89.1	7
8	Canada	88.0	8
9	Switzerland	84.3	9
10	France	82.0	10
11	Luxembourg	81.0	11
12	Denmark	80.5	12
13	Japan	78.9	1
14	United Kingdom	78.6	13
15	Portugal	78.1	14
16	United States of America	77.0	15
17	Netherlands	76.8	16
18	Germany	75.2	17
19	Austria	75.0	18
20	Belgium	74.6	19
20	Estonia	74.6	1
22	Spain	74.0	20
23	Malta	73.2	21
24	Italy	69.4	22
25	Singapore	69.2	2
26	Cyprus	68.3	2
27	Israel	68.0	1
28	Barbados	65.3	1
29	Uruguay	63.6	2
30	South Korea	62.9	3
31	Greece	62.0	3
32	Brunei Darussalam	61.7	4
33	Lithuania	58.4	4
34	Antigua and Barbuda	56.5	3
35	Slovenia	55.1	5
36	Seychelles	54.8	1
37	Bahamas	54.5	4
38	Trinidad and Tobago	54.3	5
39	Czech Republic	53.3	6
40	Maldives	52.0	1
40	Argentina	52.0	6
42	Panama	51.9	7
43	Costa Rica	51.4	8
44	Latvia	51.1	7
45	Slovakia	50.9	8
46	Mauritius	50.7	2
46	Jordan	50.7	2
48	Cuba	50.6	9
49	Russia	48.8	1
50	Chile	48.4	10
51	Kuwait	47.0	3
52	Venezuela	46.7	11
53	Taiwan	46.2	5
54	Belarus	46.1	2
55	Saint Lucia	46.0	12
56	Croatia	45.8	9
57	Brazil	44.9	13
58	Turkey	44.6	10
59	Ecuador	44.1	14
60	Colombia	44.0	15
60	Dominica	44.0	15
62	Malaysia	43.7	6
63	Grenada	43.5	17
64	Paraguay	43.3	18
64	Tunisia	43.3	4
66	St. Vincent and Grenadines	42.7	19
67	Qatar	42.1	5
68	Tonga	41.9	7
69	United Arab Emirates	41.7	6
70	Iran	41.6	7
71	Peru	41.5	20
72	Lebanon	41.2	8
73	Moldova	40.5	3
74	Poland	40.4	11
75	Jamaica	39.8	21
76	Algeria	39.4	9
77	Romania	39.2	12
78	Turkmenistan	38.7	4
79	Comoros	38.4	3
80	Nicaragua	38.2	22
80	Hungary	38.2	13
82	Mozambique	37.9	4
83	Belize	37.6	23
84	Albania	37.5	14
85	Suriname	36.9	24
86	El Salvador	36.7	25
87	Samoa	36.0	8
88	Ukraine	35.9	5
89	Malawi	35.7	5
90	Marshall Islands	34.9	9
91	Bahrain	34.7	10
92	Egypt	34.6	11
93	Thailand	34.4	10
94	Mexico	34.2	26
95	Ethiopia	33.7	6
96	Madagascar	33.6	7
97	Dominican Republic	33.5	27
98	Tanzania	33.2	8
99	Saudi Arabia	32.8	12
100	Sri Lanka	32.5	2
100	Timor-Leste	32.5	11
102	Guyana	32.1	28
102	Armenia	32.1	6
102	Kiribati	32.1	12
105	Iraq	31.8	13
105	Oman	31.8	13
107	Papua New Guinea	31.7	13
108	Micronesia	31.6	14
109	Honduras	31.3	29
110	Burundi	30.7	9
110	Montenegro	30.7	15
110	Vanuatu	30.7	15
113	Fiji	30.3	16
114	Kenya	30.0	10
114	Bolivia	30.0	30
116	Serbia	29.4	16
117	Guatemala	29.1	31
118	Kazakhstan	28.6	7
118	Bulgaria	28.6	17
118	Solomon Islands	28.6	17
121	Liberia	28.3	11
122	Haiti	28.2	32
123	Cabo Verde	28.0	12
124	Georgia	27.9	8
125	Bosnia and Herzegovina	27.8	18
126	Uganda	27.4	13
127	Niger	27.1	14
128	São Tomé and Príncpe	26.8	15
129	Mali	26.7	16
130	Viet Nam	26.5	18
131	Burkina Faso	26.1	17
132	Cambodia	25.9	19
132	Philippines	25.9	19
134	Gabon	25.7	18
135	Dem. Rep. Congo	25.1	19
136	Rwanda	24.7	20
137	Chad	24.3	21
138	Zimbabwe	23.9	22
139	Zambia	23.6	23
140	Kyrgyzstan	23.5	9
141	Angola	23.1	24
142	Equatorial Guinea	22.9	25
143	Morocco	22.7	15
144	North Macedonia	22.6	19
144	Laos	22.6	21
146	Benin	22.3	26
147	Namibia	22.2	27
147	South Africa	22.2	27
149	Senegal	22.1	29
149	Azerbaijan	22.1	10
151	Sierra Leone	21.6	30
152	Indonesia	21.5	22
153	Mauritania	21.1	31
154	Guinea	21.0	32
154	Togo	21.0	32
156	Gambia	20.7	34
157	China	20.6	23
158	Djibouti	19.6	35
158	Bhutan	19.6	3
160	Guinea-Bissau	19.4	36
161	Eritrea	19.3	37
162	Central African Republic	19.0	38
163	Côte d'Ivoire	18.2	39
164	Botswana	17.1	40
165	Eswatini	16.9	41
165	Myanmar	16.9	24
167	Republic of Congo	16.7	42
167	Uzbekistan	16.7	11
169	Sudan	15.6	16
170	Afghanistan	15.5	4
171	Ghana	15.3	43
172	Mongolia	14.9	25
173	Bangladesh	14.4	5
174	Nigeria	13.8	44
175	Cameroon	13.2	45
176	Tajikistan	12.2	12
177	Lesotho	11.1	46
178	Nepal	9.5	6
179	India	7.8	7
180	Pakistan	5.7	8

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 and scores on Air Quality.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Barbados	65.3	1
Uruguay	63.6	2
Antigua and Barbuda	56.5	3
Bahamas	54.5	4
Trinidad and Tobago	54.3	5
Argentina	52.0	6
Panama	51.9	7
Costa Rica	51.4	8
Cuba	50.6	9
Chile	48.4	10
Venezuela	46.7	11
Saint Lucia	46.0	12
Brazil	44.9	13
Ecuador	44.1	14
Colombia	44.0	15
Dominica	44.0	15
Grenada	43.5	17
Paraguay	43.3	18
St. Vincent and Grenadines	42.7	19
Peru	41.5	20
Jamaica	39.8	21
Nicaragua	38.2	22
Belize	37.6	23
Suriname	36.9	24
El Salvador	36.7	25
Mexico	34.2	26
Dominican Republic	33.5	27
Guyana	32.1	28
Honduras	31.3	29
Bolivia	30.0	30
Guatemala	29.1	31
Haiti	28.2	32

EASTERN EUROPE

Country	Score	Reg. Rank
Estonia	74.6	1
Cyprus	68.3	2
Greece	62.0	3
Lithuania	58.4	4
Slovenia	55.1	5
Czech Republic	53.3	6
Latvia	51.1	7
Slovakia	50.9	8
Croatia	45.8	9
Turkey	44.6	10
Poland	40.4	11
Romania	39.2	12
Hungary	38.2	13
Albania	37.5	14
Montenegro	30.7	15
Serbia	29.4	16
Bulgaria	28.6	17
Bosnia and Herzegovina	27.8	18
North Macedonia	22.6	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Maldives	52.0	1
Sri Lanka	32.5	2
Bhutan	19.6	3
Afghanistan	15.5	4
Bangladesh	14.4	5
Nepal	9.5	6
India	7.8	7
Pakistan	5.7	8

GLOBAL WEST

Country	Score	Reg. Rank
Iceland	96.0	1
Sweden	94.0	2
Finland	93.5	3
New Zealand	93.2	4
Norway	92.4	5
Australia	91.1	6
Ireland	89.1	7
Canada	88.0	8
Switzerland	84.3	9
France	82.0	10
Luxembourg	81.0	11
Denmark	80.5	12
United Kingdom	78.6	13
Portugal	78.1	14
United States of America	77.0	15
Netherlands	76.8	16
Germany	75.2	17
Austria	75.0	18
Belgium	74.6	19
Spain	74.0	20
Malta	73.2	21
Italy	69.4	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Russia	48.8	1
Belarus	46.1	2
Moldova	40.5	3
Turkmenistan	38.7	4
Ukraine	35.9	5
Armenia	32.1	6
Kazakhstan	28.6	7
Georgia	27.9	8
Kyrgyzstan	23.5	9
Azerbaijan	22.1	10
Uzbekistan	16.7	11
Tajikistan	12.2	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Japan	78.9	1
Singapore	69.2	2
South Korea	62.9	3
Brunei Darussalam	61.7	4
Taiwan	46.2	5
Malaysia	43.7	6
Tonga	41.9	7
Samoa	36.0	8
Marshall Islands	34.9	9
Thailand	34.4	10
Timor-Leste	32.5	11
Kiribati	32.1	12
Papua New Guinea	31.7	13
Micronesia	31.6	14
Vanuatu	30.7	15
Fiji	30.3	16
Solomon Islands	28.6	17
Viet Nam	26.5	18
Cambodia	25.9	19
Philippines	25.9	19
Laos	22.6	21
Indonesia	21.5	22
China	20.6	23
Myanmar	16.9	24
Mongolia	14.9	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Seychelles	54.8	1
Mauritius	50.7	2
Comoros	38.4	3
Mozambique	37.9	4
Malawi	35.7	5
Ethiopia	33.7	6
Madagascar	33.6	7
Tanzania	33.2	8
Burundi	30.7	9
Kenya	30.0	10
Liberia	28.3	11
Cabo Verde	28.0	12
Uganda	27.4	13
Niger	27.1	14
Sao Tome and Principe	26.8	15
Mali	26.7	16
Burkina Faso	26.1	17
Gabon	25.7	18
Dem. Rep. Congo	25.1	19
Rwanda	24.7	20
Chad	24.3	21
Zimbabwe	23.9	22
Zambia	23.6	23
Angola	23.1	24
Equatorial Guinea	22.9	25
Benin	22.3	26
Namibia	22.2	27
South Africa	22.2	27
Senegal	22.1	29
Sierra Leone	21.6	30
Mauritania	21.1	31
Guinea	21.0	32
Togo	21.0	32
Gambia	20.7	34
Djibouti	19.6	35
Guinea-Bissau	19.4	36
Eritrea	19.3	37
Central African Republic	19.0	38
Cote d'Ivoire	18.2	39
Botswana	17.1	40
Eswatini	16.9	41
Republic of Congo	16.7	42
Ghana	15.3	43
Nigeria	13.8	44
Cameroon	13.2	45
Lesotho	11.1	46

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Israel	68.0	1
Jordan	50.7	2
Kuwait	47.0	3
Tunisia	43.3	4
Qatar	42.1	5
United Arab Emirates	41.7	6
Iran	41.6	7
Lebanon	41.2	8
Algeria	39.4	9
Bahrain	34.7	10
Egypt	34.6	11
Saudi Arabia	32.8	12
Iraq	31.8	13
Oman	31.8	13
Morocco	22.7	15
Sudan	15.6	16

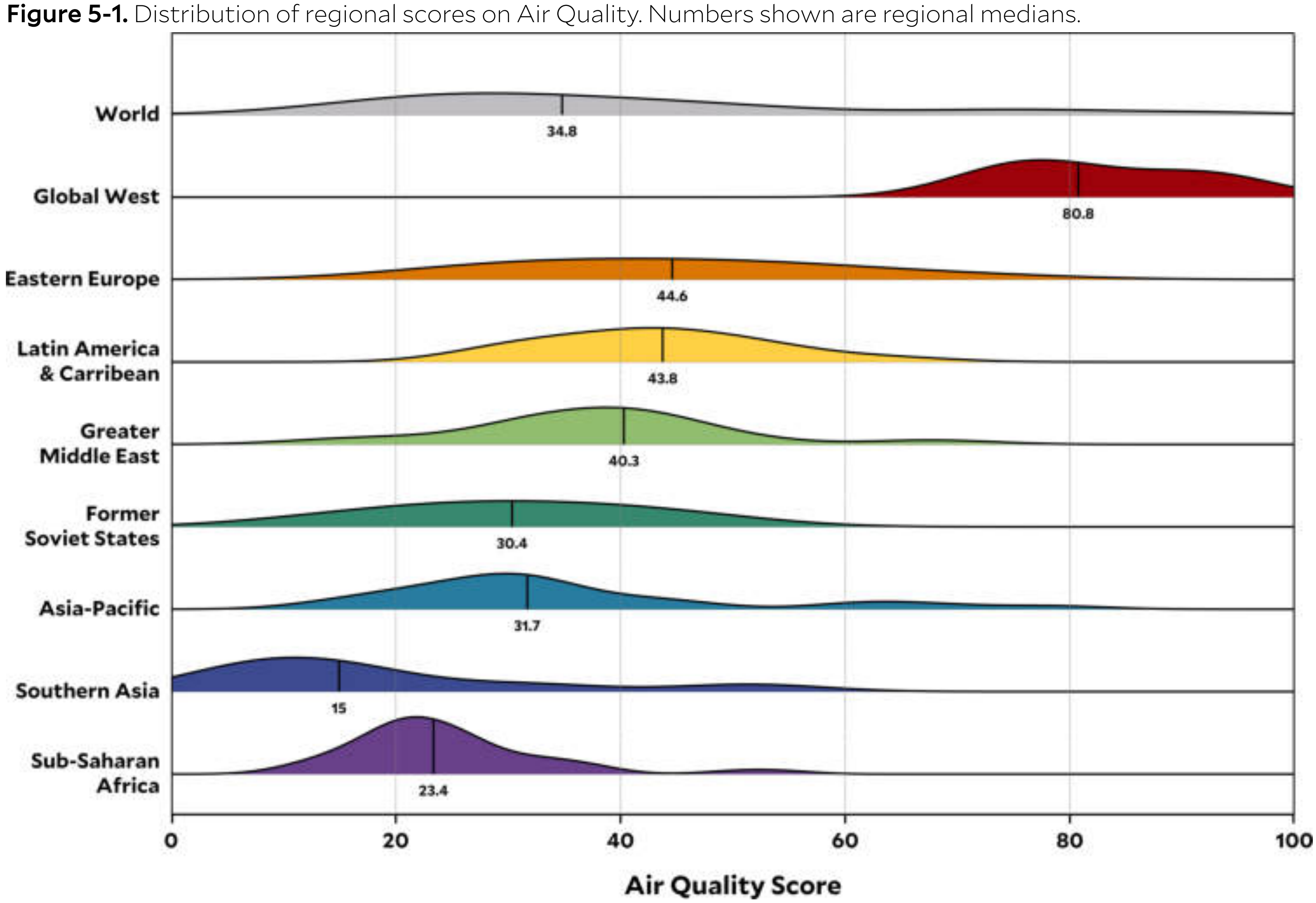
2. Global Trends

Exposure to air pollutants is the fourth leading cause of premature death worldwide (Boogaard et al., 2019; Murray et al., 2020a). Over 4.2 million people die each year from breathing unsafe levels of outdoor air pollution, in addition to the 3.8 million deaths linked to indoor air pollution produced by hazardous household cooking and heating fuels (World Health Organization, 2022). Cutting-edge insights now indicate that lower concentrations of air pollution adversely affect human health than previously reported (Hoffmann et al., 2021; Shaddick et al., 2020). Almost every human alive today faces an increased risk of heart disease, stroke, and cancer from breathing polluted air.

On the global scale, total premature deaths from air pollution have held steady over the past 30 years. However, this total reflects improvements in household air quality that have been countered by increased deaths from ambient fine particulate matter (Figure 5-2). Worldwide deaths attributed to ground-level ozone exposure have increased slightly. Although total deaths from poor air quality have remained relatively constant, we note that DALY rates (deaths per 100,000 people) have declined uniformly since 1990 — suggesting that policymakers in many countries are successfully improving air quality even as populations grow.

Global trends can hide regional differences in air quality. The contrast between high- and low-income countries is particularly stark for particulate matter exposure. While over 80% of high-income countries fall below the World Health Organization's guidelines for particulate matter, less than 1% of low and middle-income countries do (World Health Organization, 2022). Exposure to other air pollutants, like NO_X, is still nearly as bad in wealthy nations as in developing ones. Global concentrations of most air pollutants have risen steadily in recent decades. Disease and deaths from air pollution are preventable. Policymakers can improve public health by monitoring trends, reducing emissions, and mitigating exposure to

Figure 5-1. Distribution of regional scores on Air Quality. Numbers shown are regional medians.



hazardous air pollutants. The prevalence of poor air quality is increasingly apparent. Over 6,000 cities in 117 countries now monitor air quality — a significant increase from the 1,100 cities in 91 countries a decade ago. A wealth of new data from the developing world demonstrates that most countries have successfully reduced household air pollution. Iraq, Saudi Arabia, and Egypt in particular have enacted policies to use cleaner heating and cooking fuels and keep out desert dust, making substantial strides in this area over the past 10 years (Amoatey et al., 2018; Woolley et al., 2021). However, many nations, including India and China, rely heavily on coal to support rapid economic and population growth. Fossil fuel combustion emits hazardous air pollutants, contributing to poor ambient air quality in these major countries. China could avoid nearly half a million premature deaths by peaking their fossil fuel consumption before 2030 (Tang et al., 2022).

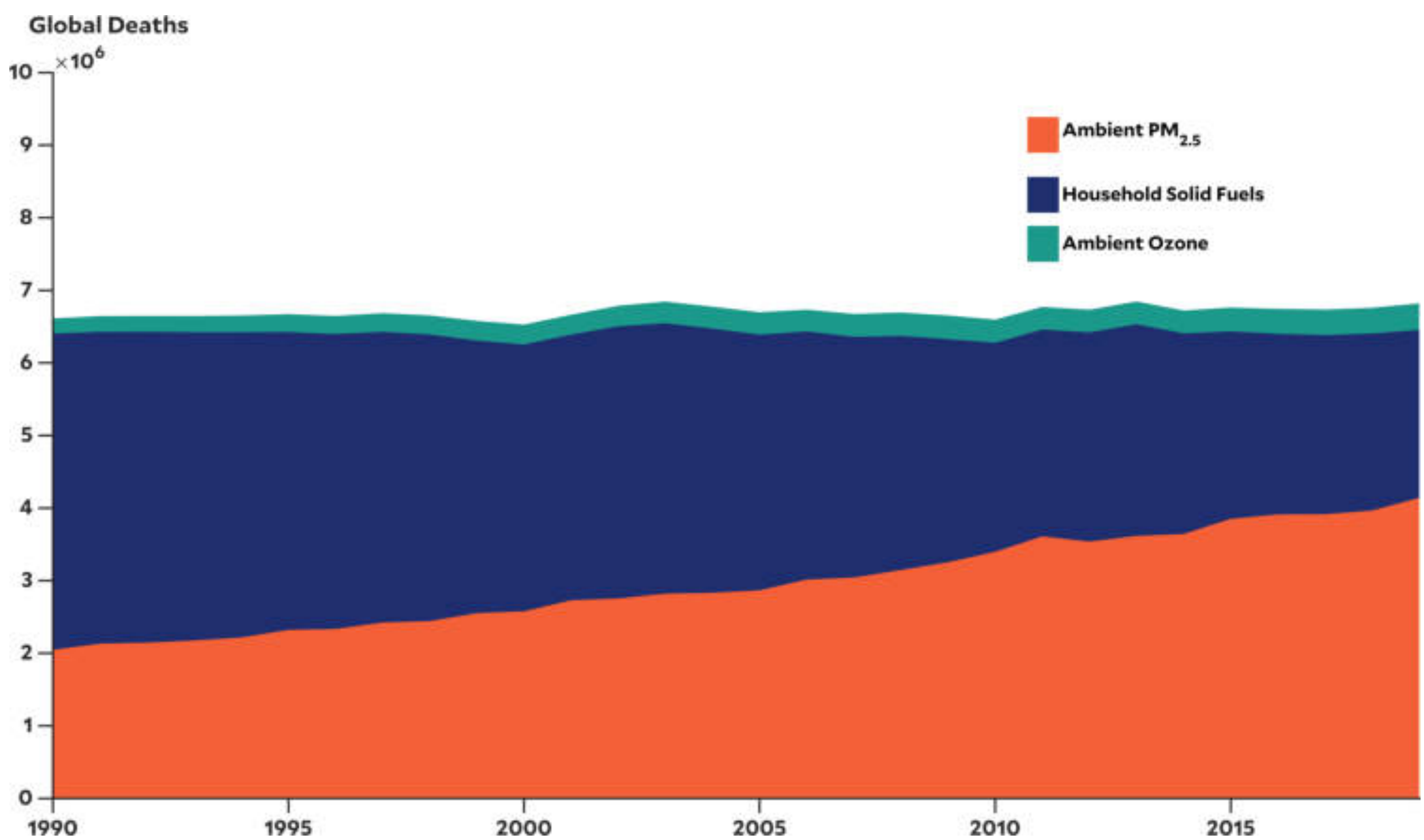
3. Leaders and Laggards

Despite worrying global trends, several leaders stand out among their peers. Iceland, Sweden, Finland, New Zealand, and Norway top the 2022 EPI rankings, driven largely by low exposure to harmful airborne particulate matter. Nordic countries lead the world in air quality, yet even these countries are not free from air quality's health impacts. Premature mortality from air quality in Denmark, Finland, Norway, and Sweden cause 7 billion Euros of lost economic potential each year. Countries who have successfully mitigated industrial pollution can still make strides toward improving air quality by targeting emissions from the transportation and heating sectors (Li and Managi, 2021).

Outside of the Global West, Estonia, Singapore, and Israel score highly. Japan has made significant strides in improving urban air quality recently, with now over 70% of transport in cities like Tokyo done via electrified trains (Logan et al., 2021). Uruguay leads its Latin American peers, in part due to policies reducing wood smoke pollution borrowed from successful Chilean regulations (Jorquera et al., 2019).

Countries in Southern and Southeastern Asia have some of the worst air quality in the world. Pakistan, India, and Nepal receive the worst scores. Multiple sources of air pollutants in these countries mean policymakers must reform regulations across multiple sectors to successfully improve air quality. Household fuel combustion is the largest contributor to India's particulate matter emissions, followed by nearly equal contributions from industry and power generation (Ganguly et al., 2021).

Figure 5-2. Global deaths attributable to air pollutant exposure. Source: Global Burden of Disease.



Over 1.6 million deaths result from air pollution in India annually, accounting for about 18% of total deaths and causing $30 billion in economic losses (Pandey et al., 2021). Indian policymakers could improve air quality by reducing post-monsoon agricultural burning, adopting successful policies recently implemented in Egypt that recycle biomass instead of burning it (Cusworth et al., 2018; El-Dewany et al., 2018).

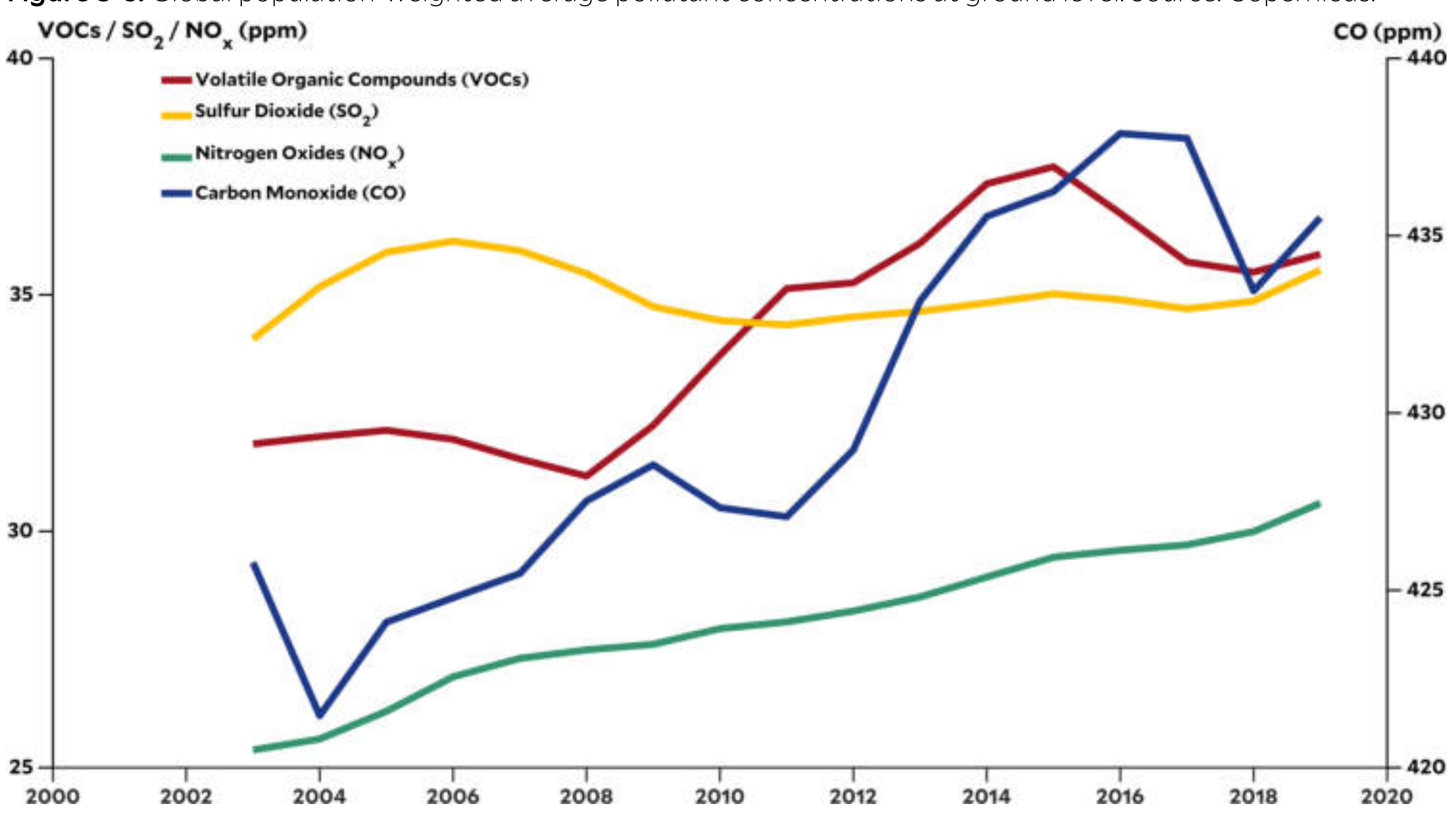
Top-performing countries in the overall Air Quality issue category receive lower scores for the four new indicators introduced in the 2022 EPI. Residents in the Global West are still exposed to high levels of NO_x and CO, pollutants resulting from fossil-fuel powered vehicles in urban environments. China is among the worst countries in terms of NO_x, SO_2, and CO exposure. Despite recent policy programs to mitigate air pollution — for instance, China's 13th Five-Year Plan mandated a 15% decrease in SO_2 and NO_x emissions between 2015 and 2020 (China State Council, 2016) — the impact of top-down centralized policies may be plateauing (Wang, 2021). China may realize continued improvements in air quality by enacting more decentralized and region-specific emissions control policies (Wu et al., 2018).

Many countries have trended toward cleaner air in recent decades. Japan, Singapore, the Netherlands, and the United States are among the countries that have achieved the greatest reductions in NO_x exposure since 2008. Mexico has made progress toward reducing exposure to SO_2 — its most critical air pollutant — even though ambient concentrations remain high. Although SO_2 has natural sources, the majority of emissions come from anthropogenic activities like fossil fuel combustion (Fioletov et al., 2016). Policy efforts near population centers like Mexico City to use low-sulfur fuels for electricity generating units may be yielding improvements in air quality (Meraz et al., 2015; Sosa E. et al., 2020).

4. Methods

Effective air quality indicators inform policies to mitigate the impacts of unsafe air on public health. To support regulatory revisions, we measure air quality by health costs using two variables. When available, we base indicators on the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rates). In the absence of DALY rate data, we base indicators on the

Figure 5-3. Global population-weighted average pollutant concentrations at ground level. Source: Copernicus.



population-weighted average ambient ground level concentration of harmful air pollutants.

The Institute for Health Metrics and Evaluation's Global Burden of Disease initiative compiles DALY rates for $PM_{2.5}$ exposure, ozone exposure, and exposure to indoor air pollution from the combustion of household solid fuels. Breathing air with high levels of $PM_{2.5}$ and ozone can lead to several diseases of the heart and lungs, increases the risk of cancer, and exacerbates asthma (Boogaard et al., 2019; Soledayo Babatola, 2018). Ozone is a vital component of the upper atmosphere, where it blocks harmful cancer-causing radiation from the sun. However, at ground-level, ozone is a noxious pollutant that causes smog and aggravates respiratory illnesses. While indoor air is cleaner in many parts of the world, some residents of India and other countries still suffer from remarkably poor household air quality (Greenstone et al., 2021; Rao et al., 2021).

Air pollution is not constrained by geopolitical boundaries. Emissions in one country can travel to neighboring ones, harming human health far away from the original source. Particulate emissions in China are known to cause episodes of unsafe air quality in Japan and South Korea (Lee et al., 2019). Through satellite measurements, ground-based monitoring networks, emissions inventories, and transport models, researchers are working to better quantify the prevalence of transboundary air pollution. Since it is still difficult to conclusively ascribe pollution to certain sources, however, the EPI's air quality indicators focus on tracking trends of pollutant concentrations and health impacts strictly within country borders.

Indicator Background

The three health-impact-based indicators — $PM_{2.5}$, ozone, and household solid fuels — are grounded in the Comprehensive Risk Assessment framework established by the Global Burden of Disease initiative. This framework estimates exposure to hazardous air quality before calculating risks, attributable deaths, and DALY rates. The Institute for Health Metrics and Evaluation quantifies exposure based on satellite data for $PM_{2.5}$ and ozone exposure, but relies on surveys for exposure to household air pollutants. Once ambient concentrations are derived, the framework then uses public health models to estimate premature mortality. These figures are converted to DALY rates, allowing indicators to evaluate the likelihood of death or disease to be compared across environmental health factors like air quality, water quality, and heavy metal exposure.

Fine particulate matter is more dangerous than larger particulate matter, as it can travel further into airways (Falcon-Rodriguez et al., 2016). The Global Burden of Disease initiative therefore focuses on exposure to respirable particulate matter — $PM_{2.5}$ — defined as annual average daily ground-level concentrations of particulate matter with aerodynamic diameters smaller than 2.5 μm, measured in units of $\mu g\ m^{-3}$. The same measurements apply to household air pollutant exposure from solid fuel use indoors. Research shows that short periods of elevated ozone concentration are more harmful than lower, prolonged exposure events. The Global Burden of Disease therefore defines ground-level ozone exposure by seasonal (3-month) hourly maximum ozone concentrations, measured in ppb (Forouzanfar et al., 2016).

The EPI's four exposure-based indicators — nitrogen oxides, sulfur dioxide, carbon monoxide, and volatile organic compounds — are based on ambient pollutant concentrations. We couple population density to ground-level pollutant concentrations to derive population-weighted exposure indicators that quantify the pollutant levels experienced by the average resident in each country (Wolf et al., 2022). This framework sources ambient pollutant concentrations from emissions inventories and transport models that are verified and corrected by satellite observations.

Data Sources

The $PM_{2.5}$, ozone, and household solid fuels indicators use DALY rates compiled by the Global Burden of Disease initiative of the Institute for Health Metrics and Evaluation (Murray et al., 2020a). Data for the $PM_{2.5}$ and ozone indicators are derived from satellite observations coupled to chemical transport models. Where applicable, these measurements are validated with ground-based measurements. Estimated annual-averages for $PM_{2.5}$ and ozone concentrations are produced in a $0.1^\circ \times 0.1^\circ$ spatial resolution globally-gridded dataset (Brauer et al., 2016). Data for the household solid fuels indicator are compiled through household surveys that estimate the proportion of heating and cooking fuels used in each country (Bonjour et al., 2013).

Nitrogen oxide, sulfur dioxide, carbon monoxide, and volatile organic compound concentrations are derived from the European Centre for Medium-Range Weather Forecast's Atmospheric Composition Reanalysis 4 (EAC4) datasets, freely available from the Copernicus Atmospheric Monitoring Services' Atmospheric Data Store (ads.atmosphere.copernicus.eu). The chemical mechanisms used in the model are an extended version of the Carbon Bond 2005 (CB05) mechanism implemented in the CTM Transport Model 5 (TM5). The population-weighting framework uses SEDAC's Gridded Population of the World v4.11dataset (CIESIN et al., 2018).

Limitations

Global Burden of Disease estimates for air pollutant exposure exclude larger aerosols (PM_{10}), atmospheric lead, and other air pollutants. The Copernicus air pollutant concentration data have higher uncertainty in regions with less extensive monitoring networks and emissions inventories.

When deriving DALY rates from air pollutant exposure data, the Global Burden of Disease initiative uses the latest scientific data to provide key assumptions about health risks. Despite a burgeoning research agenda to better constrain these relationships, statistical uncertainties in DALY rates persist. These knowledge gaps are exacerbated by fragmented air monitoring networks and imperfect data on the relationship between exposure and health outcomes. Although DALY rates are standardized to support performance comparisons between populations, the most critical air pollutant varies by region. In urban areas, exposure to ambient $PM_{2.5}$ and ozone are the predominant contributors to poor health outcomes. In cleaner rural environments, however, household air quality may be of greater import. Policymakers should therefore exercise care when comparing DALY rates between populations with very different urbanized fractions.

Chapter 6. Sanitation & Drinking Water

1. Introduction

Ensuring universal access to safely managed sanitation and drinking water promotes human health and sustainable development. Clean water and proper sanitation are essential to preventing the transmission of disease (Prüss-Üstün et al., 2008), including the COVID-19 virus (Otto et al., 2020). Despite the importance of safe water maintaining an individual's well-being, 2 billion people lack access to clean drinking water and 3.6 billion people lack basic sanitation services (UN-Water, 2021).

As climate change warms the world, ecosystems that provide water shrink, making water access more unpredictable and scarce (UN-Water, 2021). These trends exacerbate gender inequalities in societies, as the burden of fetching clean water from far-away sources often falls on women (Kayser et al., 2019). The 2022 EPI Sanitation & Drinking Water metrics track diseases and deaths from exposure to unsafe sanitation and drinking water, providing countries with insights on whether their water infrastructure is sufficient to maintain public health.

2. Indicators

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.

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 6-1. Global rankings on Sanitation & Drinking Water.

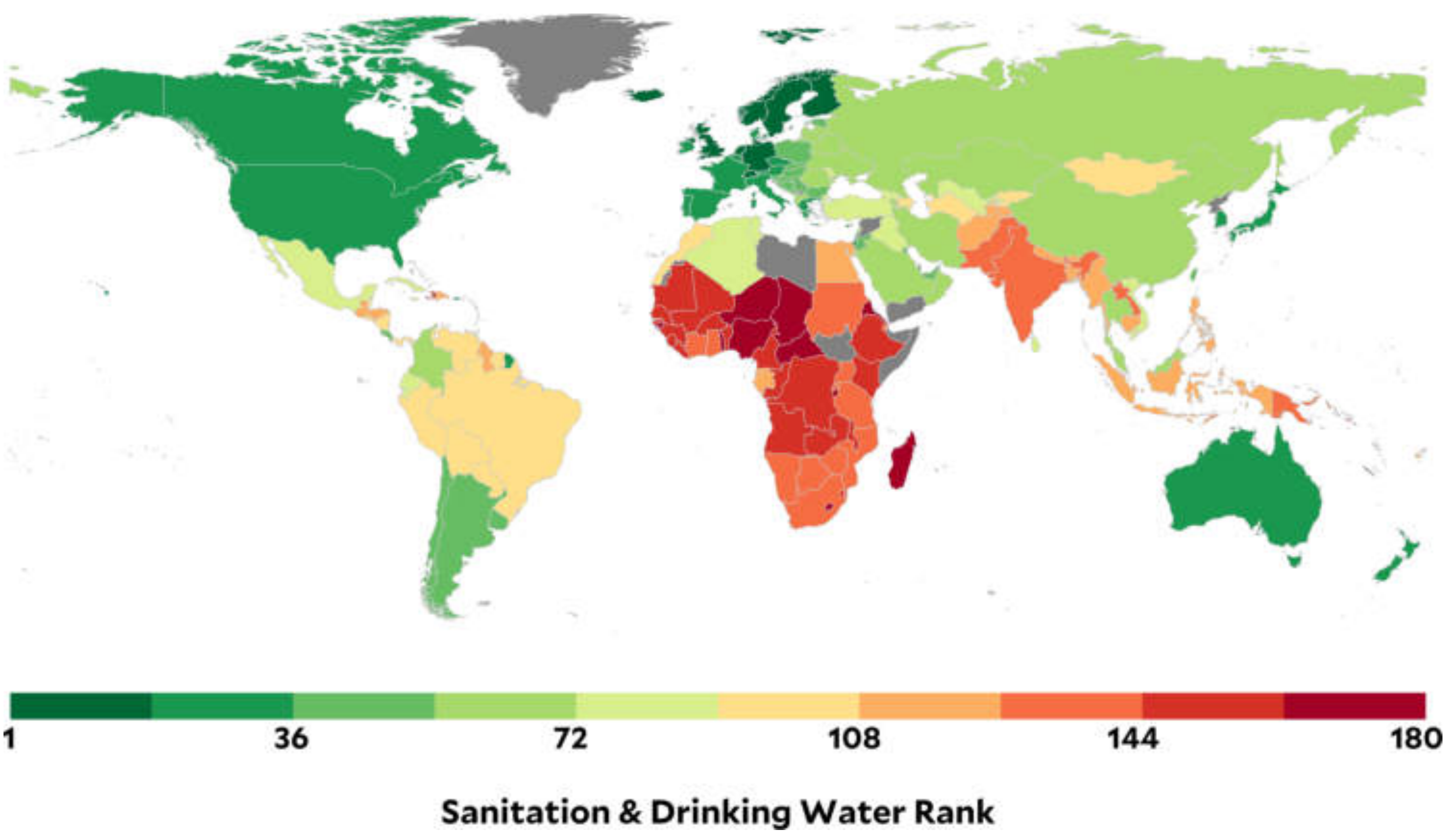


Table 6-1. Global rankings, scores, and regional rankings (REG) on Sanitation & Drinking Water.

RANK	COUNTRY	SCORE	REG
1	Finland	100.0	1
1	Iceland	100.0	1
1	Netherlands	100.0	1
1	Norway	100.0	1
1	Switzerland	100.0	1
1	United Kingdom	100.0	1
7	Malta	99.8	7
8	Germany	99.1	8
9	Luxembourg	98.7	9
10	Sweden	98.6	10
11	Italy	98.3	11
12	Greece	98.2	1
13	Denmark	97.5	12
14	Ireland	97.4	13
15	Spain	96.9	14
16	France	96.3	15
17	Japan	95.1	1
18	Austria	94.7	16
19	Cyprus	94.0	2
20	Belgium	93.6	17
21	Singapore	93.3	2
22	Israel	92.9	1
23	South Korea	90.8	3
24	Canada	88.1	18
25	Australia	87.1	19
26	United States of America	86.1	20
27	Brunei Darussalam	85.7	4
28	Portugal	83.5	21
29	New Zealand	80.4	22
30	Czech Republic	76.5	3
31	Slovenia	74.7	4
32	Taiwan	72.4	5
33	Slovakia	71.9	5
34	Poland	71.8	6
35	Uruguay	70.8	1
36	Croatia	70.3	7
37	Bulgaria	68.4	8
38	Chile	68.1	2
39	Kuwait	67.5	2
40	United Arab Emirates	67.2	3
41	Qatar	66.6	4
42	Costa Rica	66.2	3
43	Montenegro	65.6	9
43	Serbia	65.6	9
45	Mauritius	65.5	1
46	Argentina	64.8	4
47	Jordan	62.7	5
48	Hungary	62.2	11
49	Estonia	61.9	12
50	Bosnia and Herzegovina	61.5	13
51	North Macedonia	61.1	14
52	Belarus	60.5	1
53	Lebanon	59.8	6
54	China	59.5	6
55	Saudi Arabia	59.3	7
56	Latvia	59.1	15
57	Lithuania	58.4	16
58	Oman	58.3	8
59	Malaysia	57.6	7
60	Armenia	57.3	2
61	Bahrain	56.6	9
62	Romania	56.0	17
63	Colombia	55.9	5
63	Thailand	55.9	8
65	Russia	55.5	3
66	Kazakhstan	55.2	4
66	Ukraine	55.2	4
68	Bahamas	55.0	6
69	Albania	54.1	18
70	Iran	53.7	10
71	Trinidad and Tobago	53.4	7
72	Algeria	53.3	11
73	Mexico	52.9	8
74	Viet Nam	52.8	9
75	Turkey	52.7	19
76	Tunisia	52.6	12
77	Uzbekistan	52.1	6
78	Barbados	52.0	9
79	Georgia	51.7	7
80	Seychelles	51.5	2
81	Ecuador	50.3	10
82	Antigua and Barbuda	50.1	11
83	Moldova	50.0	8
84	Cuba	49.7	12
84	Iraq	49.7	13
86	Jamaica	49.4	13
87	Samoa	49.3	10
88	Sri Lanka	48.5	1
89	Maldives	47.8	2
90	Dominica	47.6	14
90	Paraguay	47.6	14
92	Turkmenistan	47.4	9
93	Grenada	47.1	16
94	Venezuela	46.8	17
95	Tonga	46.5	11
96	Brazil	46.2	18
97	Azerbaijan	45.6	10
97	Kyrgyzstan	45.6	10
99	Saint Lucia	45.4	19
100	Panama	43.6	20
100	St. Vincent and Grenadines	43.6	20
102	Mongolia	43.2	12
103	Peru	43.1	22
104	Nicaragua	42.9	23
105	Belize	42.7	24
106	El Salvador	41.7	25
107	Morocco	40.9	14
108	Bolivia	40.1	26
109	Suriname	39.4	27
110	Dominican Republic	39.0	28
110	Philippines	39.0	13
112	Egypt	36.7	15
113	Cabo Verde	35.6	3
114	Micronesia	35.5	14
115	São Tomé and Príncpe	35.3	4
115	Guyana	35.3	29
117	Fiji	34.7	15
118	Cambodia	34.3	16
119	Equatorial Guinea	33.2	5
120	Marshall Islands	32.3	17
121	Honduras	31.8	30
122	Bhutan	31.2	3
123	Tajikistan	30.9	12
123	Myanmar	30.9	18
125	Indonesia	28.5	19
126	Guatemala	28.3	31
127	Afghanistan	28.1	4
128	Gabon	27.7	6
129	Bangladesh	27.4	5
130	Nepal	27.1	6
131	Laos	26.6	20
132	Timor-Leste	26.0	21
133	South Africa	24.7	7
134	Sudan	22.4	16
135	Vanuatu	21.5	22
136	Botswana	20.9	8
136	Ghana	20.9	8
138	Namibia	19.7	10
139	India	19.5	7
140	Gambia	19.2	11
141	Tanzania	18.5	12
142	Djibouti	18.3	13
143	Uganda	17.6	14
144	Pakistan	17.5	8
145	Côte d'Ivoire	17.3	15
146	Rwanda	16.9	16
146	Zimbabwe	16.9	16
148	Mozambique	16.4	18
149	Kiribati	16.3	23
150	Papua New Guinea	15.6	24
151	Comoros	15.2	19
152	Republic of Congo	14.6	20
153	Haiti	14.1	32
153	Solomon Islands	14.1	25
155	Kenya	13.7	21
156	Dem. Rep. Congo	13.6	22
156	Mauritania	13.6	22
158	Benin	13.5	24
158	Zambia	13.5	24
160	Senegal	13.1	26
161	Angola	12.8	27
162	Eswatini	12.6	28
163	Malawi	12.1	29
164	Sierra Leone	11.6	30
165	Guinea	11.3	31
166	Ethiopia	11.0	32
167	Liberia	9.9	33
168	Mali	8.3	34
169	Burkina Faso	7.8	35
169	Cameroon	7.8	35
171	Lesotho	7.3	37
172	Guinea-Bissau	6.8	38
173	Eritrea	6.4	39
174	Madagascar	6.0	40
175	Burundi	5.4	41
176	Togo	5.2	42
177	Nigeria	5.0	43
178	Niger	1.5	44
179	Central African Republic	0.0	45
179	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 and scores on Sanitation & Drinking Water.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Uruguay	70.8	1
Chile	68.1	2
Costa Rica	66.2	3
Argentina	64.8	4
Colombia	55.9	5
Bahamas	55.0	6
Trinidad and Tobago	53.4	7
Mexico	52.9	8
Barbados	52.0	9
Ecuador	50.3	10
Antigua and Barbuda	50.1	11
Cuba	49.7	12
Jamaica	49.4	13
Dominica	47.6	14
Paraguay	47.6	14
Grenada	47.1	16
Venezuela	46.8	17
Brazil	46.2	18
Saint Lucia	45.4	19
Panama	43.6	20
St. Vincent and Grenadines	43.6	20
Peru	43.1	22
Nicaragua	42.9	23
Belize	42.7	24
El Salvador	41.7	25
Bolivia	40.1	26
Suriname	39.4	27
Dominican Republic	39.0	28
Guyana	35.3	29
Honduras	31.8	30
Guatemala	28.3	31
Haiti	14.1	32

EASTERN EUROPE

Country	Score	Reg. Rank
Greece	98.2	1
Cyprus	94.0	2
Czech Republic	76.5	3
Slovenia	74.7	4
Slovakia	71.9	5
Poland	71.8	6
Croatia	70.3	7
Bulgaria	68.4	8
Montenegro	65.6	9
Serbia	65.6	9
Hungary	62.2	11
Estonia	61.9	12
Bosnia and Herzegovina	61.5	13
North Macedonia	61.1	14
Latvia	59.1	15
Lithuania	58.4	16
Romania	56.0	17
Albania	54.1	18
Turkey	52.7	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Sri Lanka	48.5	1
Maldives	47.8	2
Bhutan	31.2	3
Afghanistan	28.1	4
Bangladesh	27.4	5
Nepal	27.1	6
India	19.5	7
Pakistan	17.5	8

GLOBAL WEST

Country	Score	Reg. Rank
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
Malta	99.8	7
Germany	99.1	8
Luxembourg	98.7	9
Sweden	98.6	10
Italy	98.3	11
Denmark	97.5	12
Ireland	97.4	13
Spain	96.9	14
France	96.3	15
Austria	94.7	16
Belgium	93.6	17
Canada	88.1	18
Australia	87.1	19
United States of America	86.1	20
Portugal	83.5	21
New Zealand	80.4	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Belarus	60.5	1
Armenia	57.3	2
Russia	55.5	3
Kazakhstan	55.2	4
Ukraine	55.2	4
Uzbekistan	52.1	6
Georgia	51.7	7
Moldova	50.0	8
Turkmenistan	47.4	9
Azerbaijan	45.6	10
Kyrgyzstan	45.6	10
Tajikistan	30.9	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Japan	95.1	1
Singapore	93.3	2
South Korea	90.8	3
Brunei Darussalam	85.7	4
Taiwan	72.4	5
China	59.5	6
Malaysia	57.6	7
Thailand	55.9	8
Viet Nam	52.8	9
Samoa	49.3	10
Tonga	46.5	11
Mongolia	43.2	12
Philippines	39.0	13
Micronesia	35.5	14
Fiji	34.7	15
Cambodia	34.3	16
Marshall Islands	32.3	17
Myanmar	30.9	18
Indonesia	28.5	19
Laos	26.6	20
Timor-Leste	26.0	21
Vanuatu	21.5	22
Kiribati	16.3	23
Papua New Guinea	15.6	24
Solomon Islands	14.1	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Mauritius	65.5	1
Seychelles	51.5	2
Cabo Verde	35.6	3
Sao Tome and Principe	35.3	4
Equatorial Guinea	33.2	5
Gabon	27.7	6
South Africa	24.7	7
Botswana	20.9	8
Ghana	20.9	8
Namibia	19.7	10
Gambia	19.2	11
Tanzania	18.5	12
Djibouti	18.3	13
Uganda	17.6	14
Cote d'Ivoire	17.3	15
Rwanda	16.9	16
Zimbabwe	16.9	16
Mozambique	16.4	18
Comoros	15.2	19
Republic of Congo	14.6	20
Kenya	13.7	21
Dem. Rep. Congo	13.6	22
Mauritania	13.6	22
Benin	13.5	24
Zambia	13.5	24
Senegal	13.1	26
Angola	12.8	27
Eswatini	12.6	28
Malawi	12.1	29
Sierra Leone	11.6	30
Guinea	11.3	31
Ethiopia	11.0	32
Liberia	9.9	33
Mali	8.3	34
Burkina Faso	7.8	35
Cameroon	7.8	35
Lesotho	7.3	37
Guinea-Bissau	6.8	38
Eritrea	6.4	39
Madagascar	6.0	40
Burundi	5.4	41
Togo	5.2	42
Nigeria	5.0	43
Niger	1.5	44
Central African Republic	0.0	45
Chad	0.0	45

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Israel	92.9	1
Kuwait	67.5	2
United Arab Emirates	67.2	3
Qatar	66.6	4
Jordan	62.7	5
Lebanon	59.8	6
Saudi Arabia	59.3	7
Oman	58.3	8
Bahrain	56.6	9
Iran	53.7	10
Algeria	53.3	11
Tunisia	52.6	12
Iraq	49.7	13
Morocco	40.9	14
Egypt	36.7	15
Sudan	22.4	16

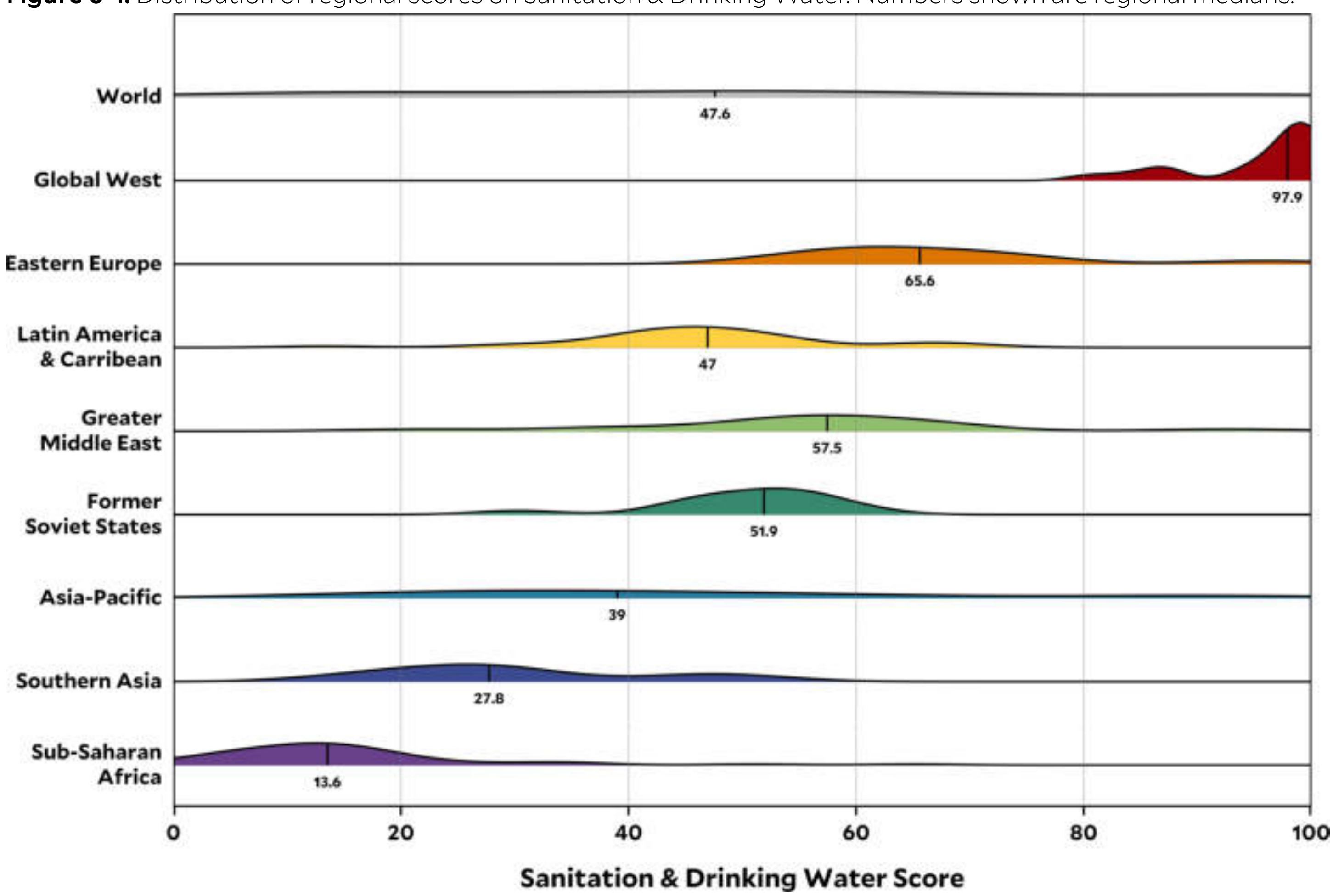
2. Global Trends

The world remains far from establishing universal access to safely managed drinking water and sanitation services. Between 2000 and 2020, however, 2 billion individuals gained access to clean water and 2.4 billion individuals gained improved sanitation services (WHO and UNICEF, 2021). Figure 6-2 shows that the number of lives lost due to unsafe water or inadequate sanitation has steadily decreased for the last thirty years.

Sustainable Development Goal 6 outlines a target of ensuring available and safely managed water for all by 2030 (Sadoff et al., 2020). While this ambitious target highlights the importance of clean water, reaching it will not be easy. Achieving universal access to both safely managed drinking water and sanitation services in this timeline will require a four-fold increase in current levels of progress (UN-Water, 2021). Without substantial investment, an estimated 1.6 billion people will lack access to safe drinking water at home and 2.8 billion people will lack safe sanitation services by 2030 (WHO and UNICEF, 2021).

Geographic inequities in access to safe drinking water and sanitation exist in many regions (Prüss-Üstün et al., 2008). While, on average, 74% of the global population drinks safe water, access ranges widely from 96% in Europe and North America to just 54% in Sub-Saharan Africa (UN-Water, 2021; WHO and UNICEF, 2021). Poor countries house the majority of individuals who face unsafe conditions — over 50% of those who lack access to safe drinking water and 40% of those who lack basic sanitation services live in the least developed countries (UN-Water, 2021). Water insecurity is particularly threatening to rural communities, who often lack improved drinking water and sanitation infrastructure. In urban areas, population growth has outpaced progress, meaning there are more people currently without at least a basic water and sanitation service than there were in 2000 (UNICEF, 2020).

Figure 6-1. Distribution of regional scores on Sanitation & Drinking Water. Numbers shown are regional medians.



3. Leaders and Laggards

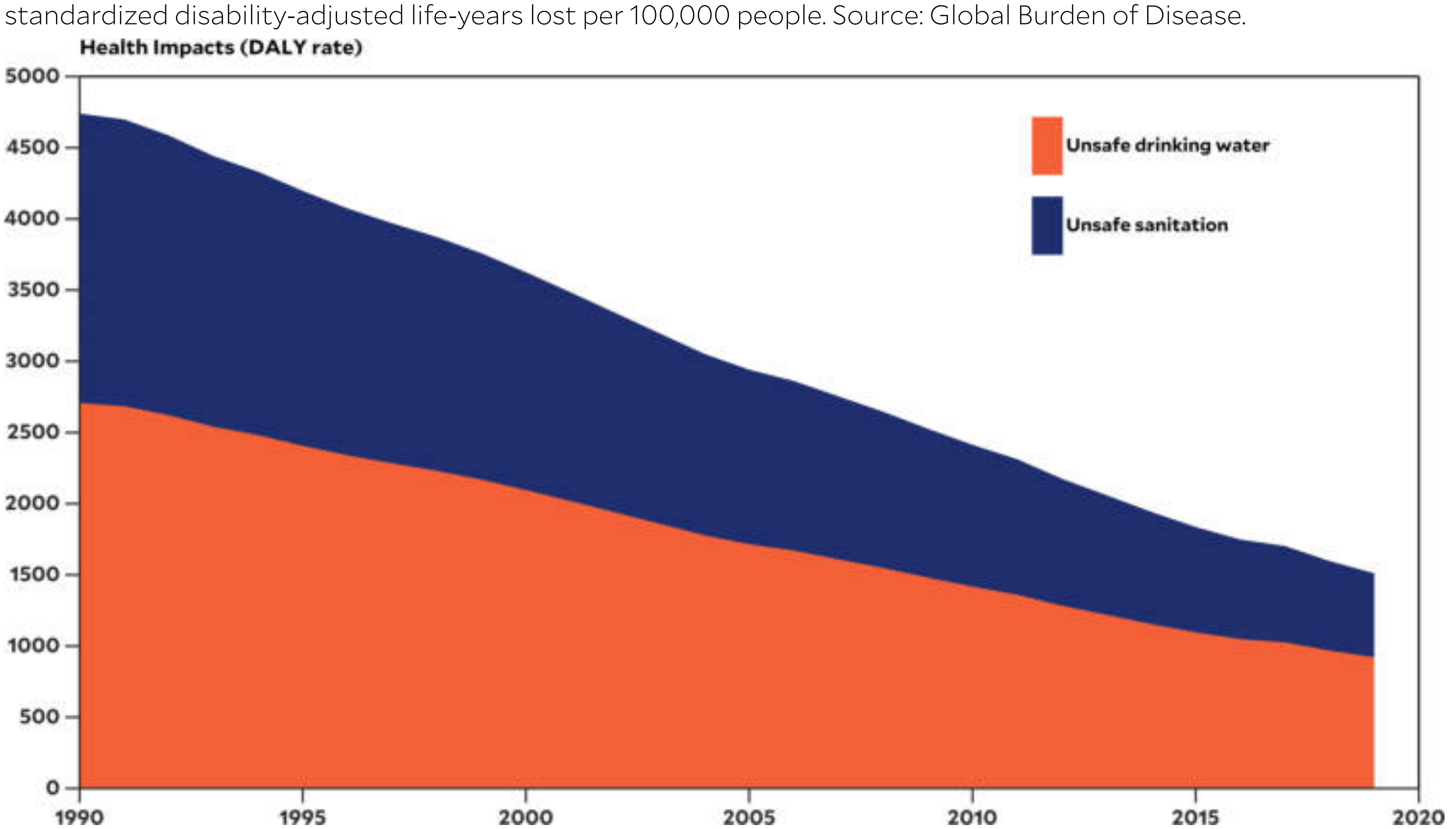
Wealthy countries in the Global West lead the world in the Sanitation & Drinking Water issue category, with minimal deaths related to exposure to unsafe sanitation and unsafe drinking water. Several of the top-performing countries are in the European Union, highlighting these countries' continued commitment to policies that promote safely managing water and sanitation. In December 2020, the European Union updated the Drinking Water Directive to confront emerging pollutants, like microplastics, and to increase information accessibility for citizens (European Commission, 2020a).

Several small island developing countries land in the middle of Sanitation & Drinking Water rankings. Nearly 70% of small island developing states face water scarcity, slowing progress to provide safe water for residents. In addition, climate change consequences, including sea level rise, variable rainfall, and increased frequency of severe weather events, are exacerbating water shortages (UNCTAD, 2021). Singapore, however, stands out as a leader among these countries. While the country experiences heavy rainfall, its small surface area prevents the nation from establishing water storage units and aquifers. Singapore has recently expanded infrastructure like rainwater catchment systems and recycling processes to supplement imports from Malaysia and adequately supply water (UNCTAD, 2021). Nationally set water prices and education programs further encourage residents not to waste water (UNCTAD, 2021).

Despite being the largest economy in Southeast Asia, Indonesia still faces risks from unsafe sanitation practices and drinking water. Almost 25 million people in Indonesia lack access to toilets or latrines, leading to contaminated water supplies and the spread of diarrheal diseases (UNICEF, 2022). In West Java, fecal matter and heavy metals pollute the Citarum River, which millions of Indonesians rely on for water and food (Price and Price, 2017). Responding to pressure from international organizations, the Indonesian government has established a cleaning program with the intent to make the river's water drinkable by 2025. The decentralized framework and poor enforcement of Indonesia's environmental regulations, however, presents challenges on the road to improvement (Holzhacker et al., 2016).

Many Sub-Saharan African countries receive low rankings in Sanitation & Drinking Water. In 2020, half of the individuals who lacked access to basic drinking water lived in this region (WHO and UNICEF, 2021). Geographic inequalities also exist at the sub-national level. Safe drinking water access ranges from upwards of 50% in urban areas

Figure 6-2. Global progress on health outcomes from unsafe sanitation and drinking water. DALY rates are age-standardized disability-adjusted life-years lost per 100,000 people. Source: Global Burden of Disease.



to just 13% in rural areas (WHO and UNICEF, 2021). In recent years, many countries in Sub-Saharan Africa have increased access to improved wells and springs, but access to piped water — a more reliable source — remains uncommon (Deshpande et al., 2020). Insufficient infrastructure, as well as a disproportionate distribution of water storage units, fuels these disparities. In addition, transboundary water laws have contributed to conflict over water in sub-Saharan Africa. For example, the 1959 Nile Basin agreement established Sudan and Egypt as the only actors with power over the allocation of Nile resources, despite the vested interests of several other nearby countries (Tatlock, 2006). To ensure broader access to water resources, the region should seek multilateral input on how to sustainably manage the Nile (Ashour et al., 2019).

4. Methods

In 2010, the World Health Organization General Assembly officially recognized the human right to water and sanitation. Sustainable Development Goal target 6.1 seeks to secure access to safe drinking water for all (Sadoff et al., 2020). The definition of safe and accessible drinking water has evolved with time, posing an evolving challenge for policymakers striving to keep up with standards. In recent years, global water quality monitoring metrics have emphasized good health outcomes more than simply accessible supplies. 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 2022 EPI uses two indicators to measure health outcomes from unsafe sanitation and drinking water: unsafe sanitation and unsafe drinking water. Data from IHME's latest GBD update undergird these two indicators.

Indicator Background

Unsafe sanitation and unsafe drinking water use the GBD's Comprehensive Risk Assessment (CRA) framework to estimate the impacts of exposure to unsafe sanitation and drinking water, measured by Disability-Adjusted Life Years (DALYs) lost per 100,000 persons (Kyu et al., 2018). This provides a standard metric for comparing performance across countries. The metrics first examine the estimated exposure to health risks in each country. For these indicators, 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).

The second step uses statistical models to estimate the portion of deaths and DALYs lost attributable to those risks.

Data Sources

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). These estimates were then pooled, corrected for bias, and further adjusted with other covariates. Data are freely available from the GBD results tool: https://vizhub.healthdata.org/gbd-results/

Limitations

It remains difficult to track all adverse health outcomes from the lack of safe drinking water and sanitation. The GBD evaluates three key measures: diarrheal diseases, typhoid fever, and paratyphoid fever. Data on the health risks and outcomes from diarrheal disease are much stronger than the studies on typhoid and paratyphoid, stemming from gaps in the literature and on-the-ground data on the prevalence of these illnesses.

Unsafe sanitation and unsafe drinking water currently only track adverse health outcomes from exposure to biological risks, such as bacteria. Risks of illness or death from chemical contaminants, like lead and pesticides, are not considered. Despite their exclusion here, exposure to chemical pollutants poses serious health concerns in both the developed and developing world.

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). Even piped water sources and groundwater from wells (as opposed to open water) may be contaminated by soil pollutants or nearby latrine pits (Back et al., 2018). Infrastructure is not always indicative of health outcomes.

Chapter 7. Heavy Metals

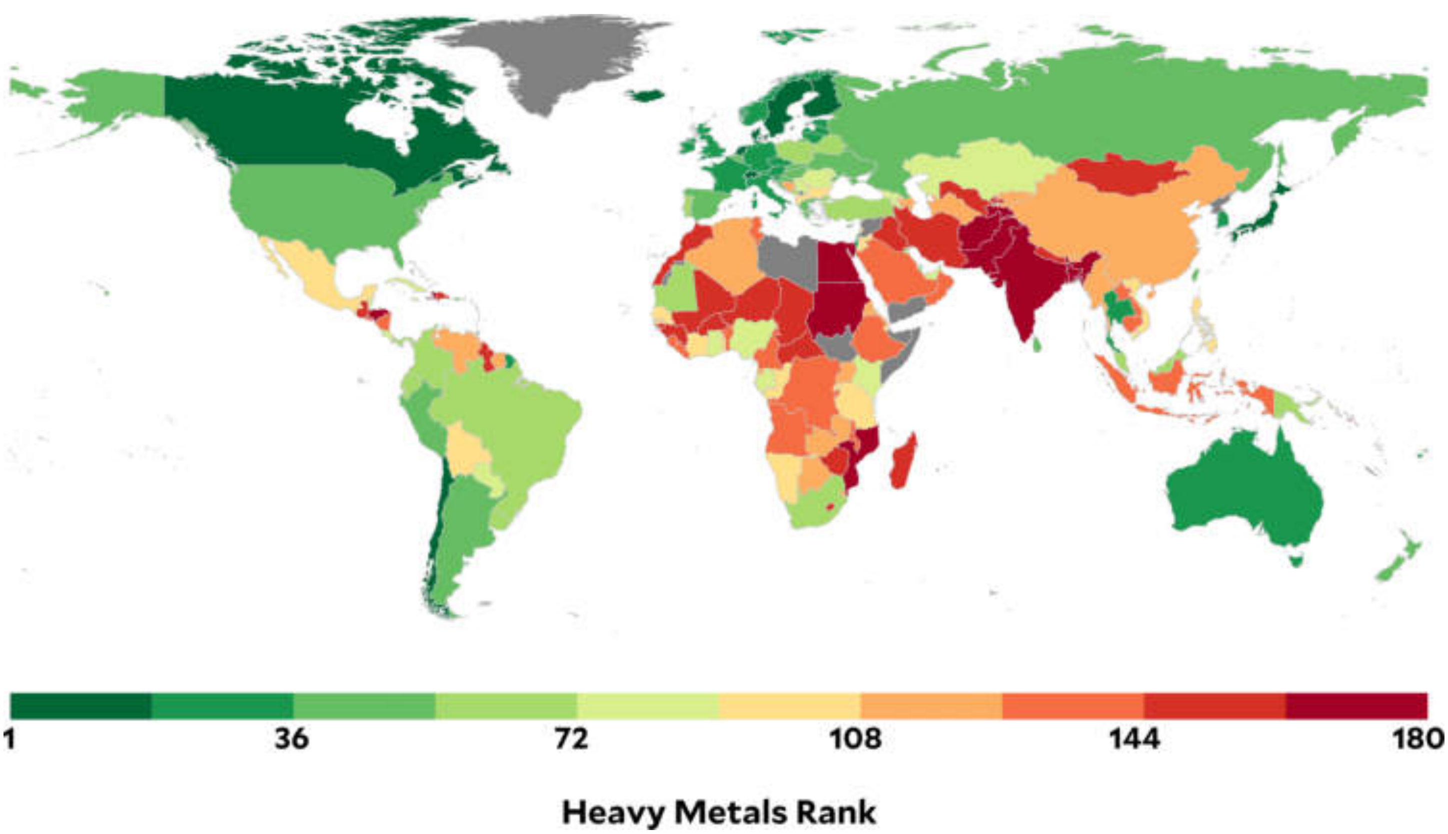
1. Introduction

Exposure to heavy metals, such as lead, arsenic, mercury, and others, can result in prolonged and even irreversible damage to human health. Lead is an especially potent heavy metal due to its severe effects on brain development in children (Marshall et al., 2020). Recent analysis also demonstrates that even low levels of lead exposure can lead to poor health outcomes in adults (Lanphear et al., 2018). According to the World Health Organization, there is no level of lead exposure that is safe. Exposure occurs from air or water pollution, tainted foods, industrial exposure, or the ingestion of leaded paints. Despite the serious health implications of exposure to other heavy metals (Rahaman et al., 2021; Zhang et al., 2021), the lack of global data leaves the EPI to choose lead exposure as a representative measure of heavy metal pollution. We encourage countries to better monitor emissions and exposure to other toxic metal pollutants, especially as electronic waste heightens the risk of heavy metal contamination (Michael and Sugumar, 2013).

2. Indicators

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 7-1. Global rankings on Heavy Metals.



Chapter 7

Table 7-1. Global rankings, scores, and regional rankings (REG) on Heavy Metals.

RANK	COUNTRY	SCORE	REG
1	Denmark	100.0	1
1	Finland	100.0	1
1	Japan	100.0	1
4	Sweden	96.9	3
5	Chile	96.8	1
6	Canada	95.6	4
7	Iceland	95.1	5
7	Luxembourg	95.1	5
9	Netherlands	94.1	7
10	Switzerland	94.0	8
11	United Kingdom	93.6	9
12	Norway	93.0	10
13	Israel	91.1	1
14	Austria	90.7	11
15	Germany	89.8	12
16	South Korea	88.4	2
17	Slovenia	87.2	1
18	Estonia	86.5	2
19	Singapore	84.5	3
20	France	83.1	13
21	Lithuania	83.0	3
22	Ireland	81.8	14
23	Trinidad and Tobago	81.1	2
24	Thailand	80.7	4
25	Italy	80.6	15
26	Tonga	77.9	5
27	Latvia	77.5	4
28	Australia	76.4	16
29	Fiji	76.1	6
30	Czech Republic	75.5	5
31	United States of America	75.1	17
32	New Zealand	74.6	18
33	Croatia	74.2	6
34	Taiwan	72.8	7
35	Argentina	72.2	3
36	Sri Lanka	71.6	1
37	Russia	71.3	1
38	Spain	70.5	19
39	Barbados	69.6	4
40	Cyprus	68.6	7
40	Greece	68.6	7
42	Ukraine	68.4	2
42	Slovakia	68.4	9
44	Seychelles	67.8	1
44	Samoa	67.8	8
46	Brunei Darussalam	67.6	9
47	Peru	67.4	5
47	Hungary	67.4	10
49	Belgium	66.6	20
50	Bahamas	66.3	6
51	Mauritius	66.0	2
52	Portugal	64.6	21
53	Poland	64.5	11
54	Montenegro	64.4	12
55	Ecuador	62.3	7
56	Uruguay	61.5	8
57	Malaysia	61.4	10
58	Colombia	61.1	9
59	Turkey	60.8	13
60	Antigua and Barbuda	59.8	10
61	Papua New Guinea	59.6	11
62	Cabo Verde	58.7	3
63	Qatar	58.4	2
64	Brazil	58.2	11
65	South Africa	58.1	4
66	Bahrain	58.0	3
67	Belarus	57.0	3
68	Panama	56.8	12
69	Kuwait	56.1	4
70	Mauritania	55.1	5
71	Maldives	54.7	2
72	Ghana	54.6	6
73	Moldova	54.0	4
74	Belize	53.8	13
75	United Arab Emirates	53.6	5
76	Gabon	53.4	7
77	Costa Rica	53.1	14
78	Kazakhstan	52.2	5
79	Dominica	52.1	15
80	Saint Lucia	51.2	16
81	Nigeria	50.9	8
82	Romania	50.8	14
83	Paraguay	50.6	17
84	Serbia	50.4	15
85	Armenia	50.2	6
86	Kenya	49.9	9
86	Malta	49.9	22
88	Georgia	49.3	7
89	Jamaica	48.2	18
90	Cuba	47.6	19
91	Philippines	47.4	12
92	Viet Nam	47.1	13
93	Senegal	47.0	10
94	Comoros	46.4	11
95	Jordan	46.1	6
95	North Macedonia	46.1	16
97	Marshall Islands	46.0	14
98	Djibouti	45.6	12
99	Albania	45.5	17
100	Bulgaria	45.2	18
101	Mexico	45.1	20
102	Vanuatu	44.9	15
103	Rwanda	44.6	13
104	Republic of Congo	44.4	14
105	São Tomé and Príncpe	44.3	15
106	Côte d'Ivoire	44.2	16
107	Namibia	43.9	17
108	Togo	43.1	18
109	Tanzania	43.0	19
109	Bolivia	43.0	21
109	Lebanon	43.0	7
112	Turkmenistan	42.9	8
113	Bhutan	42.6	3
113	Suriname	42.6	22
115	Venezuela	42.5	23
116	Bosnia and Herzegovina	42.3	19
117	Zambia	41.7	20
118	Uganda	41.3	21
118	Grenada	41.3	24
120	Micronesia	40.9	16
121	Azerbaijan	40.4	9
122	Kyrgyzstan	40.2	10
123	Eswatini	39.6	22
124	Equatorial Guinea	39.5	23
125	Botswana	39.2	24
126	Algeria	38.3	8
127	Eritrea	37.8	25
128	Myanmar	37.6	17
129	China	37.0	18
130	Malawi	36.8	26
130	Sierra Leone	36.8	26
132	Angola	36.7	28
132	Liberia	36.7	28
134	Gambia	36.5	30
134	Oman	36.5	9
134	Kiribati	36.5	19
137	Benin	36.2	31
138	Tunisia	35.9	10
139	Cameroon	35.6	32
140	Dem. Rep. Congo	35.5	33
141	Burundi	35.2	34
141	Ethiopia	35.2	34
143	El Salvador	34.9	25
143	Saudi Arabia	34.9	11
145	Cambodia	34.5	20
146	St. Vincent and Grenadines	34.2	26
147	Laos	34.1	21
148	Nicaragua	34.0	27
148	Indonesia	34.0	22
150	Timor-Leste	33.8	23
151	Mongolia	32.6	24
152	Madagascar	32.4	36
153	Guinea	32.3	37
154	Zimbabwe	32.1	38
155	Mali	31.9	39
156	Guatemala	30.1	28
157	Dominican Republic	29.5	29
158	Burkina Faso	29.1	40
158	Iraq	29.1	12
160	Chad	28.6	41
161	Morocco	28.4	13
162	Guinea-Bissau	28.0	42
163	Uzbekistan	27.3	11
164	Iran	26.9	14
165	Niger	26.8	43
166	Nepal	26.7	4
167	Solomon Islands	25.0	25
168	Lesotho	24.5	44
169	Guyana	24.4	30
170	Central African Republic	23.5	45
171	Mozambique	23.3	46
172	Bangladesh	22.8	5
173	Pakistan	22.5	6
174	India	20.6	7
175	Honduras	20.2	31
176	Tajikistan	15.3	12
177	Egypt	13.1	15
178	Haiti	11.7	32
179	Sudan	6.7	16
180	Afghanistan	0.0	8

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 and scores on Heavy Metals.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Chile	96.8	1
Trinidad and Tobago	81.1	2
Argentina	72.2	3
Barbados	69.6	4
Peru	67.4	5
Bahamas	66.3	6
Ecuador	62.3	7
Uruguay	61.5	8
Colombia	61.1	9
Antigua and Barbuda	59.8	10
Brazil	58.2	11
Panama	56.8	12
Belize	53.8	13
Costa Rica	53.1	14
Dominica	52.1	15
Saint Lucia	51.2	16
Paraguay	50.6	17
Jamaica	48.2	18
Cuba	47.6	19
Mexico	45.1	20
Bolivia	43.0	21
Suriname	42.6	22
Venezuela	42.5	23
Grenada	41.3	24
El Salvador	34.9	25
St. Vincent and Grenadines	34.2	26
Nicaragua	34.0	27
Guatemala	30.1	28
Dominican Republic	29.5	29
Guyana	24.4	30
Honduras	20.2	31
Haiti	11.7	32

EASTERN EUROPE

Country	Score	Reg. Rank
Slovenia	87.2	1
Estonia	86.5	2
Lithuania	83.0	3
Latvia	77.5	4
Czech Republic	75.5	5
Croatia	74.2	6
Cyprus	68.6	7
Greece	68.6	7
Slovakia	68.4	9
Hungary	67.4	10
Poland	64.5	11
Montenegro	64.4	12
Turkey	60.8	13
Romania	50.8	14
Serbia	50.4	15
North Macedonia	46.1	16
Albania	45.5	17
Bulgaria	45.2	18
Bosnia and Herzegovina	42.3	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Sri Lanka	71.6	1
Maldives	54.7	2
Bhutan	42.6	3
Nepal	26.7	4
Bangladesh	22.8	5
Pakistan	22.5	6
India	20.6	7
Afghanistan	0.0	8

GLOBAL WEST

Country	Score	Reg. Rank
Denmark	100.0	1
Finland	100.0	1
Sweden	96.9	3
Canada	95.6	4
Iceland	95.1	5
Luxembourg	95.1	5
Netherlands	94.1	7
Switzerland	94.0	8
United Kingdom	93.6	9
Norway	93.0	10
Austria	90.7	11
Germany	89.8	12
France	83.1	13
Ireland	81.8	14
Italy	80.6	15
Australia	76.4	16
United States of America	75.1	17
New Zealand	74.6	18
Spain	70.5	19
Belgium	66.6	20
Portugal	64.6	21
Malta	49.9	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Russia	71.3	1
Ukraine	68.4	2
Belarus	57.0	3
Moldova	54.0	4
Kazakhstan	52.2	5
Armenia	50.2	6
Georgia	49.3	7
Turkmenistan	42.9	8
Azerbaijan	40.4	9
Kyrgyzstan	40.2	10
Uzbekistan	27.3	11
Tajikistan	15.3	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Japan	100.0	1
South Korea	88.4	2
Singapore	84.5	3
Thailand	80.7	4
Tonga	77.9	5
Fiji	76.1	6
Taiwan	72.8	7
Samoa	67.8	8
Brunei Darussalam	67.6	9
Malaysia	61.4	10
Papua New Guinea	59.6	11
Philippines	47.4	12
Viet Nam	47.1	13
Marshall Islands	46.0	14
Vanuatu	44.9	15
Micronesia	40.9	16
Myanmar	37.6	17
China	37.0	18
Kiribati	36.5	19
Cambodia	34.5	20
Laos	34.1	21
Indonesia	34.0	22
Timor-Leste	33.8	23
Mongolia	32.6	24
Solomon Islands	25.0	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Seychelles	67.8	1
Mauritius	66.0	2
Cabo Verde	58.7	3
South Africa	58.1	4
Mauritania	55.1	5
Ghana	54.6	6
Gabon	53.4	7
Nigeria	50.9	8
Kenya	49.9	9
Senegal	47.0	10
Comoros	46.4	11
Djibouti	45.6	12
Rwanda	44.6	13
Republic of Congo	44.4	14
Sao Tome and Principe	44.3	15
Cote d'Ivoire	44.2	16
Namibia	43.9	17
Togo	43.1	18
Tanzania	43.0	19
Zambia	41.7	20
Uganda	41.3	21
Eswatini	39.6	22
Equatorial Guinea	39.5	23
Botswana	39.2	24
Eritrea	37.8	25
Malawi	36.8	26
Sierra Leone	36.8	26
Angola	36.7	28
Liberia	36.7	28
Gambia	36.5	30
Benin	36.2	31
Cameroon	35.6	32
Dem. Rep. Congo	35.5	33
Burundi	35.2	34
Ethiopia	35.2	34
Madagascar	32.4	36
Guinea	32.3	37
Zimbabwe	32.1	38
Mali	31.9	39
Burkina Faso	29.1	40
Chad	28.6	41
Guinea-Bissau	28.0	42
Niger	26.8	43
Lesotho	24.5	44
Central African Republic	23.5	45
Mozambique	23.3	46

GREATER MIDDLE EAST

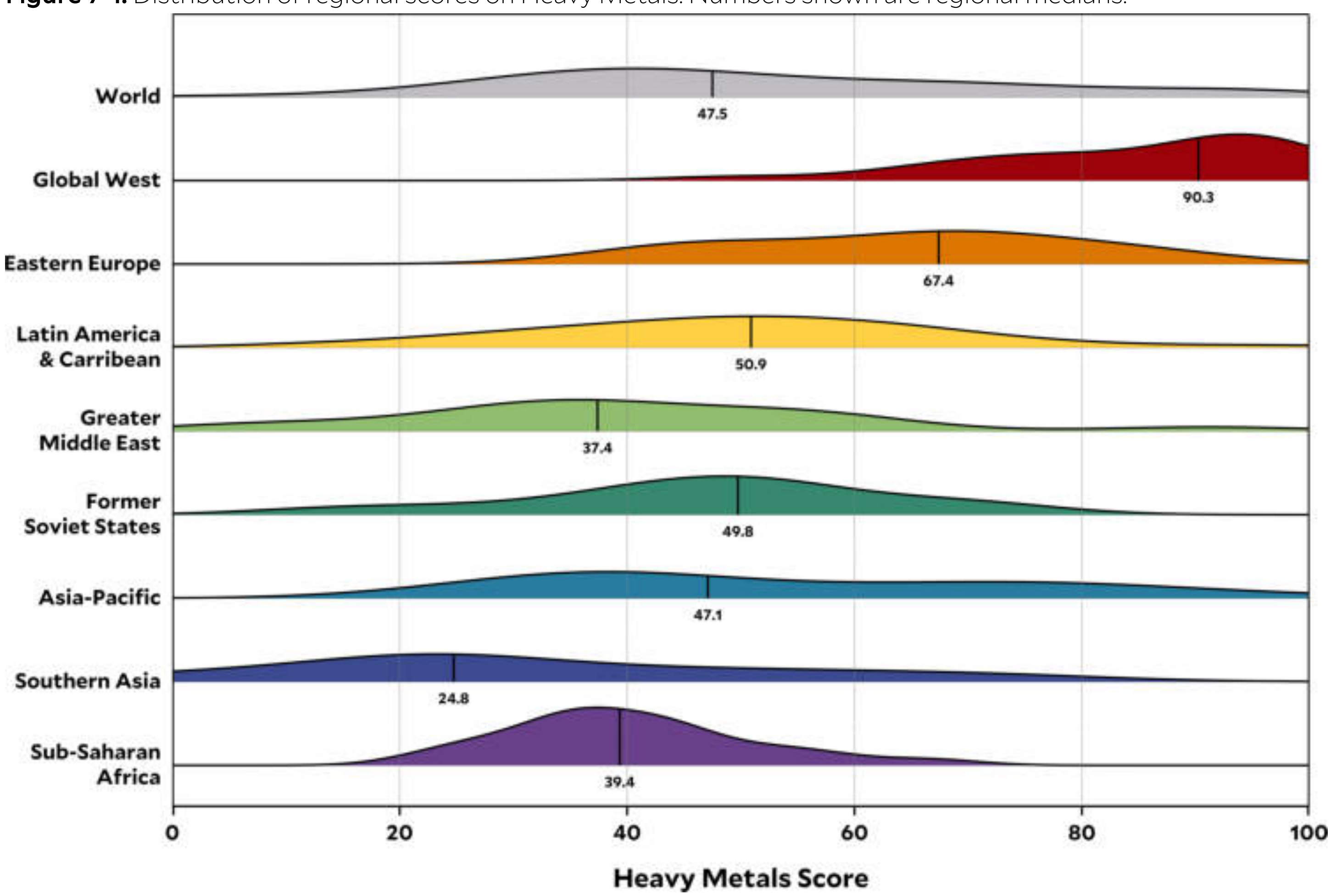
Country	Score	Reg. Rank
Israel	91.1	1
Qatar	58.4	2
Bahrain	58.0	3
Kuwait	56.1	4
United Arab Emirates	53.6	5
Jordan	46.1	6
Lebanon	43.0	7
Algeria	38.3	8
Oman	36.5	9
Tunisia	35.9	10
Saudi Arabia	34.9	11
Iraq	29.1	12
Morocco	28.4	13
Iran	26.9	14
Egypt	13.1	15
Sudan	6.7	16

2. Global Trends

Heavy metal exposure remains an environmental health issue worldwide, despite domestic and international policy commitments to phase out lead use and mitigate lead contamination. In one bright spot, 2021 marked the global end of leaded gasoline use in vehicles, with Algeria using the last of its reserves (Gamillo, 2021). A century's worth of lead emissions is still felt, however, even in regions that ceased leaded-fuel use decades ago (Laidlaw et al., 2012). Today, the predominant sources of lead exposure are contaminated drinking water, lead-laced food products, and lead paint (Obeng-Gyasi, 2019). Middle- and low-income countries that recycle lead-acid batteries, like Pakistan and Indonesia, must also contend with high rates of workplace exposure (Basit et al., 2015; Haryanto, 2016).

While the world has made progress on improving air and water quality in recent decades, Figure 7-2 illustrates that lead exposure presents a stubborn challenge to public health officials. Global DALY rates from lead exposure have fallen by 24% since 1990 — a much slower decline than for air pollution (49%) and water pollution (65%). One cause for this slow decline may be that exposure can be difficult to determine or avoid. Lead poisoning symptoms are commonplace, leading many exposure events to go undiagnosed and sources unmitigated (Tsai et al., 2017). The health risks linked to lead exposure include depression, anemia, nausea, high blood pressure, heart disease, kidney disease, and reduced fertility/miscarriages. Lead poisoning symptoms are most pronounced in children: but once symptoms appear, exposure may already have caused permanent neurological damage (Raymond and Brown, 2017; Vorvolakos et al., 2016).

Figure 7-1. Distribution of regional scores on Heavy Metals. Numbers shown are regional medians.



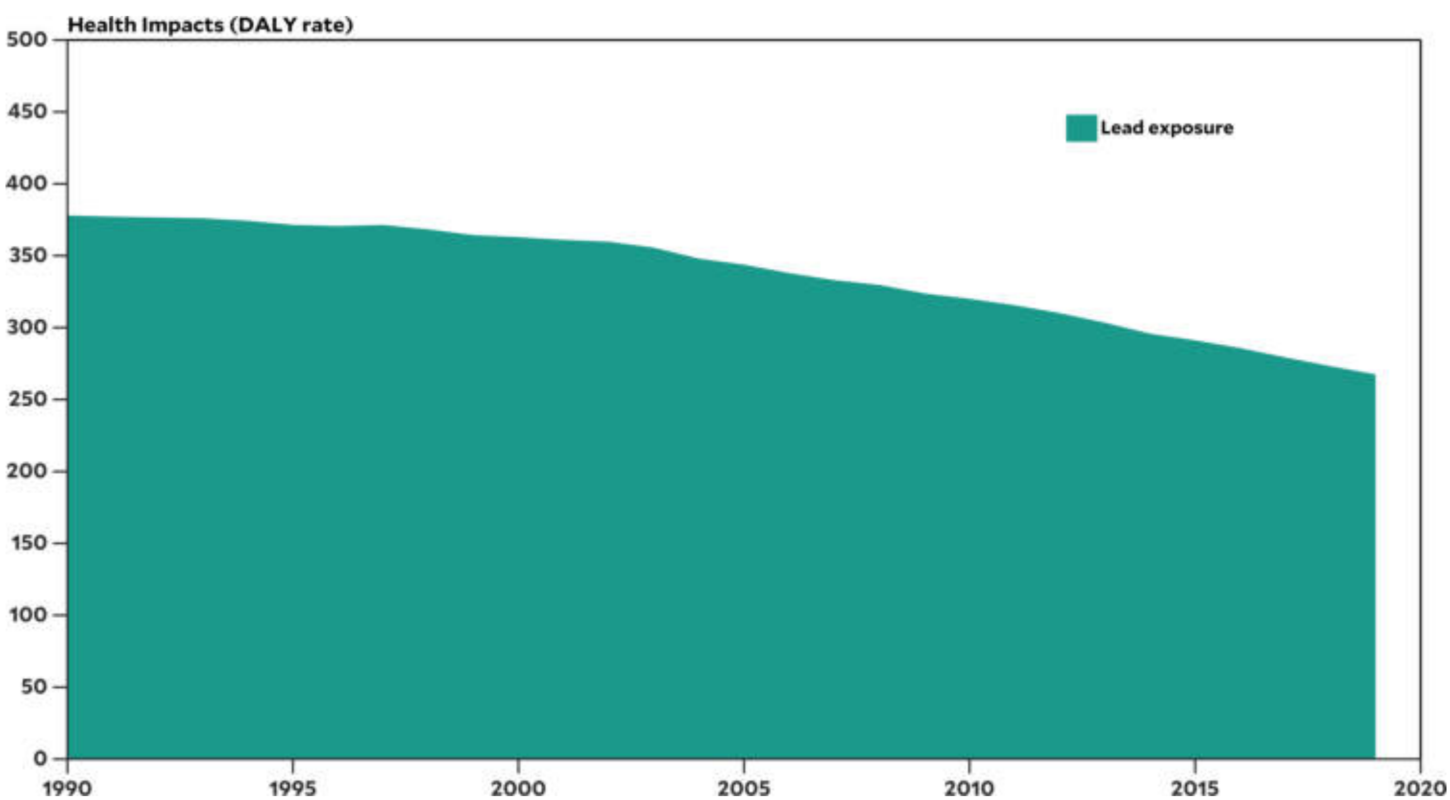
Despite the global recognition of heavy metal toxicity, lead exposure resulted in over one million premature deaths globally in 2017 (Roth et al., 2018). To mitigate poisoning and reduce environmental concentrations, the WHO, United Nations Environment Programme (UNEP), and Global Environmental Facility organize the Global Alliance to Eliminate Lead Paint. As of 2020, 79 countries had instituted legally binding controls to limit the production, import and sale of lead paints (UNEP, 2020). Global progress remains compartmentalized, however. While almost every country in the Global West has enacted lead paint laws, just 11% of African countries have. These regulations generally use one of two approaches. The first is to establish a regulatory limit on the total concentration of lead in paint from all sources, giving manufacturers more flexibility to meet the standard. A second option is to establish a set of chemical-specific regulatory limits based on the individual risks of individual paint components. Both approaches have effectively limited lead content in paints (UNEP, 2020).

3. Leaders and Laggards

High-performers in the Heavy Metals issue category include many members of the European Union, such as Finland, Denmark, and Sweden. Leaders outside of the Global West include Japan (100), Chile (96.8), and Israel (91.1). The success of these countries stems from the phaseout of leaded gasoline in the 1970s coupled with the effective monitoring of public health, such as blood-level testing (Löfgren and Hammar, 2000; Smolders et al., 2010). Many high scoring countries have also moved to ban or limit lead use in paint (UNEP, 2020). Japan has stridently reduced lead contamination in food, successfully mitigating one of the leading sources of lead exposure in children (Watanabe et al., 2013). Lead blood levels in Japanese pregnant women decreased five to tenfold recently, signaling the success of policies aiming to improve child development (Nakayama et al., 2019).

Laggards consist of mainly middle- and low-income countries, including Afghanistan and Sudan, which lack sufficient lead control regulations and implement few occupational health standards. Surma, a cosmetic often applied to infants in Afghanistan, is a prevalent source of lead exposure (McMichael and Stoff, 2018). In a recent analysis, some Surma samples contained over 80% lead by weight. Metal smelting and battery processing industries in the region also contribute to high incidents of respirable lead (Engelbrecht et al., 2009). Low-scoring countries often do not have lead exposure screening processes or detailed investigations into sources, making it difficult for residents to avoid exposure and mitigate risks (Landrigan et al., 2018).

Figure 7-2. Global progress on reducing the health impacts of lead exposure. DALY rates are age-standardized disability-adjusted life-years lost per 100,000 people. Source: Global Burden of Disease.



Lead paint remains a source of exposure in many countries, even in ones that have long since minimized its use. Peeling or chipping paint in older homes poses a threat to children. Older paint often contains lead acetate, a sweet-tasting compound that entices children to consume paint flakes. As chips turn into dust, residents in older neighborhoods are also exposed to airborne lead sources (Laidlaw and Taylor, 2011). The global paint trade complicates regulations. China, the world's largest producer and exporter of paint, has had limited lead content in paint since 1986. However, research consistently demonstrates that paints exceeding these standards remain on the market (O'Connor et al., 2018).

Drinking water also continues to be a source of lead exposure throughout the developed and developing world. In Pakistan, for instance, leaded pipes leach unsafe levels of heavy metals into supplies. One study found that 89% of water sources in Karachi had lead levels exceeding the WHO's concentration limit of 10 µg/L (Sánchez-Triana et al., 2015). In many other regions, the problem is compounded by the lack of data on lead pipe use, making it difficult to quantify the full extent of exposure (Jarvis and Fawell, 2021). Even when countries move to replace lead water mains with more sustainable materials, the effects of exposure linger for years. As the United States moves to upgrade its public drinking water infrastructure in the aftermath of several high-profile lead exposure events, like the Flint Water Crisis (Pieper et al., 2018), over half of the adult population is still affected by exposure from their childhoods (McFarland et al., 2022).

4. Methods

Although lead poisoning can be measured using 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). Many countries, however, lack the resources to conduct comprehensive BLL monitoring, holding back our understanding of lead poisoning's geographic and socioeconomic factors (Meyer et al., 2008). Countries with high-exposure-risk zones should strive to implement more standardized monitoring and data collection on lead contamination (Attina and Trasande, 2013).

Indicator Background

Lead exposure is classified in two ways: acute and chronic lead poisoning. While acute events are indicative of severe and shorter-term exposure, chronic events describe repeated exposure, often at lower concentrations. 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, 2017). Chronic lead exposure is more pervasive in adults due to long-term occupational exposure. Long-term exposure is not measured by BLL but by micrograms of lead per gram of bone. Concentrations in human samples give evidence of how widespread lead exposure is in a population, from which epidemiologists infer the risks of death and disease.

Data Sources

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 provides the most comprehensive (in time and geography) public health data on lead exposure. The GBD examines mortality and morbidity trends based on major diseases, injuries, and risk factors from lead exposure. To produce data, the GBD project uses measurements from 332 unique studies on bone and bone samples. The 2022 EPI uses GBD estimates on disability-adjusted life year (DALY) rates from 1990 to 2019. These standardized rates allow for comparisons of performance across countries.

Limitations

The GBD is the leading epidemiological study on environmental risks. The lead exposure indicator, however, has several limitations that stem from sparse underlying data. 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. In addition, the GDB models are based on assumptions linking lead exposure to actual health outcomes and the incidence of disease and death across populations. While the lead exposure indicator is the best available metric on this important environmental health risk, improved exposure and epidemiological measurements — especially in low- and middle-income countries — would provide better insight into the health outcomes associated with environmental lead exposure.

Chapter 8. Waste Management

1. Introduction

Effective waste management is a critical component to any country's sustainability agenda. Solid waste produces 5% of global greenhouse gas emissions (Kaza et al., 2018; Maria et al., 2020). Uncontrolled waste sustains disease-spreading vermin, contaminates food and water sources via leaching and dumping, and can degrade air quality through haphazard incineration (Wiedinmyer et al., 2014). In countries of all income levels, waste management policies have not kept pace with increased waste generation. This divergence has intensified plastic dumping in oceans, where plastic waste makes up 80% of large litter (Morales-Caselles et al., 2021). Plastic threatens at least 800 species of marine life and poses poorly-understood health risks to humans who consume increasing quantities of it in seafood (Pew and SYSTEMIQ, 2020).

A wealth of research points to waste's far-reaching environmental effects during the COVID-19 pandemic (Adyel, 2020; Patrício Silva et al., 2021). It is too soon to evaluate the long-term impact of the COVID-19 pandemic on plastic pollution. Certain outcomes, however, are already clear: the use of personal protective equipment and plastic packaging during the pandemic spurred an upsurge in pollution, especially from low- and middle-income countries, and interrupted waste management systems around the world (Benson et al., 2021b).

The growing threat of poor waste management comes at a time when this critical issue remains understudied. Global solid waste generation is projected to increase by 70% by 2050, much of that in the form of plastics (Kaza et al., 2018). With less than half of global waste currently disposed of properly, waste management systems worldwide are unprepared for the future (Kaza et al., 2018).

This chapter illustrates how investments in waste management infrastructure today can affect environmental health and ecosystem quality outcomes for generations.

2. Indicators

Controlled Solid Waste (50% 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.

Recycling Rates (25% of issue category)
We measure *recycling rates* as the proportion of post-consumer recyclable materials (metal, plastic, paper, and glass) recycled in each country.

Ocean Plastic Pollution (25% of issue category)
We measure *ocean plastic pollution* as the absolute quantity, in millions of metric tons, of plastics a country releases into the oceans each year.

Map 8-1. Global rankings on Waste Management.

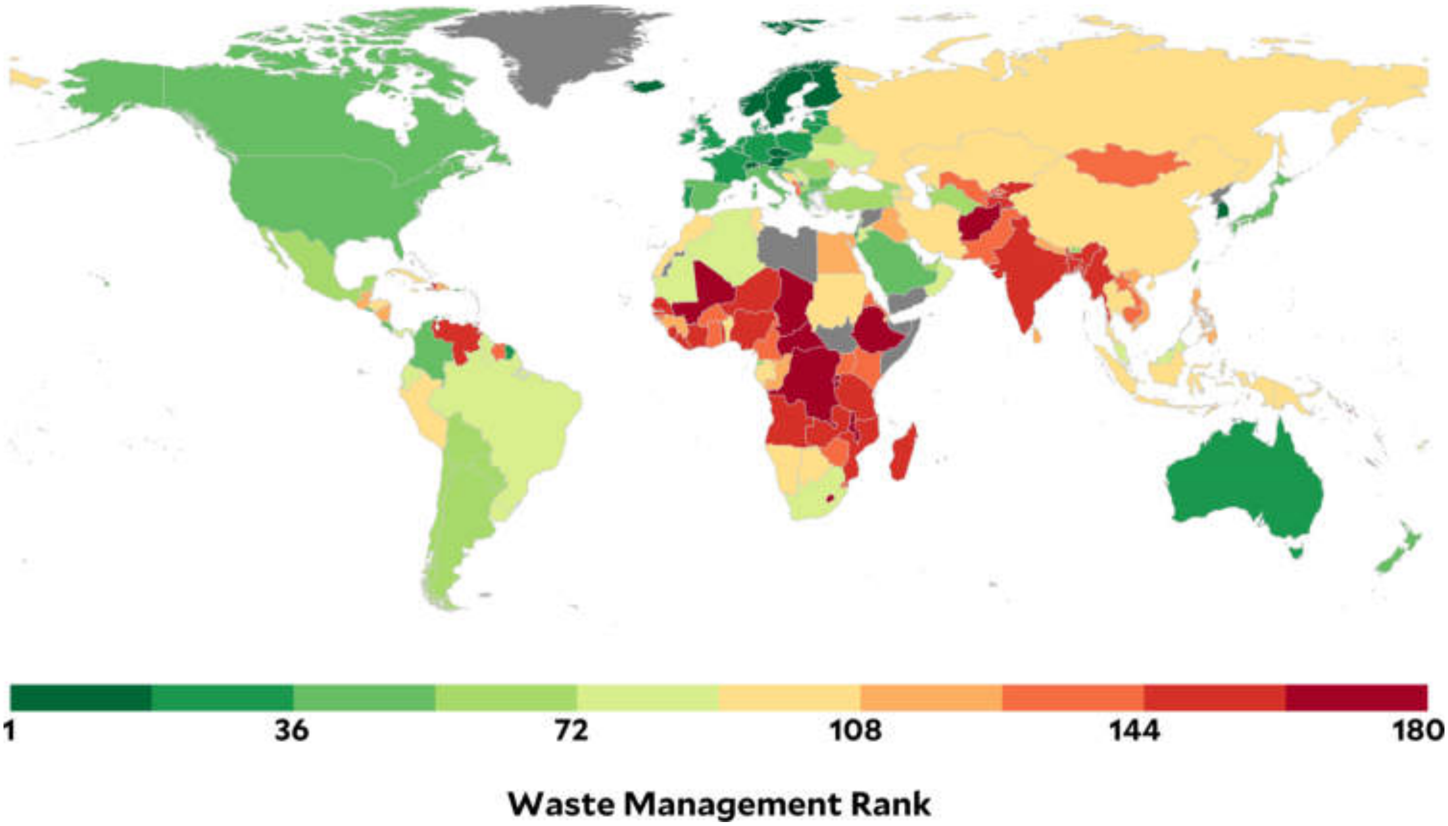


Table 8-1. Global rankings, scores, and regional rankings (REG) on Waste Management.

RANK	COUNTRY	SCORE	REG
1	Luxembourg	79.1	1
2	Austria	77.4	2
3	Switzerland	76.4	3
4	Czech Republic	74.9	1
5	Iceland	73.9	4
6	South Korea	72.0	1
7	Singapore	71.7	2
8	Sweden	70.8	5
9	Norway	70.7	6
10	Finland	69.6	7
11	Australia	69.0	8
11	Germany	69.0	8
13	Denmark	68.3	10
14	Belgium	68.0	11
15	Ireland	67.9	12
16	Mauritius	67.4	1
16	Lithuania	67.4	2
18	Estonia	66.7	3
18	Slovenia	66.7	3
20	Netherlands	66.2	13
21	France	63.8	14
22	Poland	63.7	5
23	Malta	63.5	15
24	Latvia	63.0	6
25	Israel	62.7	1
26	United Kingdom	62.6	16
27	Portugal	62.5	17
28	Bahrain	62.4	2
29	Antigua and Barbuda	62.3	1
30	Slovakia	62.2	7
31	Spain	61.4	18
32	New Zealand	60.9	19
33	Qatar	60.6	3
33	Italy	60.6	20
35	Colombia	60.3	2
35	Saudi Arabia	60.3	4
37	Greece	59.9	8
38	Brunei Darussalam	59.7	3
39	Canada	59.5	21
40	Taiwan	59.2	4
41	Barbados	59.0	3
42	Cyprus	58.9	9
43	Bulgaria	58.8	10
44	Saint Lucia	55.4	4
45	Croatia	55.3	11
46	United States of America	54.3	22
47	Japan	52.8	5
48	Costa Rica	52.5	5
49	El Salvador	52.1	6
50	Samoa	51.2	6
51	Grenada	51.1	7
52	Bolivia	50.0	8
53	Belarus	49.1	1
54	Dominica	48.5	9
54	Turkmenistan	48.5	2
56	St. Vincent and Grenadines	47.4	10
57	Equatorial Guinea	46.5	2
58	Chile	46.4	11
59	Romania	45.6	12
60	Seychelles	44.4	3
60	Lebanon	44.4	5
62	Mexico	43.5	12
63	Bhutan	43.4	1
63	United Arab Emirates	43.4	6
63	Hungary	43.4	13
66	Georgia	43.1	3
67	Argentina	42.4	13
68	North Macedonia	42.1	14
69	Paraguay	41.0	14
70	Turkey	40.6	15
71	Serbia	40.3	16
72	Jordan	40.0	7
73	South Africa	39.2	4
74	Marshall Islands	38.8	7
75	Brazil	38.7	15
76	Panama	38.6	16
77	Ecuador	38.5	17
77	Uruguay	38.5	17
79	Armenia	37.5	4
80	Vanuatu	36.5	8
81	Bahamas	36.2	19
82	Mauritania	35.5	5
83	Fiji	34.0	9
84	Malaysia	33.8	10
85	Guyana	33.7	20
86	Oman	32.8	8
87	Kuwait	32.3	9
88	Algeria	32.0	10
88	Ukraine	32.0	5
90	Tonga	31.7	11
91	Bosnia and Herzegovina	30.9	17
92	Morocco	30.8	11
92	Azerbaijan	30.8	6
94	Gabon	30.5	6
95	Benin	29.7	7
96	Indonesia	29.5	12
97	Iran	28.7	12
98	Cuba	28.6	21
98	China	28.6	13
100	Thailand	28.5	14
101	Honduras	28.4	22
102	Sudan	28.1	13
103	Jamaica	28.0	23
104	Peru	27.7	24
104	Kazakhstan	27.7	7
104	Russia	27.7	7
107	Botswana	27.3	8
108	Namibia	26.5	9
109	Tunisia	26.2	14
110	Papua New Guinea	25.8	15
111	Viet Nam	25.6	16
112	Maldives	25.0	2
113	Nepal	24.7	3
114	Cabo Verde	24.1	10
115	Republic of Congo	23.7	11
116	Belize	23.4	25
116	Philippines	23.4	17
118	Iraq	21.1	15
119	Guatemala	20.6	26
120	São Tomé and Príncpe	20.4	12
121	Egypt	19.8	16
122	Nicaragua	19.3	27
123	Sri Lanka	19.1	4
124	Guinea	18.9	13
125	Timor-Leste	18.3	18
126	Dominican Republic	18.2	28
126	Kiribati	18.2	19
128	Moldova	17.7	9
129	Djibouti	16.9	14
130	Burkina Faso	16.7	15
130	Laos	16.7	20
132	Suriname	15.9	29
132	Uzbekistan	15.9	10
134	Pakistan	15.8	5
135	Mongolia	15.7	21
136	Comoros	15.5	16
136	Montenegro	15.5	18
138	Cameroon	15.4	17
139	Eritrea	15.3	18
140	Micronesia	14.9	22
141	Eswatini	14.6	19
142	Gambia	14.5	20
143	Guinea-Bissau	14.3	21
144	Cambodia	13.7	23
145	Ghana	13.6	22
146	Albania	13.4	19
147	Kenya	13.3	23
147	Zimbabwe	13.3	23
147	Trinidad and Tobago	13.3	30
150	Uganda	13.2	25
151	India	12.9	6
152	Nigeria	12.7	26
153	Sierra Leone	12.1	27
153	Venezuela	12.1	31
155	Liberia	11.9	28
156	Madagascar	11.2	29
156	Senegal	11.2	29
158	Solomon Islands	11.1	24
159	Côte d'Ivoire	11.0	31
160	Bangladesh	10.5	7
161	Tanzania	10.4	32
162	Togo	10.3	33
163	Mozambique	9.8	34
164	Angola	9.6	35
165	Haiti	9.4	32
166	Niger	8.4	36
167	Myanmar	8.2	25
168	Kyrgyzstan	7.2	11
169	Zambia	6.9	37
170	Tajikistan	6.4	12
171	Lesotho	5.9	38
172	Chad	5.1	39
173	Ethiopia	5.0	40
174	Mali	4.5	41
174	Rwanda	4.5	41
176	Afghanistan	4.4	8
177	Dem. Rep. Congo	4.1	43
178	Malawi	3.5	44
179	Central African Republic	3.4	45
180	Burundi	2.7	46

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 and scores on Waste Management.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Antigua and Barbuda	62.3	1
Colombia	60.3	2
Barbados	59.0	3
Saint Lucia	55.4	4
Costa Rica	52.5	5
El Salvador	52.1	6
Grenada	51.1	7
Bolivia	50.0	8
Dominica	48.5	9
St. Vincent and Grenadines	47.4	10
Chile	46.4	11
Mexico	43.5	12
Argentina	42.4	13
Paraguay	41.0	14
Brazil	38.7	15
Panama	38.6	16
Ecuador	38.5	17
Uruguay	38.5	17
Bahamas	36.2	19
Guyana	33.7	20
Cuba	28.6	21
Honduras	28.4	22
Jamaica	28.0	23
Peru	27.7	24
Belize	23.4	25
Guatemala	20.6	26
Nicaragua	19.3	27
Dominican Republic	18.2	28
Suriname	15.9	29
Trinidad and Tobago	13.3	30
Venezuela	12.1	31
Haiti	9.4	32

EASTERN EUROPE

Country	Score	Reg. Rank
Czech Republic	74.9	1
Lithuania	67.4	2
Estonia	66.7	3
Slovenia	66.7	3
Poland	63.7	5
Latvia	63.0	6
Slovakia	62.2	7
Greece	59.9	8
Cyprus	58.9	9
Bulgaria	58.8	10
Croatia	55.3	11
Romania	45.6	12
Hungary	43.4	13
North Macedonia	42.1	14
Turkey	40.6	15
Serbia	40.3	16
Bosnia and Herzegovina	30.9	17
Montenegro	15.5	18
Albania	13.4	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Bhutan	43.4	1
Maldives	25.0	2
Nepal	24.7	3
Sri Lanka	19.1	4
Pakistan	15.8	5
India	12.9	6
Bangladesh	10.5	7
Afghanistan	4.4	8

GLOBAL WEST

Country	Score	Reg. Rank
Luxembourg	79.1	1
Austria	77.4	2
Switzerland	76.4	3
Iceland	73.9	4
Sweden	70.8	5
Norway	70.7	6
Finland	69.6	7
Australia	69.0	8
Germany	69.0	8
Denmark	68.3	10
Belgium	68.0	11
Ireland	67.9	12
Netherlands	66.2	13
France	63.8	14
Malta	63.5	15
United Kingdom	62.6	16
Portugal	62.5	17
Spain	61.4	18
New Zealand	60.9	19
Italy	60.6	20
Canada	59.5	21
United States of America	54.3	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Belarus	49.1	1
Turkmenistan	48.5	2
Georgia	43.1	3
Armenia	37.5	4
Ukraine	32.0	5
Azerbaijan	30.8	6
Kazakhstan	27.7	7
Russia	27.7	7
Moldova	17.7	9
Uzbekistan	15.9	10
Kyrgyzstan	7.2	11
Tajikistan	6.4	12

ASIA-PACIFIC

Country	Score	Reg. Rank
South Korea	72.0	1
Singapore	71.7	2
Brunei Darussalam	59.7	3
Taiwan	59.2	4
Japan	52.8	5
Samoa	51.2	6
Marshall Islands	38.8	7
Vanuatu	36.5	8
Fiji	34.0	9
Malaysia	33.8	10
Tonga	31.7	11
Indonesia	29.5	12
China	28.6	13
Thailand	28.5	14
Papua New Guinea	25.8	15
Viet Nam	25.6	16
Philippines	23.4	17
Timor-Leste	18.3	18
Kiribati	18.2	19
Laos	16.7	20
Mongolia	15.7	21
Micronesia	14.9	22
Cambodia	13.7	23
Solomon Islands	11.1	24
Myanmar	8.2	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Mauritius	67.4	1
Equatorial Guinea	46.5	2
Seychelles	44.4	3
South Africa	39.2	4
Mauritania	35.5	5
Gabon	30.5	6
Benin	29.7	7
Botswana	27.3	8
Namibia	26.5	9
Cabo Verde	24.1	10
Republic of Congo	23.7	11
Sao Tome and Principe	20.4	12
Guinea	18.9	13
Djibouti	16.9	14
Burkina Faso	16.7	15
Comoros	15.5	16
Cameroon	15.4	17
Eritrea	15.3	18
Eswatini	14.6	19
Gambia	14.5	20
Guinea-Bissau	14.3	21
Ghana	13.6	22
Kenya	13.3	23
Zimbabwe	13.3	23
Uganda	13.2	25
Nigeria	12.7	26
Sierra Leone	12.1	27
Liberia	11.9	28
Madagascar	11.2	29
Senegal	11.2	29
Cote d'Ivoire	11.0	31
Tanzania	10.4	32
Togo	10.3	33
Mozambique	9.8	34
Angola	9.6	35
Niger	8.4	36
Zambia	6.9	37
Lesotho	5.9	38
Chad	5.1	39
Ethiopia	5.0	40
Mali	4.5	41
Rwanda	4.5	41
Dem. Rep. Congo	4.1	43
Malawi	3.5	44
Central African Republic	3.4	45
Burundi	2.7	46

GREATER MIDDLE EAST

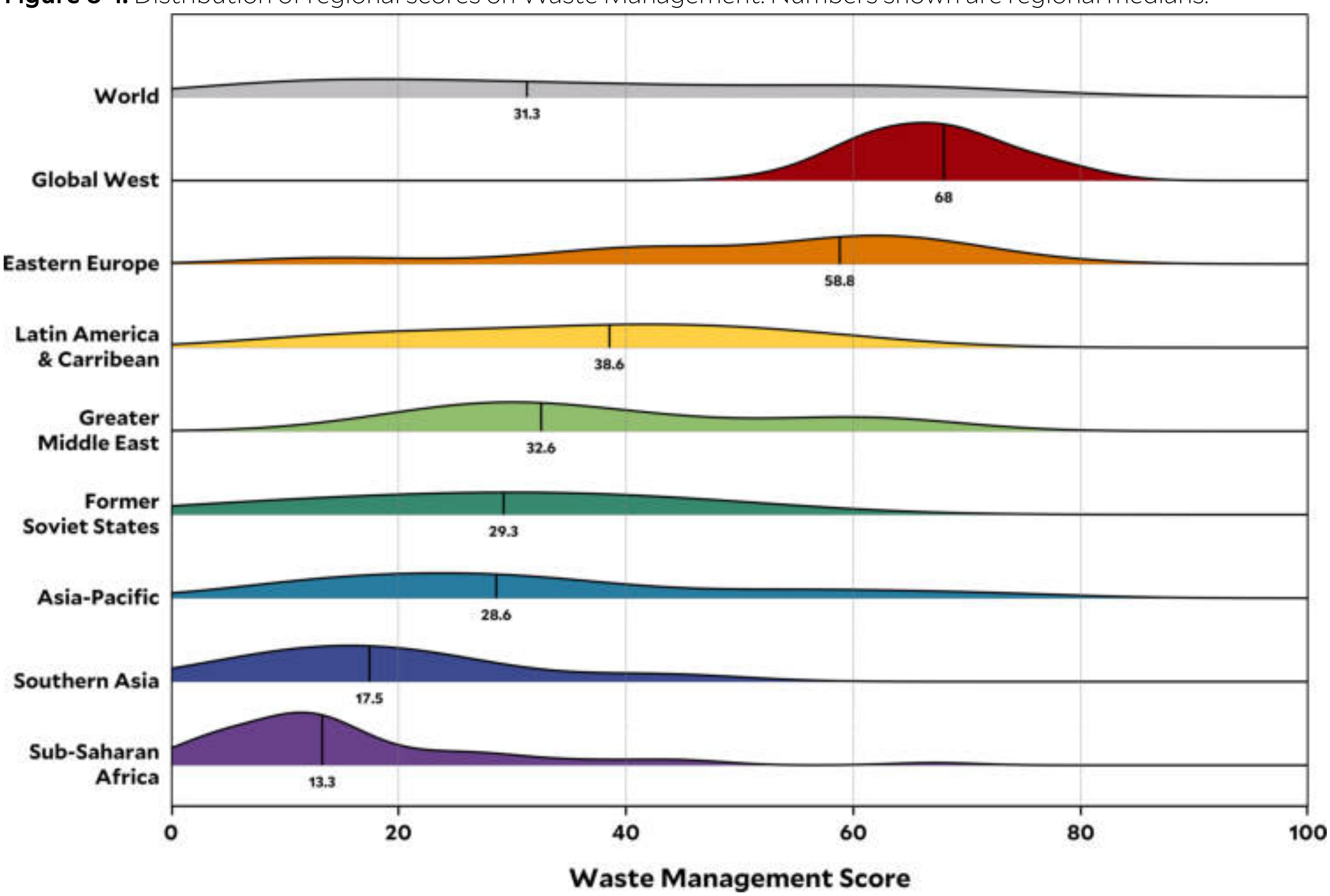
Country	Score	Reg. Rank
Israel	62.7	1
Bahrain	62.4	2
Qatar	60.6	3
Saudi Arabia	60.3	4
Lebanon	44.4	5
United Arab Emirates	43.4	6
Jordan	40.0	7
Oman	32.8	8
Kuwait	32.3	9
Algeria	32.0	10
Morocco	30.8	11
Iran	28.7	12
Sudan	28.1	13
Tunisia	26.2	14
Iraq	21.1	15
Egypt	19.8	16

2. Global Trends

The 2022 EPI delivers several significant advancements in waste management metrics. We introduce a pilot indicator on ocean plastic pollution. Increasing global plastic waste generation has intensified plastic dumping in oceans, where plastic waste makes up 80% of large litter (Morales-Caselles et al., 2021). Plastic threatens marine life and poses health risks to humans who consume microplastics in seafood (Pew and SYSTEMIQ, 2020). As of 2020, marine plastic pollution appears to be near its peak due to a combination of reduced dependency on dumps in low- and middle-income countries and a plateau in per capita waste generation globally (Chen et al., 2020). Reaching the peak, however, does not necessarily imply a quick decrease. There is a risk that marine plastic pollution may instead plateau at a peak level, especially as the COVID-19 pandemic spurs increased plastic use and improper disposal. Global plastic waste itself is still increasing, with only ten countries emitting over 55% of marine plastics and pollution growing quickly in developing countries in Sub-Saharan Africa and the Greater Middle East. The recently proposed Global Plastics Treaty, which emerged out of the United Nations Environment Assembly at Nairobi in March 2022, offers hope in this area as a legally binding instrument to end plastic pollution by tackling the problem from production to disposal.

The EPI also introduces a pilot indicator on recycling rates, marking an improvement in our Waste Management coverage. Despite consistent public campaigns and an increasing understanding of the problem of pollution, global recycling rates are poor (Chow et al., 2017; Debrah et al., 2021). The world recycles only 24% of recyclable post-consumer material. These low recycling rates are the consequence of a lack of recycling initiatives or a lack of processing capacity for recyclable waste. Countries that succeed in recycling emerge in many regions: countries in Europe, Oceania, and Southeast Asia are among the best performers in this category (Figure 8-1). The success of countries across different levels of wealth and geographic scales points to the possibility of improving recycling rates globally. Recycling data, however, remains spotty and hard to assess, and better tracking of recycl-

Figure 8-1. Distribution of regional scores on Waste Management. Numbers shown are regional medians.



ables from initial disposal to end destination is vital to more fully characterize the world's waste management performance.

Poor waste management has cross-cutting environmental implications. Around the world, five billion people lack access to either regular waste collection or controlled disposal services for municipal solid waste (Wilson and Velis, 2015). Uncontrolled and uncollected waste has severe public and environmental health costs, estimated to be five to ten times more economically damaging than the costs of bringing global waste management to healthy levels (Wilson and Velis, 2015). Untreated waste imposes health care costs in the form of respiratory diseases, contaminates water supplies and cropland, and acts as a reservoir for disease and vermin. Mismanaged waste also has consequences for climate change: research suggests that better waste management practices — like gas capture, recycling, and anaerobic digestion — could mitigate 10% of global greenhouse gas emissions (Dehoust et al., 2010).

3. Leaders and Laggards

High-income countries score highly on the controlled solid waste metric, with eight of the ten best-scoring nations located in Northern Europe. Leaders in this issue area have adopted waste management hierarchies that prioritize recycling, composting, and waste-to-energy incineration for value recovery from waste material. The Netherlands, for example, has eliminated mismanaged waste by improving its recycling rate to over 77% and adopting waste-to-energy programs (Rijkswaterstaat, 2022). In The Netherlands, landfills are used only as a last resort. The four highest-performing Nordic countries—Sweden, Denmark, Norway, and Finland—have implemented similar practices. In Sweden, which has embraced a "Zero Waste" vision, less than one percent of waste is mismanaged. As in the Netherlands, Sweden organizes waste management according to a hierarchy that emphasizes preventing waste generation and makes extensive use of energy recovery (Avfall Sverige, 2022). In 2020, 46% of household waste was converted to energy in Sweden (Sverige, 2021). Transitioning to a circular economy that reduces waste generation is a policy objective for Sweden and its neighbors, including Denmark and Norway (Kjaer, 2013; OECD, 2019b).

Outside of Europe, many high-income Asian countries have robust waste management systems. Singapore, where less than one percent of waste is mismanaged, leads in this category. Like its European peers, Singapore uses recycling and incineration extensively. Non-recyclable waste is sent to one of four waste-to-energy plants and any remaining refuse disposed of at Singapore's sole landfill (Singapore National Environment Agency, 2021).

As waste production has grown with rising incomes, the small size of their territory has become a problem for Singapore and other high-performing Asian countries like Taiwan (Ong et al., 2019; Weng and Chang, 2001; Xue et al., 2015; Young et al., 2010). Governments in the region have enacted sustainability regulations to stop landfill overcrowding and reduce waste generation. Moving away from landfills to focus on preventative waste management is a unifying trait among countries that excel in waste management.

Mauritius is one of a few upper-middle-income countries that markedly outperforms its peers. The island sustainably disposes of 99.5% of its solid waste, the second-best performance in the world. This success is partially due to the Mare Chicose Landfill, one of the only sanitary landfills in a small island developing state. Waste generated in Mauritius is gathered by one of 12 management authorities, transferred to one of five transfer points, and sent to the landfill. Composting also plays an important role in waste management, as 54% of waste is organic in Mauritius. A large composting plant operating in the country since 2011 keeps organic waste out of landfills (Beerachee, 2012; Kowlesser, 2012). Increasing waste generation, landfill saturation, low recycling rates, and a recent decrease in composting rates pose challenges to Mauritius. To minimize waste, policymakers have enacted legislation to limit the use of plastic water bottles and ban plastic bags. These policies seek to reduce pressure on the island's landfill and waste management systems. Other successful programs include industrial waste exchanges, which divert waste from landfills to serve as industrial resources (Kowlesser, 2012, 2020; PAGE, 2017).

Despite the obstacles to creating more sustainable waste management systems, especially in low- and middle-income countries, a declining number of countries are entirely unable to control solid waste. Only 13 countries still have more than 99% uncontrolled solid waste. Most of these countries are located in Sub-Saharan Africa. Albania is an exception, falling far behind its Eastern European peers. Waste collection is present in major cities, but the main form of disposal is in uncontrolled sites prone to leaching, contamination, and greenhouse gas emissions (EEA, 2018; Oncioiu et al., 2020). Waste collection in rural areas is scarce. The same is true of recycling and incineration across the country. With European Union support, the Albanian Ministry of Environment is preparing to enhance the country's integrated waste management (GIZ, 2021).

Kiribati, one of several island states with low scores in this issue area, has successfully reduced plastic waste through recycling programs like the "Keep Kiribati Beautiful" campaign (Asian Development Bank, 2014). Still, the country manages only about 20% of waste sustainably, with municipal authorities collecting only 38%. About 35% of waste is dumped into the ocean (Asian Development Bank, 2014). New Zealand has supported Kiribati's efforts to improve its waste management by funding the Green Bag system, a garbage collection program for residents of two islands in Kiribati that uses payments to incentivize reliable waste aggregation (Asian Development Bank, 2014; Leney, 2006; Niemi et al., 2019).

China has seen the most significant improvement in ocean plastic pollution over the last decade. In 2010, the country was the largest source of ocean plastics (Jambeck et al., 2015). Pollution has been decreasing since 2010, however, in correlation with rising GDP and lower reliance on dumps for plastic disposal. A major shift in policy came in 2017, when China banned imports of most plastic waste (Wen et al., 2021). Prior to the ban, 71% of the 8.88 million tons of plastic waste China imported annually was buried or mismanaged. Much of it ended up in the sea. The ban has induced many developed nations to increase recycling and reduce plastic waste generation (Wen et al., 2021).

While China's ocean plastic pollution has decreased, other countries in Southeast and South Asia have emerged as new pollution hotspots. Indonesia and India are the top two generators of marine plastic waste. Indonesia generates 1.4 million tons of ocean plastic each year, 16% of the global total, but the island nation has taken several positive steps to counteract these problems. Twenty-five Indonesian cities implemented bans or levies on plastic bags and other single-use plastics in 2016 (Pew and SYSTEMIQ, 2020). The national government has also committed $1 billion a year toward reducing marine waste by 70% by 2025 (Langenheim, 2017). These policies seem to be making headway: Indonesia's total marine plastic pollution decreased for the first time between 2015 and 2020.

India is charting an opposite course from Indonesia (Jagath et al., 2019). The country remains slightly behind Indonesia in terms of absolute plastic pollution, at 13% of the global total. But the amount of plastics it generates each year is rising. In 2018, the Modi Administration took a positive step by announcing plans to phase out single-use plastics by 2022 (Carrington, 2018). The challenge India faces applies across the developing world. The top five producers of ocean plastic pollution—Indonesia, India, the United States, Brazil, and Thailand—are responsible for 43% of global ocean plastic pollution.

The countries seeing the greatest growth in marine plastic emissions primarily fall in the Greater Middle East and Sub-Saharan Africa. Although these countries emit much less than the world's largest polluters, their trends are cause for concern. Liberia currently emits only 0.1% of global marine plastic waste, but total emissions grew by over 100% from 2010 to 2020. A similar trajectory is visible across the Global South (Ayeleru et al., 2020; Babayemi et al., 2019; Oyake-Ombis et al., 2015). Many African countries have been proactive in confronting plastic waste and marine plastic pollution. Over half already have bans on plastic bags or single-use plastics (Carlos Bezerra et al., 2021). But the essentiality of plastic products for services like providing clean drinking water in water sachets has lessened the effectiveness of these bans, especially over the course of the pandemic (Adam et al., 2020; Arimiyaw et al., 2021; Benson et al., 2021a).

The most easily solvable challenge in ocean plastics lies in high-income countries like the United States, one of the world's ten biggest producers of marine plastic waste (Borrelle et al., 2020; Law et al., 2020). The United States and its peers in the Global West have strong waste management systems and effectively dispose of waste. High per capita plastic consumption, however, means that even small failure rates in capturing waste have serious consequences. High-income countries may see successful returns from policies encouraging plastic alternatives, promoting reuse, and onshoring and expanding recycling programs to reduce waste generation and energy consumption (OECD, 2018, 2019a; Pew and SYSTEMIQ, 2020; Wen et al., 2021)

The top performer in recycling rate is South Korea. The nation's jongnyangje system mandates that residents must sort all household waste into different categories (common waste, compost, recyclables, and large waste) to avoid fines (Belcher, 2022). The country also bans certain single-use plastic items, offers deposits for plastic bottles, and has a system of extended producer responsibility for plastics. Until the COVID-19 pandemic, this system had worked well for decades. While South Koreans continue to recycle at rates higher than the rest of the world, increased plastic production during the pandemic, as well as China's cessation of recyclable imports, have hurt the South Korean recycling industry and left some recycling collectors paying for recyclables to be taken off their hands (Kim, 2020). Despite these challenges, South Korea is well-positioned to maintain its high recycling rates and continue its commitment to an increasingly circular economy.

The worst performers in the recycling indicator are Togo, Brazil, Bhutan, Chile, and Serbia. The geographic and political spread of these countries points to the widespread nature of the world's recycling problem. Chile, which does well on controlled solid waste, has struggled to spread recycling knowhow, expand the coverage of recycling services, and adopt a waste disposal model that emphasizes aggregating waste to landfills (Valenzuela-Levi, 2019, 2021). An increased focus on Chile's environmental policies during the nation's ongoing constitutional convention offers an opportunity to begin improving the country's recycling record (Surma, 2022).

4. Methods

Much of the world lacks reliable information on the composition, collection rates, and even scope of public services offered to residents. This data gap has hindered recent attempts to construct waste-related environmental metrics (UNEP, 2015). The 2022 EPI synthesizes information from a variety of sources — including country reports, non-governmental organizations, and the scientific literature — to develop a set of indicators to monitor country performance and track country trends in the Waste Management issue category.

Ultimately, waste's final destination serves as the greatest determinant of its environmental impact. The best treatment or disposal strategies depend on geographic, social, and economic factors. While one community may have the space to construct landfills with gas capture, another community facing land scarcity may be best served by waste-to-energy incineration. Waste streams heavy with organic content may be best handled via anaerobic digestion, providing communities with a methane energy source (Khalid et al., 2011).

All waste management methods involve environmental tradeoffs, such as air pollution from incineration, methane emissions from landfills, or the energy costs of transporting recyclable goods long (often international) distances to central facilities. The 2022 EPI's three indicators — municipal solid waste, recycling rates, and ocean plastic pollution — provide a comprehensive worldview of waste management practices and provide rankings on how sustainably countries manage the fate of their spent materials. The EPI team recognizes that this indicator framework provides an incomplete understanding of waste, and emphasizes the need for additional research and data to better quantify waste's impacts on public and environmental health.

Indicator Background

We measure Controlled solid waste as the percentage of generated municipal solid waste that a country collects and treats with methods aiming to minimize environmental impact. Sustainable methods of disposal include strategies like sanitary landfills, recycling, anaerobic digestion, and incineration. Uncontrolled disposal methods include open landfills and ocean dumping.

Recycling rate measures the proportion of post-consumer recyclable materials that each country sorts for recycling. Recyclable materials include glass, metal, plastic, and paper. We emphasize here that the data underpinning this indicator are estimates for recycling rates based on waste stream composition. Other factors, such as the international transport of recyclable material and the rejection of material during waste stream processing, may reduce actual recycling rates.

Ocean plastic pollution measures the mass of post-consumer plastics entering the ocean through dumping or through riverine input. Emissions are based on models using waste composition and management as inputs: coastal areas with higher plastic use and less effective waste management strategies are modeled to emit more plastic pollution (Chen et al., 2020).

Data Sources

The data underpinning the Controlled solid waste come from a variety of sources, including academic sources and non-governmental reports based on country surveys. Primary estimates from Kaza et al. 2018, supplemented by estimates from the literature (Jambeck et al., 2015; Law et al., 2020; Lebreton and Andrady, 2019). All sources report the proportion of mismanaged waste at the country level within the past decade.

Data for recycling rate come from Chen et al. 2020. This study uses waste composition, as reported in Kaza et al.'s 2018 *What a Waste* report, population, and economic variables in a Bayesian model to estimate the fate of metal, glass, plastic, and paper materials in municipal waste streams. We refer the reader to the Chen et al. 2020 methodology for further information.

We source Ocean plastic pollution data from Chen et al. 2020 and Meijer et al. 2021. These studies estimate plastic waste inputs into the ocean based on the amount of mismanaged plastic waste within 50 miles of a country's coastline. Wind, precipitation, and river size are also used to estimate inputs from river sources, as opposed to litter (Meijer et al., 2021).

Limitations

The challenges of measuring waste management worldwide remain pressing. A key limitation of this indicator is the coarseness of the data. The localized nature of waste management prohibits comprehensive data collection, particularly in low-income countries but even in countries with high levels of development.

Transboundary flow of material adds to the difficulty of accurately quantifying waste management. Many countries stop reporting recycling after recyclables have left their borders, meaning it is hard to gauge whether waste that is intended for recycling is in fact recycled. A recent report on U.S. recycling rates estimated that U.S. recycling was almost 10% lower than the EPI's data suggests as a result of discrepancies related to international processing and the COVID-19 pandemic (Last Beach Cleanup and Beyond Plastics, 2022).

Changes in Chinese waste importation policy have also, as explained above, dramatically affected recycling in the developed world, where waste is now often sent to landfills rather than recycled or exported. Poor recycling rates worldwide are not just a consequence of a lack of recycling education or economic incentives. They are also a direct consequence of failing to build up domestic infrastructure for handling recyclable materials.

Opportunities to refine our methods and expand the EPI's scope of Waste Management metrics will likely grow as more countries focus on waste management as a critical element of sustainable development and climate change mitigation. Increasingly, countries consider waste-sector actions in their Nationally Determined Contributions under the Paris Climate Agreement (Powell et al., 2018). These commitments signal the development of improved waste data collection and management systems, which will lead to better metrics and ultimately more sustainable waste management practices in the years ahead.

Chapter 9. Biodiversity & Habitat

1. Introduction

Biodiversity is a critical aspect of planetary health and supports the functioning of human societies, economies, and well-being (Ekins and Gupta, 2019). The direct and indirect economic benefits of biodiversity and ecosystem services — estimated to be $125 trillion per year (Costanza et al., 2014) — stem from protection against extreme weather events like storms and floods, climatic regulation, and their sources of food, energy, medicinal, and raw materials. Healthy and vibrant ecosystems also provide incalculable cultural and spiritual benefits to people globally, including aesthetic and ethical value (Deb and Malhotra, 1997; Laurila-Pant et al., 2015). To sustain this wealth of benefits, living organisms require habitat conditions that suit their needs, whether in tropical rainforests or deserts.

Despite the immense economic and cultural value of biodiversity, scientific analyses and policy discussions demonstrate a worldwide deterioration in biodiversity and natural habitats due to human activity (Mooney and Mace, 2009). An estimated one million species are at risk of extinction in the coming decades (IPBES, 2019). Conservation experts largely attribute biodiversity loss to human-caused habitat destruction, with 30-50% of global land, more than half of all freshwater, and 25% of primary production in upwelling ocean regions being utilized by humans (Crutzen, 2016). The Biodiversity & Habitat issue category assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders.

2. Indicators

Terrestrial Biome Protection, National & Global Weights (45% of issue category)
Two indicators of *terrestrial biome protection* measure the proportion of 14 important biomes maintained by protected areas within a country. Rarer biomes are given greater emphasis when aggregated to the country and global level, weighted according to the proportion of the country's total area covered by each biome type (national weights), or the proportion of global terrestrial area covered by each biome type (global weights).

Marine Protected Areas (22% of issue category)
Marine protected areas measures the percentage of a country's exclusive economic zone (EEZ) that falls within marine protected areas (MPAs).

Protected Area Representativeness Index (PARI) (14% of issue category)
The Protected Area Representativeness Index measures the extent to which a country's terrestrial protected areas are ecologically representative of the species within that country.

Species Habitat Index (SHI) (8% of issue category)
The *Species Habitat Index* measures the average proportion of species' suitable habitat remaining within a country relative to the baseline year 2001, with each species weighted according to the proportion of their global range that is found within the country.

Species Protection Index (SPI) (8% of issue category)
The *Species Protection Index* measures the average proportion of suitable habitat for all of a country's species located within protected areas.

Biodiversity Habitat Index (BHI) (3% of issue category)
The *Biodiversity Habitat Index* estimates the change in biological diversity within a country due to habitat loss, degradation, and fragmentation across that country, with higher scores indicating less habitat loss.

Map 9-1. Global rankings on Biodiversity & Habitat.

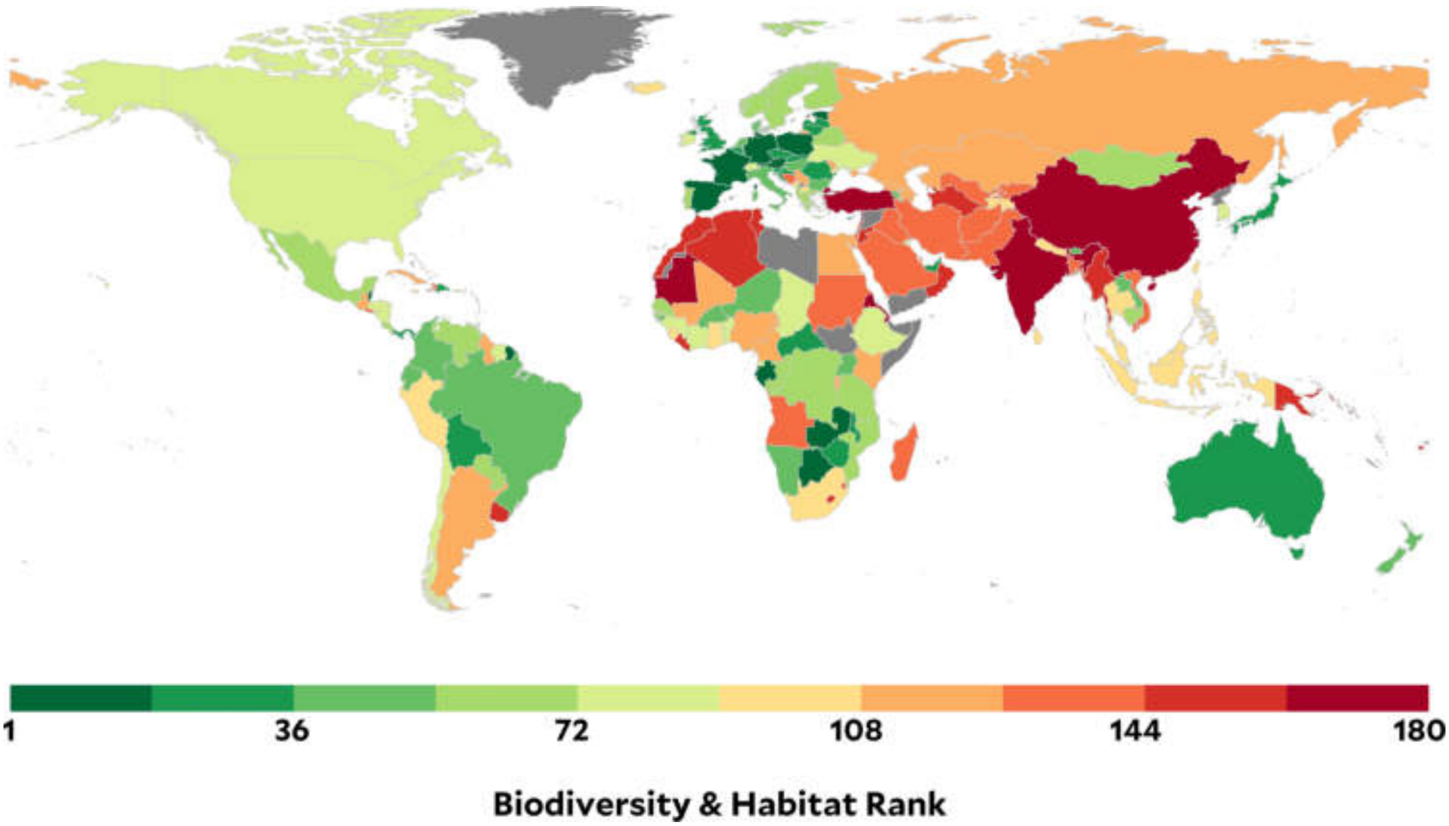


Table 9-1. Global rankings, scores, and regional rankings (REG) on Biodiversity & Habitat.

RANK	COUNTRY	SCORE	REG
1	Belize	91.9	1
2	Zambia	91.0	1
3	Botswana	89.3	2
4	Germany	88.5	1
5	Poland	87.3	1
6	France	86.5	2
7	Austria	86.0	3
7	Estonia	86.0	2
9	Spain	85.8	4
10	Gabon	85.1	3
11	Luxembourg	84.8	5
12	Slovenia	84.5	3
13	Lithuania	84.4	4
14	Latvia	84.3	5
15	Zimbabwe	83.7	4
15	Panama	83.7	2
17	Czech Republic	83.3	6
18	Slovakia	82.7	7
19	Bolivia	82.6	3
20	Malawi	82.4	5
20	Belgium	82.4	6
22	Australia	82.1	7
23	United Kingdom	81.5	8
23	Croatia	81.5	8
25	Romania	81.1	9
26	Japan	80.8	1
27	Dominican Republic	80.7	4
28	Bahamas	80.4	5
29	United Arab Emirates	80.3	1
30	Central African Republic	80.2	6
31	Netherlands	80.1	9
32	Bhutan	79.6	1
33	Burkina Faso	78.5	7
34	Cyprus	78.3	10
35	Brazil	78.2	6
36	Hungary	78.0	11
37	Colombia	77.4	7
38	Niger	77.1	8
39	Denmark	76.9	10
40	New Zealand	76.6	11
41	Italy	76.5	12
42	Guinea-Bissau	76.2	9
43	Seychelles	76.1	10
44	Uganda	75.8	11
45	Ecuador	75.2	8
46	Bulgaria	75.1	12
47	Laos	74.9	2
48	Namibia	73.9	12
49	Armenia	73.3	1
50	Malta	72.9	13
51	Kiribati	72.6	3
52	Venezuela	71.5	9
53	Norway	71.2	14
54	Finland	71.1	15
55	Portugal	70.5	16
56	Tanzania	70.1	13
57	Mexico	69.8	10
58	Greece	69.1	13
59	Sweden	68.8	17
60	Dem. Rep. Congo	68.6	14
61	Costa Rica	68.5	11
62	Mongolia	67.7	4
63	Republic of Congo	67.5	15
64	Belarus	66.9	2
65	Cambodia	65.8	5
66	Trinidad and Tobago	65.3	12
67	Mozambique	65.2	16
68	Senegal	65.1	17
69	Paraguay	64.3	13
70	Albania	63.9	14
71	Benin	63.6	18
72	Canada	62.9	18
73	Equatorial Guinea	62.5	19
73	Switzerland	62.5	19
75	Chad	62.4	20
76	Ukraine	61.7	3
77	Chile	61.3	14
78	South Korea	61.0	6
79	Honduras	60.7	15
80	Guinea	60.6	21
80	United States of America	60.6	20
82	Nicaragua	60.1	16
83	Kuwait	60.0	2
84	Ireland	59.6	21
85	Suriname	59.5	17
86	Ethiopia	59.2	22
86	Togo	59.2	22
88	São Tomé and Prìncpe	59.1	24
89	Brunei Darussalam	58.5	7
90	Côte d'Ivoire	58.2	25
91	Taiwan	58.0	8
92	North Macedonia	57.9	15
93	Tajikistan	57.6	4
94	Sri Lanka	57.5	2
95	Iceland	57.0	22
96	Timor-Leste	54.9	9
97	South Africa	54.7	26
98	Dominica	54.5	18
98	Peru	54.5	18
100	Antigua and Barbuda	54.2	20
100	Philippines	54.2	10
102	Comoros	53.9	27
103	Jamaica	53.2	21
104	Ghana	52.9	28
105	Montenegro	52.6	16
106	Malaysia	51.9	11
107	Thailand	51.4	12
108	Sierra Leone	51.2	29
108	Indonesia	51.2	13
110	Nepal	51.1	3
111	Qatar	50.1	3
112	Moldova	49.8	5
113	Kazakhstan	48.6	6
114	Rwanda	47.6	30
115	Mali	46.9	31
116	Serbia	46.7	17
117	Kenya	46.4	32
118	Azerbaijan	46.2	7
119	Cuba	46.1	22
119	Guyana	46.1	22
121	Nigeria	45.7	33
122	St. Vincent and Grenadines	45.6	24
123	Russia	44.4	8
124	Egypt	42.5	4
125	Argentina	42.4	25
126	Burundi	42.3	34
127	Gambia	42.2	35
128	Cameroon	42.0	36
129	Guatemala	41.3	26
130	Georgia	40.4	9
131	Israel	39.7	5
132	Bangladesh	37.4	4
132	Pakistan	37.4	4
134	Sudan	37.0	6
135	Saint Lucia	36.7	27
136	Haiti	35.4	28
137	Bosnia and Herzegovina	34.1	18
138	Uzbekistan	33.8	10
139	Tonga	31.9	14
140	El Salvador	31.4	29
141	Madagascar	31.0	37
142	Afghanistan	30.7	6
143	Angola	30.1	38
144	Saudi Arabia	29.3	7
145	Grenada	29.0	30
146	Eswatini	28.7	39
147	Kyrgyzstan	28.5	11
148	Iraq	28.3	8
149	Viet Nam	27.9	15
150	Iran	27.3	9
151	Samoa	26.9	16
152	Liberia	26.8	40
153	Tunisia	26.4	10
154	Singapore	25.3	17
155	Jordan	24.1	11
156	Turkmenistan	22.9	12
157	Algeria	22.7	12
158	Myanmar	21.8	18
159	Oman	20.2	13
160	Vanuatu	20.0	19
161	Mauritius	18.0	41
162	Uruguay	17.8	31
163	Morocco	16.6	14
164	Fiji	16.4	20
165	Papua New Guinea	16.3	21
166	Bahrain	15.3	15
167	Lesotho	13.7	42
168	Barbados	13.6	32
169	Lebanon	12.8	16
170	Cabo Verde	12.1	43
171	Maldives	11.3	7
172	Djibouti	10.8	44
173	Mauritania	10.7	45
174	China	9.4	22
175	Eritrea	8.8	46
176	Solomon Islands	8.3	23
177	Marshall Islands	8.0	24
178	Turkey	7.5	19
179	India	5.8	8
180	Micronesia	3.6	25

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 and scores on Biodiversity & Habitat.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Belize	91.9	1
Panama	83.7	2
Bolivia	82.6	3
Dominican Republic	80.7	4
Bahamas	80.4	5
Brazil	78.2	6
Colombia	77.4	7
Ecuador	75.2	8
Venezuela	71.5	9
Mexico	69.8	10
Costa Rica	68.5	11
Trinidad and Tobago	65.3	12
Paraguay	64.3	13
Chile	61.3	14
Honduras	60.7	15
Nicaragua	60.1	16
Suriname	59.5	17
Dominica	54.5	18
Peru	54.5	18
Antigua and Barbuda	54.2	20
Jamaica	53.2	21
Cuba	46.1	22
Guyana	46.1	22
St. Vincent and Grenadines	45.6	24
Argentina	42.4	25
Guatemala	41.3	26
Saint Lucia	36.7	27
Haiti	35.4	28
El Salvador	31.4	29
Grenada	29.0	30
Uruguay	17.8	31
Barbados	13.6	32

EASTERN EUROPE

Country	Score	Reg. Rank
Poland	87.3	1
Estonia	86.0	2
Slovenia	84.5	3
Lithuania	84.4	4
Latvia	84.3	5
Czech Republic	83.3	6
Slovakia	82.7	7
Croatia	81.5	8
Romania	81.1	9
Cyprus	78.3	10
Hungary	78.0	11
Bulgaria	75.1	12
Greece	69.1	13
Albania	63.9	14
North Macedonia	57.9	15
Montenegro	52.6	16
Serbia	46.7	17
Bosnia and Herzegovina	34.1	18
Turkey	7.5	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Bhutan	79.6	1
Sri Lanka	57.5	2
Nepal	51.1	3
Bangladesh	37.4	4
Pakistan	37.4	4
Afghanistan	30.7	6
Maldives	11.3	7
India	5.8	8

GLOBAL WEST

Country	Score	Reg. Rank
Germany	88.5	1
France	86.5	2
Austria	86.0	3
Spain	85.8	4
Luxembourg	84.8	5
Belgium	82.4	6
Australia	82.1	7
United Kingdom	81.5	8
Netherlands	80.1	9
Denmark	76.9	10
New Zealand	76.6	11
Italy	76.5	12
Malta	72.9	13
Norway	71.2	14
Finland	71.1	15
Portugal	70.5	16
Sweden	68.8	17
Canada	62.9	18
Switzerland	62.5	19
United States of America	60.6	20
Ireland	59.6	21
Iceland	57.0	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Armenia	73.3	1
Belarus	66.9	2
Ukraine	61.7	3
Tajikistan	57.6	4
Moldova	49.8	5
Kazakhstan	48.6	6
Azerbaijan	46.2	7
Russia	44.4	8
Georgia	40.4	9
Uzbekistan	33.8	10
Kyrgyzstan	28.5	11
Turkmenistan	22.9	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Japan	80.8	1
Laos	74.9	2
Kiribati	72.6	3
Mongolia	67.7	4
Cambodia	65.8	5
South Korea	61.0	6
Brunei Darussalam	58.5	7
Taiwan	58.0	8
Timor-Leste	54.9	9
Philippines	54.2	10
Malaysia	51.9	11
Thailand	51.4	12
Indonesia	51.2	13
Tonga	31.9	14
Viet Nam	27.9	15
Samoa	26.9	16
Singapore	25.3	17
Myanmar	21.8	18
Vanuatu	20.0	19
Fiji	16.4	20
Papua New Guinea	16.3	21
China	9.4	22
Solomon Islands	8.3	23
Marshall Islands	8.0	24
Micronesia	3.6	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Zambia	91.0	1
Botswana	89.3	2
Gabon	85.1	3
Zimbabwe	83.7	4
Malawi	82.4	5
Central African Republic	80.2	6
Burkina Faso	78.5	7
Niger	77.1	8
Guinea-Bissau	76.2	9
Seychelles	76.1	10
Uganda	75.8	11
Namibia	73.9	12
Tanzania	70.1	13
Dem. Rep. Congo	68.6	14
Republic of Congo	67.5	15
Mozambique	65.2	16
Senegal	65.1	17
Benin	63.6	18
Equatorial Guinea	62.5	19
Chad	62.4	20
Guinea	60.6	21
Ethiopia	59.2	22
Togo	59.2	22
Sao Tome and Principe	59.1	24
Cote d'Ivoire	58.2	25
South Africa	54.7	26
Comoros	53.9	27
Ghana	52.9	28
Sierra Leone	51.2	29
Rwanda	47.6	30
Mali	46.9	31
Kenya	46.4	32
Nigeria	45.7	33
Burundi	42.3	34
Gambia	42.2	35
Cameroon	42.0	36
Madagascar	31.0	37
Angola	30.1	38
Eswatini	28.7	39
Liberia	26.8	40
Mauritius	18.0	41
Lesotho	13.7	42
Cabo Verde	12.1	43
Djibouti	10.8	44
Mauritania	10.7	45
Eritrea	8.8	46

GREATER MIDDLE EAST

Country	Score	Reg. Rank
United Arab Emirates	80.3	1
Kuwait	60.0	2
Qatar	50.1	3
Egypt	42.5	4
Israel	39.7	5
Sudan	37.0	6
Saudi Arabia	29.3	7
Iraq	28.3	8
Iran	27.3	9
Tunisia	26.4	10
Jordan	24.1	11
Algeria	22.7	12
Oman	20.2	13
Morocco	16.6	14
Bahrain	15.3	15
Lebanon	12.8	16

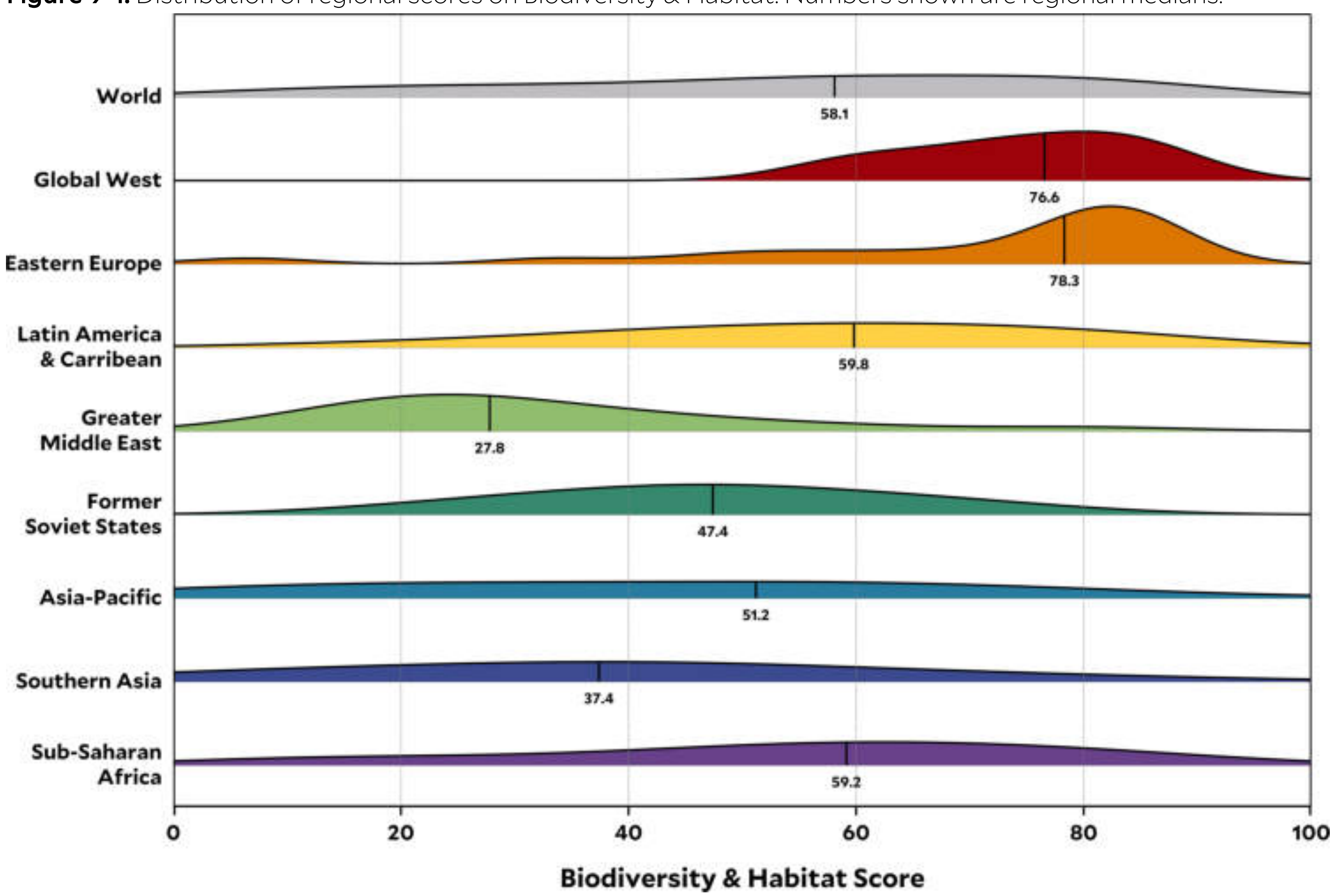
2. Global Trends

Despite the poor state of the world's ecosystems, the 2022 EPI offers some hope that global efforts to protect critical habitats and improve ecosystem vitality are increasing — albeit at a sluggish pace. Over one million species are at risk of extinction, with 500,000 terrestrial species lacking the habitat necessary for their long-term survival (IPBES, 2019). Research also suggests that, due to human pressures on the environment, we are living through a mass die-off event (Barnosky et al., 2011; Spalding and Hull, 2021). Extinction rates are up to 1,000 times higher than background rates (De Vos et al., 2015). The 2022 Biodiversity & Habitat indicators assess which countries are making progress in protecting biodiversity and habitat, which countries are backsliding, and what the general trends are globally.

The median Biodiversity & Habitat score rose 4.2 points over the last decade across the globe. The greatest change in overall Biodiversity & Habitat scores came from the Global West, which saw a median rise of 7.2 points over the past decade. The region with the smallest change in Biodiversity & Habitat score, the Greater Middle East, had median growth of 2.7 points. The majority of global improvement was due to increases in the Protected Area Representativeness Index and the Species Protection Index, with a median rise of 11.3 and 3.3 points, respectively. However, median Species Habitat Index scores fell by a median of 6.5.

Countries have also made strides toward reaching some of the Aichi Biodiversity Targets. One of the greatest successes within the Biodiversity & Habitat issue category is a global effort to designate more marine protected areas (MPAs). With over 15% of global coastlines protected, the world has surpassed Aichi Target 11, defined as a goal of reaching 10% global coverage by 2020. At the country level, 32 nations have achieved at least 10% coverage in their coastal and marine territories, more than double the number from a decade ago.

Figure 9-1. Distribution of regional scores on Biodiversity & Habitat. Numbers shown are regional medians.



Expanding marine protected areas also enhances carbon sequestration (Hopkins et al., 2016). Carefully-protected marine areas can help mitigate climate change, but there are still challenges to their implementation, including establishing effective adaptive management techniques (Hopkins et al., 2020). Using Brazil's MPAs as a case study, higher levels of research, investment, human resources, social participation, and lower levels of user-manager conflict were found to have a high impact on management effectiveness (Oliveira Júnior et al., 2016). Reaching the Aichi Biodiversity Target is a significant global achievement, but the range in country scores in marine protected areas illustrates that many nations still need significant improvements to the designation and management of their MPAs.

The world has fallen far short of reaching another important biodiversity target. Aichi Target 11 also set forth a goal of reaching 17% of terrestrial land coverage by 2020, yet as of 2022, only 12.6% of lands are protected. Forty-two countries have achieved at least 17% coverage in each of their terrestrial biomes, nine more countries than a decade ago. Of the planet's fourteen terrestrial biomes, only four have met the 17% goal of protection (Table 9-3). These include mangroves, flooded grasslands and savannas, moist broadleaf forests, and tundra. Four terrestrial biomes have yet to surpass even the 10% global protection threshold: dry broadleaf forests, deserts and xeric shrublands, montane grasslands and shrublands, and temperate grasslands, savannas, and shrublands. The lack of adequate protection for many of the world's biomes underscores the ongoing need for greater policy focus on this important issue.

3. Leaders and Laggards

The world has made modest improvements in the protection of biodiversity and habitat, but there is still significant variation in the actions taken by different countries. A gap of 88.3 points in Biodiversity & Habitat scores separates the best-performing country, Belize, from the worst-performing country, Micronesia. Exploring countries' success stories and failures provides valuable examples for any policymaker striving to improve their own nation's conservation efforts.

Belize earns the highest overall Biodiversity & Habitat score of 91.9, with 36.6% of its terrestrial lands and 19.8% of its marine territories protected across 108 different sites (Mitchell et al., 2017). These sites have a spectrum of different management and funding strategies, allowing for a broad array of stakeholders to participate in their

Table 9-3. Leaders and laggards in protecting the world's biomes, among countries with substantial areas of those biomes. Source: World Database on Protected Areas, with analysis by EPI.

Biome Type	Global Area (km^2)	Global Protected Area (km2)	Global Protected Area (%)	Leader	Leader (%)	Laggard	Laggard (%)
Tropical & Subtropical Moist Broadleaf Forests	19,922,562	4,513,813	22.7	Venezuela	76.1	Solomon Islands	0.32
Tropical & Subtropical Dry Broadleaf Forests	3,023,544	301,395	10.0	New Caledonia	57.1	India	0.13
Tropical & Subtropical Coniferous Forests	712,258	98,905	13.9	Dominican Republic	50.0	India	0.10
Temperate Broadleaf & Mixed Forests	12,858,397	1,572,246	12.2	Greece	52.3	Turkey	0.14
Temperate Conifer Forests	4,102,094	589,528	14.4	Czech Republic	69.0	India	0.00
Boreal Forests/Taiga	15,079,287	1,626,360	10.8	Mongolia	55.3	Norway	8.89
Tropical & Subtropical Grasslands, Savannas & Shrub	20,303,798	3,333,965	16.4	Suriname	98.7	Mauritania	0.22
Temperate Grasslands, Savannas & Shrublands	10,107,391	475,780	4.7	Romania	37.8	Turkmenistan	0.00
Flooded Grasslands & Savannas	1,099,303	307,135	27.9	Namibia	96.0	Ecuador	2.29
Montane Grasslands & Shrublands	5,203,926	443,098	8.5	Venezuela	93.4	India	0.12
Tundra	8,334,496	1,581,693	19.0	France	98.7	Canada	12.17
Mediterranean Forests, Woodlands & Scrub	3,225,519	485,675	15.1	Slovenia	52.8	Turkey	0.37
Deserts & Xeric Shrublands	27,983,772	2,655,752	9.5	Ecuador	95.2	India	0.02
Mangroves	351,340	106,425	30.3	Venezuela	76.5	Papua New Guinea	0.40

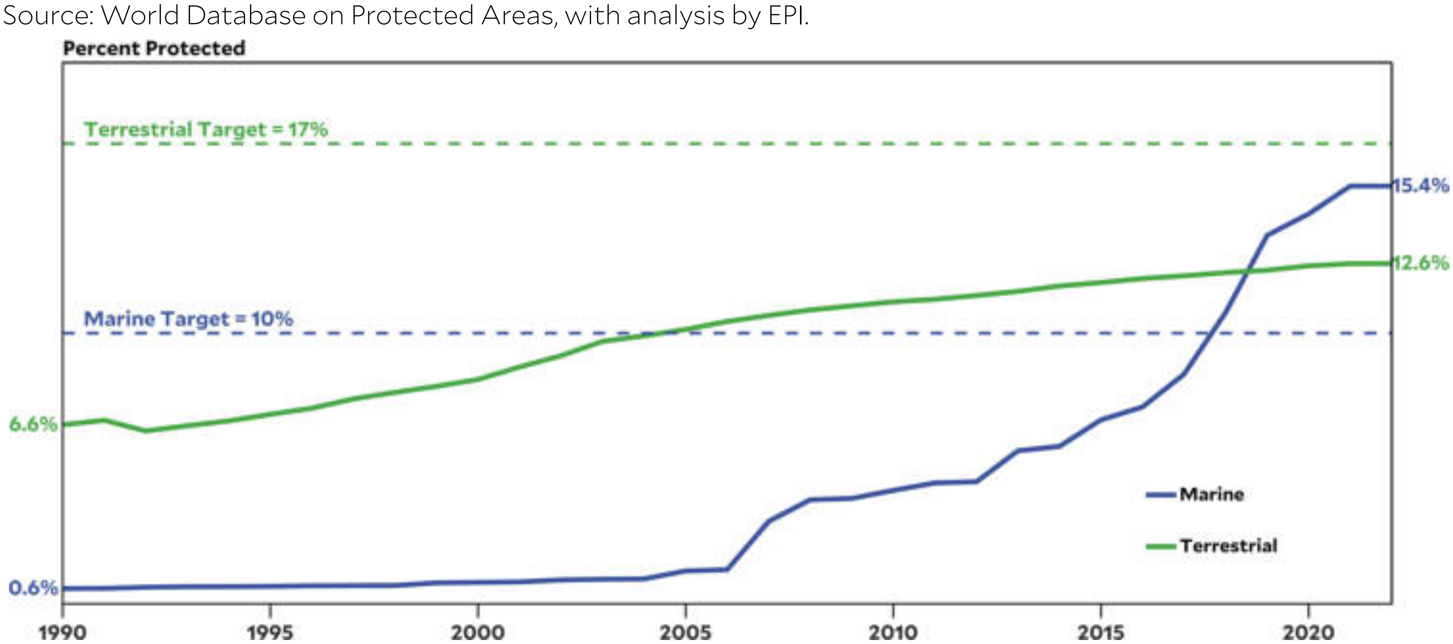
oversight. Government agencies manage just 43% of protected sites and supply only 18% of management funding (Mitchell et al., 2017). Belize relies on a dynamic system of private and local stewardship. Roughly 50% of protected sites in Belize's National Protected Areas System are co-managed, which has proven to be effective when multiple stakeholders are engaged and funding mechanisms are in place to ensure success (Williams and Tai, 2016). Broad stakeholder engagement in conservation plans can lead to greater success, yet some protected areas within Belize — such as the Mayflower Bocawina National Park — have seen dwindling support and resources (Williams and Tai, 2016), highlighting the need for continued attention to protect designated sites.

Botswana is another top-performing country in the Biodiversity & Habitat issue category, earning the third-highest score. Botswana conserves more than 17% of all but one of its seven ecoregions and over 29% of its total territory (Botswana Department of Environmental Affairs, 2016). Like Belize, Botswana's protected lands are maintained by a variety of management strategies. The country has 22 protected areas established by the central government, with an additional 11% of national land managed by a network of over 53 community-operated programs (Leepile and Arntzen, 2016; Mbaiwa, 2015). While the extent of success varies, many of these community organizations have contributed to the reduction of poaching, expansion of wildlife monitoring, and growth in wildlife conservation efforts due to increased awareness and commitments (Mbaiwa, 2015). Conservation researchers, however, should continue to monitor how Botswana's flora and fauna will respond to the increasing ecological pressure of climate change (Urich et al., 2021).

European countries generally exhibit high Biodiversity & Habitat scores, with Germany, Poland, France, Austria, Estonia, and Spain all being among the top ten countries. Approximately one quarter of the European Union's land is protected (Fischer et al., 2018). Under the Birds and Habitats Directives, vital breeding and resting grounds for endangered and threatened avian species are required to be designated as Natura 2000 sites, affording these areas special protections (European Commission, 2020b). The network of Natura 2000 sites protects 6% of marine and 18% of terrestrial areas within the EU. Croatia accomplished a remarkable 44.7-point increase in its Biodiversity & Habitat score since 2012, in part due its designation of more than a quarter of national lands as Natura 2000 sites once it joined the EU in 2013 (Vasilijevic et al., 2018). Slovenia, however, has the greatest proportion of national area protected under Natura 2000 sites in the EU: 37% (Gallo et al., 2018). A history of sustainable forest management has further allowed Slovenia to achieve the highest level of national Mediterranean forest biome protection in the world.

Several countries have made significant advances in marine protected areas in recent years. In 2018, Chile created the 740,000 km^2 Rapa Nui Marine Protected Area, followed in 2019 by the 144,390 km^2 Diego Ramírez Drake Passage Marine Park (Germani, 2019; Neslen, 2017). The Rapa Nui MPA covers the habitat of 142 endemic and 27 threatened and endangered species, including two whale and four sea turtle species. South Africa designated 20 new MPAs in 2019, covering 5% of national marine territory across different marine ecosystems (South African National Biodiversity Institute, 2019). Brazil has also seen a significant increase in its number of MPAs in recent

Figure 9-2. Global trends in terrestrial and marine protected areas, with global targets denoted by dashed lines. Source: World Database on Protected Areas, with analysis by EPI.



years, jumping 90 points in marine protected areas since 2012. Research suggests that some of these MPAs, however, still lack adequate management systems or are poorly placed: 800,000 km^2 of MPAs were designated in regions where human activity is rare or in areas that do not encompass the range of threatened species (Magris and Pressey, 2018).

Many of the lowest-scoring countries in Biodiversity & Habitat are from the Southern Asia and Asia-Pacific regions. Countries within these regions have suffered widespread habitat loss driven by infrastructure development and deforestation to support growing timber, rubber, crop, and biofuel trades (IPBES, 2019). Ecosystems in Thailand, Viet Nam, and the Philippines face further stress from tourism (Coca, 2019).

Other low-scoring nations include small island developing states like the Maldives, Micronesia, the Marshall Islands, and the Solomon Islands. Economic and population growth in these countries tests the limits of their marginal terrestrial resources. Dwindling coastal areas converted to aquaculture or structures like harbors and seawalls, paired with sea level rise-driven coastal erosion, drive a phenomenon called “coastal squeeze.” These factors are causing rapid habitat loss of island wetland, mangroves, and coral reefs (UNEP, 2014). Species on small islands have fewer options for finding new habitat as the effects of development and climate change destroy their home ecosystems (Russell and Kueffer, 2019; Taylor and Kumar, 2016). As a result, these species face greater risks of extinction (Sax and Gaines, 2008; Spatz et al., 2017).

Turkey, the third lowest-scoring country and the worst-performing Eastern European nation, has insufficiently protected biodiversity and habitat. Less than 7% of land area and 2% of marine territory is covered by protected areas, despite Turkey being home to several biodiversity hotspots and unique species (Şekercioğlu et al., 2011; UNEP-WCMC, 2021). Turkey’s immense infrastructure projects, like the Ilisu Dam, jeopardize critical habitat for threatened species, and restrict water supply in downstream countries like Syria, Iran, and Iraq (Hockenos, 2019).

4. Methods

The 2022 EPI uses the Convention on Biological Diversity’s Aichi Biodiversity targets to inform our indicators and performance targets. The Aichi Biodiversity Targets, adopted in 2010, set 20 goals aimed at conserving biodiversity and enhancing environmental benefits. Three of these goals define specific performance targets relating to the EPI’s indicators:

- 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, 2022)

The EPI’s seven Biodiversity & Habitat metrics are constructed to emphasize the importance of protected areas as an indicator of countries’ performance in biodiversity conservation. 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.

While habitat protection is an important step toward conservation, the mere designation of protected areas does not invariably lead to good environmental outcomes. The world lacks a universally defined 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).

An ideal Biodiversity & Habitat metric would factor in data on governance, management effectiveness, species population data, genetic diversity, economic impacts, and the effects of climate change. However, these data are sparse or nonexistent on the global scale. The 2022 EPI therefore relies on spatial extents of protected areas as indicators of country-level performance 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.

Terrestrial Biome Protection, National and Global Weights

The 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.

Indicator Background

We derive the *terrestrial biome protection* indicators by first calculating the proportion of each country's biomes that fall within protected areas. We then construct 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.

Data Sources

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 International Union for Conservation of Nature (IUCN). The WDPA is the world's most comprehensive protected area dataset, containing data on over 250,000 protected areas in 245 countries and territories for the years 1990 to 2022. 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 2022 update. Biome and ecoregion boundary data are derived from the World Wildlife Fund's "Terrestrial Ecoregions of the World" dataset (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) (CIESIN, 2019).

Limitations

Establishing protected areas is a necessary but insufficient condition to guarantee biodiversity conservation. Ongoing threats to protected areas are difficult to monitor using remote sensing, and evaluation of biodiversity outcomes requires repeated, consistent 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). The EPI's protected area indicators thus serve as an incomplete proxy for realized biome protection.

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 sustain local economies (Reuchlin-Hugenholtz and McKenzie, 2015). MPAs also play important but often overlooked roles in mitigating climate change (Hopkins et al., 2016).

Indicator Background

We calculate the *marine protected areas* indicator as the percentage of a country's exclusive economic zone (EEZ) covered by 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.

Data Sources

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

Limitations

Despite using the best available data through the WDPA, the *marine protected areas* indicator has several limitations. First, the indicator only accounts for MPAs within a country's EEZs and excludes MPAs in Areas Beyond National Jurisdiction (ABNJ), which comprise the majority of the world's oceans. 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, *marine protected areas* does not indicate management effectiveness or outcomes for biodiversity. The factors driving the success or failure of marine protected areas are the subject of much recent research (Claudet et al., 2020; Zupan et al., 2018). Key to better outcomes is the monitoring and enforcement of rules that come into effect when an area is designated as protected (Pendleton et al., 2018). As research advances our understanding of MPAs' ecosystem services, an additional indicator could track the degree to which a country's policies account for protected areas' climate mitigation and adaptation potentials (Hopkins et al., 2016; Wilson et al., 2020).

Protected Area Representativeness Index (PARI)

The Protected Area Representativeness Index (PARI) reflects the goal of Aichi Biodiversity Target 11 to prioritize conservation of ecologically representative habitat. Past conservation efforts have often focused on easy wins, 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 emphasizes the need for countries to ensure representative protection of the ecosystems and biological communities within their borders in order to help conserve the full diversity of life on Earth.

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). This indicator measures the representativeness of species composition in different spatial locations, ecosystems, and biological communities. The representativeness of all individual species, on the other hand, is the focus of the Species Protection Index, detailed below.

Data Sources
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. The 2022 EPI's metric relies on data from 2020.

Limitations
A better understanding of trends in ecological representativeness within protected area networks has the potential to improve conservation outcomes for a wider diversity of species. Coverage alone, however, does not guarantee that all species are prioritized or even considered by area management plans, or that protections are effective and enforced. 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.

Species Habitat Index (SHI)
The *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. The most significant driver of species extinction in terrestrial and freshwater ecosystems is habitat loss due to land-use change (IPBES, 2019). 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.

Indicator Background
The SHI 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.

Data Sources
Derivation of this metric uses 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).

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).

Species Protection Index (SPI)
The *Species Protection Index* (SPI) evaluates the degree to which each country's protected area network is ecologically representative at the species level. Whereas the PARI measures the representativeness of a country's protected area coverage of broader ecosystems and biological communities, the SPI measures the representative-ness 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.

Indicator Background
The SPI metric uses remotely sensed data, global biodi-

versity informatics, and integrative models to map suitable habitat for over 30,000 terrestrial vertebrate, invertebrate, and plant species. The EPI uses mapped data on the suitable range for each species within a country, calculating 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 to derive a country's score.

Data Sources
The SPI indicator is produced through the Map of Life and is available at its online interface, https://mol.org/. Maps of species' distributions and suitable habitats come 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.

Limitations
As with other indicators, high representativeness of protected areas does not guarantee effective management or improved species conservation outcomes. The SPI 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.

Biodiversity Habitat Index (BHI)
The *Biodiversity Habitat Index* (BHI) estimates the effects of habitat loss, degradation, and fragmentation on the expected retention of terrestrial biodiversity. According to Aichi Biodiversity Target 5, the world should halve the rate of habitat loss and significantly reduce habitat degradation and fragmentation. Whereas the SPI discussed above measures the impact of habitat loss on individual species, the BHI examines 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 degradation on the global diversity of communities and ecosystems.

Indicator Background
The BHI uses statistical models to predict the ecological similarity between areas based on geographical and abiotic environmental attributes. The models generate ecological similarity values ranging from 0 (no species in common) to 1 (all species in common) for all pairs of 1km-by-1km grid cells within a country. CSIRO then combines these ecological similarity data with data on land cover change or habitat condition. For each individual cell, CSIRO estimates the average 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.

Data Sources
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. Global Forest Change dataset and NASA's MODIS Land Cover Change dataset (Hansen et al., 2013).

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.

Chapter 10. Ecosystem Services

1. Introduction

Healthy ecosystems are crucial to human and environmental wellbeing. Forests, grasslands, and wetlands are homes to over 80% of known animal, plant, and insect species (UNEP, 2016). These ecosystems also provide food, shelter, energy, medicine, income, clean air, and water for over 1.6 million people (Oberle et al., 2019; UNEP, 2016). Collectively, these benefits are known as ecosystem services. Economists estimate that the value of these ecosystem services is 16.2 trillion USD annually and that their deterioration has resulted in substantial financial losses across various countries and industries (IPBES, 2019).

Humans harvest nearly 60 billion tons of both renewable and non-renewable resources annually (Oberle et al., 2019). Resource consumption outpaces the rates at which ecosystems can replenish water and biomass. Unsustainable natural resource use and ecosystem destruction are particularly damaging to the 900 million people living in poverty in rural areas. These individuals directly rely on ecosystem services to support food security, health systems, and roughly 22% of their income (Newcome et al., 2005).

The 2022 EPI uses three indicators — grassland loss, wetland loss, and tree cover loss — as metrics of the health of ecosystem services.

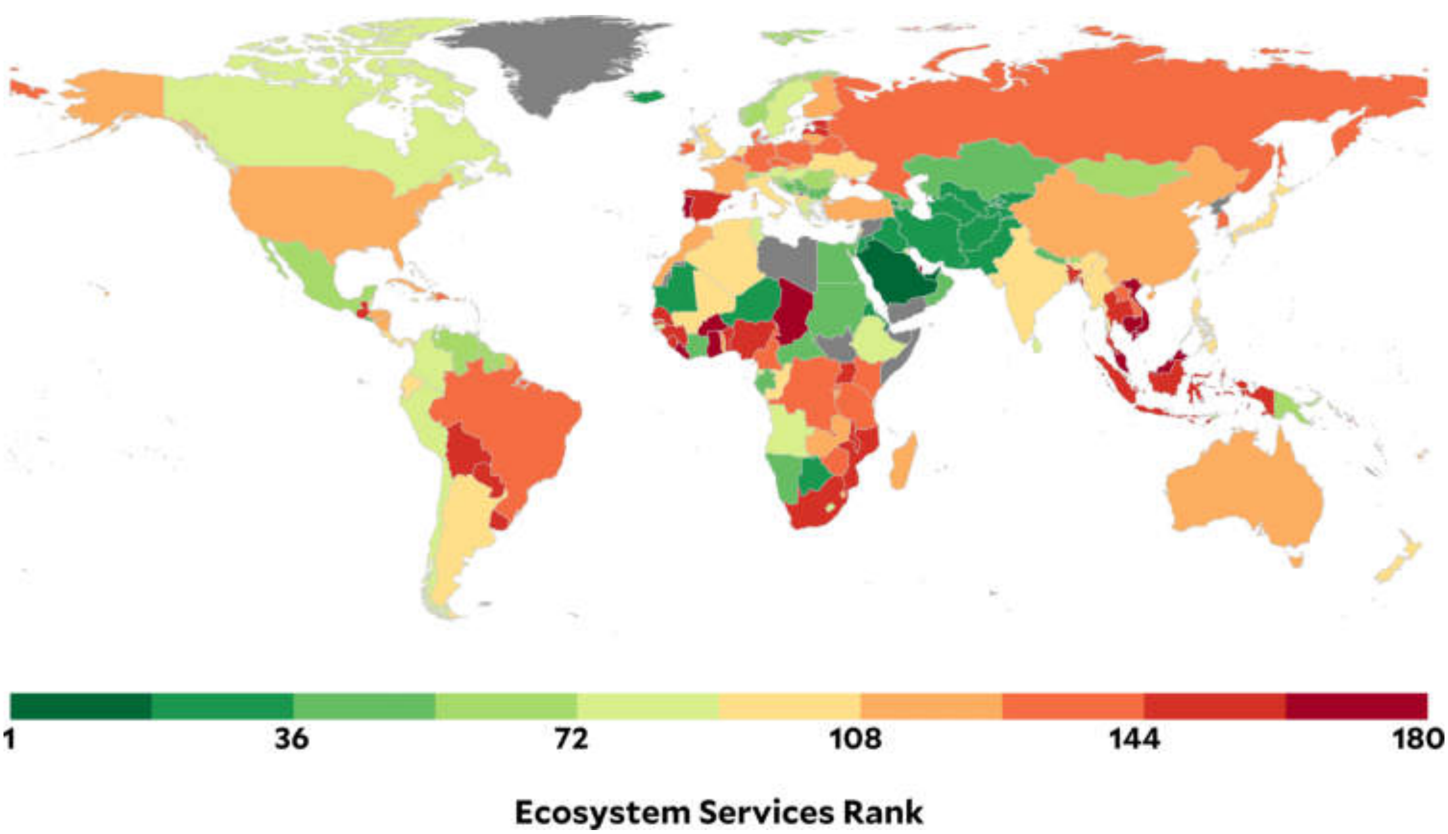
2. Indicators

Tree Cover Loss (75% of issue category)
Tree cover loss measures 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.

Grassland Loss (12.5% of issue category)
Grassland loss measures the percent reduction in a country's grassland area — defined as rangeland, pasture, and wild lands — from the reference year 1992 using a five-year moving average.

Wetland Loss (12.5% of issue category)
Wetland loss measures the percent reduction in a country's wetland area — defined as land that is covered or saturated by water for all or part of the year — from the reference year 1992 using a five-year moving average.

Map 10-1. Global rankings on Ecosystem Services.



Chapter 10

Table 10-1. Global rankings, scores, and regional rankings (REG) on Ecosystem Services.

RANK	COUNTRY	SCORE	REG
1	Djibouti	100.0	1
1	Mauritius	100.0	1
1	São Tomé and Príncpe	100.0	1
1	Maldives	100.0	1
1	Bahrain	100.0	1
1	Saudi Arabia	100.0	1
1	United Arab Emirates	100.0	1
1	Malta	100.0	1
1	Micronesia	100.0	1
10	Eritrea	90.1	4
11	Turkmenistan	84.0	1
12	Tajikistan	83.0	2
13	Niger	82.5	5
14	Mauritania	81.3	6
15	Cabo Verde	80.8	7
16	Iceland	77.4	2
17	Seychelles	71.7	8
18	Iraq	70.2	4
19	Iran	67.0	5
20	Jordan	63.2	6
21	Afghanistan	61.8	2
22	Kyrgyzstan	61.7	3
22	Uzbekistan	61.7	3
24	Pakistan	61.3	3
25	Armenia	59.7	5
26	Botswana	58.8	9
27	Azerbaijan	58.1	6
28	Côte d'Ivoire	55.5	10
29	Egypt	55.1	7
30	St. Vincent and Grenadines	51.9	1
31	Georgia	51.2	7
32	Oman	46.8	8
33	Bosnia and Herzegovina	45.4	1
34	Israel	42.2	9
35	Sudan	41.2	10
36	Kazakhstan	40.1	8
37	Central African Republic	39.7	11
37	Serbia	39.7	2
39	Antigua and Barbuda	39.5	2
40	Nepal	39.4	4
41	Namibia	39.1	12
42	Saint Lucia	38.9	3
43	Vanuatu	38.6	2
44	El Salvador	38.3	4
45	Gabon	37.7	13
46	Bulgaria	37.4	3
47	Montenegro	36.7	4
48	Trinidad and Tobago	36.0	5
49	Barbados	35.9	6
50	Grenada	35.8	7
51	Comoros	35.5	14
52	Romania	35.0	5
53	Croatia	34.4	6
53	Timor-Leste	34.4	3
55	Slovenia	34.1	7
56	Venezuela	33.6	8
57	Moldova	33.5	9
58	Bhutan	33.3	5
59	Suriname	33.1	9
60	Mexico	32.7	10
61	Cyprus	32.5	8
62	Guyana	31.5	11
63	Papua New Guinea	31.4	4
64	Mongolia	31.2	5
65	Norway	30.8	3
66	Switzerland	30.7	4
67	Sri Lanka	30.6	6
67	Colombia	30.6	12
69	Jamaica	30.1	13
70	Canada	29.8	5
71	Belize	29.7	14
71	Tunisia	29.7	11
73	Angola	29.4	15
74	Sweden	29.3	6
75	Equatorial Guinea	29.1	16
76	Kuwait	29.0	12
77	Gambia	28.5	17
78	Chile	28.4	15
79	Guinea-Bissau	28.3	18
79	Lesotho	28.3	18
81	Greece	28.1	9
81	Taiwan	28.1	6
83	Austria	28.0	7
83	Hungary	28.0	10
85	Ethiopia	27.6	20
85	Peru	27.6	16
87	New Zealand	26.9	8
88	Japan	26.8	7
89	Philippines	26.7	8
90	Mali	26.5	21
90	Republic of Congo	26.5	21
92	Lebanon	26.4	13
93	Italy	26.1	9
94	Myanmar	26.0	9
95	Ecuador	25.8	17
96	Bahamas	25.1	18
97	India	25.0	7
98	Netherlands	24.4	10
99	Albania	24.2	11
100	North Macedonia	24.0	12
101	Algeria	23.7	14
102	United Kingdom	23.6	11
103	Ukraine	23.3	10
104	Argentina	23.0	19
105	Costa Rica	22.9	20
106	Panama	22.8	21
107	Honduras	22.7	22
107	Fiji	22.7	10
109	Togo	22.4	23
110	Burundi	22.2	24
111	Turkey	22.0	13
112	Lithuania	21.9	14
113	Madagascar	21.8	25
114	China	21.6	11
115	France	21.5	12
116	Eswatini	20.9	26
117	Brunei Darussalam	20.7	12
118	Haiti	20.4	23
119	Morocco	20.1	15
119	Australia	20.1	13
119	Finland	20.1	13
119	United States of America	20.1	13
123	Zambia	19.9	27
123	Slovakia	19.9	15
125	Nicaragua	19.7	24
126	Cuba	19.2	25
127	Cameroon	19.1	28
127	Czech Republic	19.1	16
129	Tanzania	18.8	29
130	Russia	18.7	11
131	Luxembourg	18.1	16
132	Germany	17.9	17
133	Rwanda	17.8	30
134	Kenya	17.7	31
134	Zimbabwe	17.7	31
134	Belarus	17.7	12
134	Poland	17.7	17
134	South Korea	17.7	13
139	Dem. Rep. Congo	17.4	33
139	Ireland	17.4	18
141	Laos	17.2	14
142	Brazil	17.1	26
143	Dominican Republic	16.9	27
144	Denmark	16.4	19
145	Belgium	16.3	20
146	Benin	15.8	34
146	Mozambique	15.8	34
146	Sierra Leone	15.8	34
146	Latvia	15.8	18
150	Uruguay	15.7	28
151	Senegal	15.5	37
152	Thailand	15.3	15
153	Estonia	15.2	19
154	Malawi	15.0	38
155	Bangladesh	14.9	8
156	Uganda	14.6	39
157	South Africa	14.4	40
158	Dominica	14.3	29
159	Paraguay	14.1	30
160	Guinea	13.9	41
161	Indonesia	13.6	16
162	Spain	13.4	21
163	Bolivia	13.0	31
164	Guatemala	12.3	32
165	Nigeria	12.2	42
166	Solomon Islands	11.5	17
167	Ghana	10.3	43
168	Burkina Faso	9.7	44
168	Cambodia	9.7	18
170	Chad	9.0	45
171	Portugal	8.6	22
172	Viet Nam	8.5	19
173	Singapore	5.0	20
174	Malaysia	2.6	21
175	Liberia	2.4	46
176	Qatar	0.0	16
N/A	Kiribati		N/A
N/A	Marshall Islands		N/A
N/A	Samoa		N/A
N/A	Tonga		N/A

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 and scores on Ecosystem Services.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
St. Vincent and Grenadines	51.9	1
Antigua and Barbuda	39.5	2
Saint Lucia	38.9	3
El Salvador	38.3	4
Trinidad and Tobago	36.0	5
Barbados	35.9	6
Grenada	35.8	7
Venezuela	33.6	8
Suriname	33.1	9
Mexico	32.7	10
Guyana	31.5	11
Colombia	30.6	12
Jamaica	30.1	13
Belize	29.7	14
Chile	28.4	15
Peru	27.6	16
Ecuador	25.8	17
Bahamas	25.1	18
Argentina	23.0	19
Costa Rica	22.9	20
Panama	22.8	21
Honduras	22.7	22
Haiti	20.4	23
Nicaragua	19.7	24
Cuba	19.2	25
Brazil	17.1	26
Dominican Republic	16.9	27
Uruguay	15.7	28
Dominica	14.3	29
Paraguay	14.1	30
Bolivia	13.0	31
Guatemala	12.3	32

EASTERN EUROPE

Country	Score	Reg. Rank
Bosnia and Herzegovina	45.4	1
Serbia	39.7	2
Bulgaria	37.4	3
Montenegro	36.7	4
Romania	35.0	5
Croatia	34.4	6
Slovenia	34.1	7
Cyprus	32.5	8
Greece	28.1	9
Hungary	28.0	10
Albania	24.2	11
North Macedonia	24.0	12
Turkey	22.0	13
Lithuania	21.9	14
Slovakia	19.9	15
Czech Republic	19.1	16
Poland	17.7	17
Latvia	15.8	18
Estonia	15.2	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Maldives	100.0	1
Afghanistan	61.8	2
Pakistan	61.3	3
Nepal	39.4	4
Bhutan	33.3	5
Sri Lanka	30.6	6
India	25.0	7
Bangladesh	14.9	8

GLOBAL WEST

Country	Score	Reg. Rank
Malta	100.0	1
Iceland	77.4	2
Norway	30.8	3
Switzerland	30.7	4
Canada	29.8	5
Sweden	29.3	6
Austria	28.0	7
New Zealand	26.9	8
Italy	26.1	9
Netherlands	24.4	10
United Kingdom	23.6	11
France	21.5	12
Australia	20.1	13
Finland	20.1	13
United States of America	20.1	13
Luxembourg	18.1	16
Germany	17.9	17
Ireland	17.4	18
Denmark	16.4	19
Belgium	16.3	20
Spain	13.4	21
Portugal	8.6	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Turkmenistan	84.0	1
Tajikistan	83.0	2
Kyrgyzstan	61.7	3
Uzbekistan	61.7	3
Armenia	59.7	5
Azerbaijan	58.1	6
Georgia	51.2	7
Kazakhstan	40.1	8
Moldova	33.5	9
Ukraine	23.3	10
Russia	18.7	11
Belarus	17.7	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Micronesia	100.0	1
Vanuatu	38.6	2
Timor-Leste	34.4	3
Papua New Guinea	31.4	4
Mongolia	31.2	5
Taiwan	28.1	6
Japan	26.8	7
Philippines	26.7	8
Myanmar	26.0	9
Fiji	22.7	10
China	21.6	11
Brunei Darussalam	20.7	12
South Korea	17.7	13
Laos	17.2	14
Thailand	15.3	15
Indonesia	13.6	16
Solomon Islands	11.5	17
Cambodia	9.7	18
Viet Nam	8.5	19
Singapore	5.0	20
Malaysia	2.6	21
Kiribati	-	-
Marshall Islands	-	-
Samoa	-	-
Tonga	-	-

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Djibouti	100.0	1
Mauritius	100.0	1
Sao Tome and Principe	100.0	1
Eritrea	90.1	4
Niger	82.5	5
Mauritania	81.3	6
Cabo Verde	80.8	7
Seychelles	71.7	8
Botswana	58.8	9
Cote d'Ivoire	55.5	10
Central African Republic	39.7	11
Namibia	39.1	12
Gabon	37.7	13
Comoros	35.5	14
Angola	29.4	15
Equatorial Guinea	29.1	16
Gambia	28.5	17
Guinea-Bissau	28.3	18
Lesotho	28.3	18
Ethiopia	27.6	20
Mali	26.5	21
Republic of Congo	26.5	21
Togo	22.4	23
Burundi	22.2	24
Madagascar	21.8	25
Eswatini	20.9	26
Zambia	19.9	27
Cameroon	19.1	28
Tanzania	18.8	29
Rwanda	17.8	30
Kenya	17.7	31
Zimbabwe	17.7	31
Dem. Rep. Congo	17.4	33
Benin	15.8	34
Mozambique	15.8	34
Sierra Leone	15.8	34
Senegal	15.5	37
Malawi	15.0	38
Uganda	14.6	39
South Africa	14.4	40
Guinea	13.9	41
Nigeria	12.2	42
Ghana	10.3	43
Burkina Faso	9.7	44
Chad	9.0	45
Liberia	2.4	46

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Bahrain	100.0	1
Saudi Arabia	100.0	1
United Arab Emirates	100.0	1
Iraq	70.2	4
Iran	67.0	5
Jordan	63.2	6
Egypt	55.1	7
Oman	46.8	8
Israel	42.2	9
Sudan	41.2	10
Tunisia	29.7	11
Kuwait	29.0	12
Lebanon	26.4	13
Algeria	23.7	14
Morocco	20.1	15
Qatar	0.0	16

2. Global Trends

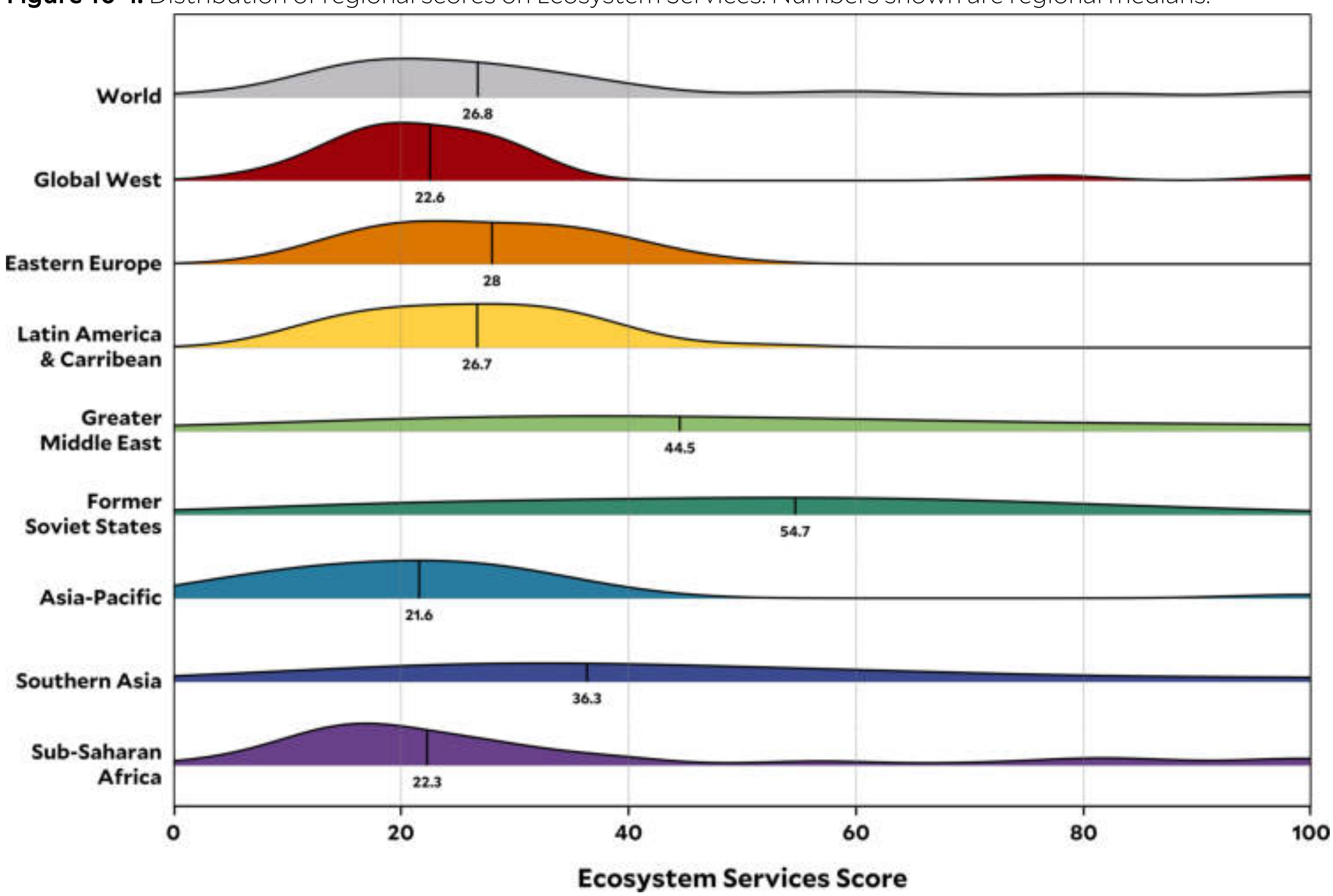
Despite international, regional, and localized efforts to preserve land, terrestrial ecosystems are rapidly deteriorating. Over 11 million hectares of tree cover were lost in 2021, with 3.75 million hectares lost within tropical primary rainforests that provide critical biodiversity and carbon storage services (Weisse and Goldman, 2022). These losses resulted in over two gigatons of carbon dioxide emissions (Harris et al., 2021).

Roughly 63% of the countries included in the EPI's dataset receive a lower score in the EPI's tree cover loss indicator than they would have ten years ago. Economists believe these trends signal difficulties for the global economy, supply chains, and human welfare in the coming decades: one study found that 55% of the global GDP or the USD equivalent of 41.7 trillion dollars is contingent on "high-functioning biodiversity and ecosystem services" (Swiss Re Institute, 2020). Degraded ecosystem services could put 20% of countries at risk of disruption to their industrial supply chains, food sources, healthcare, and other sectors.

Drivers of ecosystem loss and degradation are complex. Only about 27% of global forest loss occurs due to deforestation through permanent land-use change (Curtis et al., 2018). The remaining forest loss and degradation occurs due to forestry (26%), agricultural expansion (24%), and wildfire (23%). Forest loss from natural resource consumption is especially prevalent in developing countries, where wood is more commonly used for cooking and heating and agricultural land expansion drives deforestation (Gioda, 2019; Leblois et al., 2017). The solution is not as simple as expanding biome protections: deforestation rates drop up to 40%, but are not entirely eliminated, in protected areas (Wolf et al., 2021). Countries may be able to minimize deforestation by improving agricultural land-use efficiency and transitioning toward electrified energy sources (Assunção et al., 2016; Tanner and Johnston, 2017).

Wetlands are an important freshwater source and serve as an important breeding ground for nearly 40% of the world's terrestrial animal species (Ramsar Convention

Figure 10-1. Distribution of regional scores on Ecosystem Services. Numbers shown are regional medians.



Secretariat, 2018). Nearly 35% of wetlands have been lost since 1970, a destruction rate almost three times that of forests (Courouble et al., 2021). The loss stems from drainage, dam construction, excess sedimentation, pollution, and climate change (Ramsar Convention Secretariat, 2018). The 2022 EPI finds high levels of wetland loss in the Asia-Pacific and Latin America & the Caribbean. Asia harbors the world's largest inland wetland area with 4.1 million square kilometers, but the continent has the lowest percentage (8%) of its wetlands under formal protection (Reis et al., 2017). While Latin America & the Caribbean have attained a higher percentage of wetland protection, many of these areas are still subjected to degradation and loss from agricultural expansion, construction, and the lack of effective monitoring and conservation strategies (Wittmann et al., 2015).

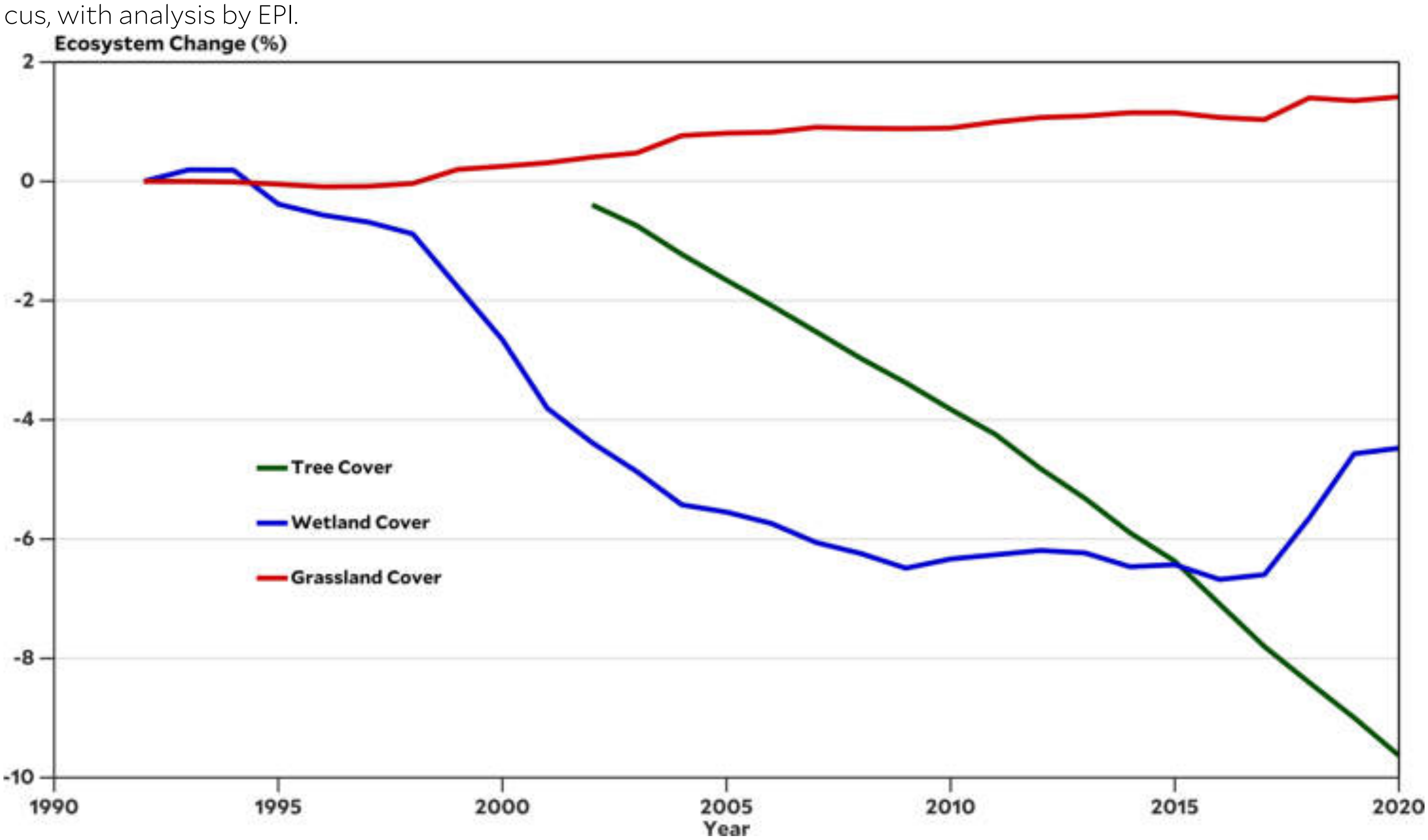
Global grasslands support the livelihoods of 800 million people and store nearly one-third of the biosphere's carbon (Blair et al., 2014). Grassland conversion to cropland, and the tilling this conversion requires, generates nearly 40 million tons of carbon emissions in the United States alone (Spawn et al., 2019). In some regions, grassland protection can be up to three times more effective at removing carbon from the atmosphere than forest conservation (Dass et al., 2018). Grasslands not only serve as habitats and spaces for livestock production but also serve as protection against flooding and erosion.

Grassland preservation has historically been threatened by overgrazing and land-use change. Newer threats include hydraulic fracturing for natural gas, mineral extraction, and biofuel production (Fletcher et al., 2011; Howden et al., 2018). Today, less than 5% of global grassland area exists under formal protection (Carbutt et al., 2017). The conservation of grasslands requires expanded protected areas and better monitoring of human impact on these critical ecosystems.

3. Leaders and Laggards

Many of the top-scoring countries in the Ecosystem Services issue category have adopted robust preservation initiatives that recognize their vast ecosystems' environmental and economic importance. Other high-scoring countries include those with small areas of forests, wetlands, and grasslands that have sought to minimize their loss.

Figure 10-2. Percent changes in global land cover by ecosystem, normalized from reference year. Source: Copernicus, with analysis by EPI.



Countries in the Greater Middle East and Sub-Saharan Africa, such as Mauritania, Niger, Eritrea, and Saudi Arabia, exhibit low deforestation rates and achieve high scores in tree cover loss. Located in arid and relatively unforested areas, some of these countries demonstrate high performance through sustainable preservation policies and programs. Burkina Faso, for instance, boasts a community-led initiative that integrates forestry management with national conservation programs (Ouedraogo, 2014).

Seychelles, one of the top-ranking countries in tree cover loss, has begun a large-scale reforestation initiative after several decades of agricultural land clearing, drought, and erosion that left 40% of the island's forests in danger of irreversible damage without intervention (Senterre, 2009). The government has begun working with local partners, including those involved with tourist management, and set forth a series of initiatives designed to preserve forests, reduce consumption, and replenish the island's ecosystems (Vermillion, 2020).

Many Southeast Asian countries — including Malaysia, Viet Nam, and Cambodia —receive low Ecosystem Services scores due to their recent large-scale deforestation initiatives to support their agricultural expansion (Russell, 2020). These countries' rapid economic and population growth have accelerated rates of forest loss, as has the growing global demand for Southeast Asian exports such as timber, palm oil, and rubber (Ivancic and Koh, 2016; Meijaard et al., 2020). Recognizing how palm oil plantations have driven deforestation in these countries, the European Union has recently announced intentions to remove palm oil from its lists of green transportation fuels (Munthe and Blenkinsop, 2019).

Many Asian-Pacific and Global West countries receive low scores in wetland loss. Taiwan, which earns a score of 16.6, only recently passed and implemented a national Wetlands Conservation Act (Su, 2014), lacks a comprehensive wetland health monitoring network (Otte et al., 2021). Several European countries also receive low scores, with Belgium, Spain, Germany, Poland, and the Netherlands falling in the bottom twenty. In the Netherlands, historically expansive coastal wetland ecosystems were fragmented to a degree where their ability to perform ecosystem services has diminished (Colijn et al., 1993). More recent initiatives have begun to restore wetlands along the North Sea (Verhoeven, 2014).

Laggards in grassland conservation include many Sub-Saharan countries: Liberia, Côte d'Ivoire, Ghana, Senegal, Malawi, and Uganda fall among the 10-worst performing countries in grassland loss. Senegalese grasslands are prone to fires, with an estimated 196,000 hectares lost per year (Sow et al., 2016). Between 1999 and 2018, Malawi lost over 14% of its established grasslands, driven mainly by cropland conversion (Gondwe et al., 2019). These examples illustrate the complexities in grassland conservation as countries strive to develop sustainably.

4. Methods

Tree Cover Loss

Indicator Background

The 2022 EPI derives *tree cover loss* by constructing a five-year moving average of the percent of forest loss in reference to a country's forest area in the year 2000 — the earliest extent of reliable data. Forest cover is defined as land area with over 30% canopy cover (Lund, 2002).

Data Sources

Tree cover data are compiled by Global Forest Watch, an open-source research 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 derived from remote sensing satellite imagery in a collaboration between the University of Maryland, Google Earth, the United States Geological Survey, and the U.S. National Aeronautics and Space Administration (NASA). The model uses Landsat satellite images to map annual tree cover loss at a 30-meter by 30-meter grid resolution.

Limitations

New generations of remote sensing technologies have brought more accurate detections of tree cover loss since monitoring began in 2001. The model uses imagery from Landsat 5, 7, and 8 satellites to monitor ground cover. The Landsat 8 data can better resolve tree cover, enabling detections of tree cover loss smaller than an individual 30-by-30 meter grid from 2013 onwards (GFW, 2021). As the methodology for quantifying tree cover loss was updated between 2010 and 2011, policymakers should exercise caution when comparing results across these years.

The Global Forest Watch data encompass only the years 2000 to 2020. Based on limitations of earlier satellite data, researchers are unable to obtain historic data on tree cover before 2000, limiting our understanding of tree cover loss before that year. Countries with substantial tree cover loss before 2000 may therefore appear to do better in the indicator than countries with the same amount of tree cover loss after 2000.

Global Forest Watch data does not differentiate between natural forest loss — such as natural forest fires or hurricane destruction — and anthropogenic forest loss. The dataset does not currently distinguish between different forest types. The loss of old-growth and native species is treated equally as a loss in newer growth forests or monoculture tree plantations, despite the former having more detrimental consequences for biodiversity and ecosystem services.

One aspect of the Global Forest Watch data is that the remotely-sensed imagery representing tree cover loss only detects loss of canopy cover, or the upper-most level of the forest structure. This limitation makes it difficult to detect early stages of forest regrowth. The data are unable to differentiate between temporary tree loss and more permanent deforestation. The model also does not monitor land cover after a forest is lost, which may present a picture of forest loss that is overly pessimistic (Pearce, 2018). New remote sensing methods coupled with forest growth models may help researchers derive more accurate characterizations of global forest loss (Curtis et al., 2018; McNicol et al., 2018; Watson et al., 2018).

Grassland and Wetland Loss

Indicator Background

The EPI derives *grassland loss* and *wetland loss* by calculating five-year moving averages of gross losses in these ecosystems. The indicators are based on percent loss compared to the grassland and wetland area in the 1992 reference year.

Data Sources

Grassland loss and *wetland loss* are derived from a time series of annual global land cover maps spanning 1992 to 2020. The maps are released by the European Space Agency's (ESA) Climate Change Initiative, covering 1992 to 2015, and the Copernicus Climate Change Service (C3S), covering 2016 to 2020. The C3S global Land Cover maps from 2016 to 2020 are consistent with the European Space Agency Climate Change Initiative global annual LC maps from 1992 to 2015 to ensure continuity (Defourny et al., 2021).

The land cover data provide globally-gridded maps at 300-meter spatial resolution classifying land surface into 22 classes, defined using the United Nations Food and Agriculture Organization's (UN FAO) Land Cover Classification System (LCCS). These classes include grassland and wetlands. To produce an uninterrupted time series, a 10-year baseline land cover map was produced from the Medium Resolution Imaging Spectrometer (MERIS) Full and Reduced Resolution archive from 2003 to 2012. The baseline map is then adjusted using changes detected from Advanced Very-High-Resolution Radiometer (AVHRR) time series from 1992 to 1999, (ii) SPOT-Vegetation (SPOT-VGT) time series from 1998 to 2012, and (iii) PROBA-Vegetation (PROBA-V) and Sentinel-3 OLCI (S3 OLCI) time series from 2013 (Defourny et al., 2021).

Limitations

Land cover characterizations derived from remotely-sensed data may not always reflect on-the-ground conditions. New techniques are improving the accuracy, spatial resolution, and temporal resolution of land cover datasets, but these methods currently extend to maps back to 2015 (Google Earth, 2022). Remote sensing techniques cannot reliably differentiate between new grassland and old-growth grasslands. Although the latter have significantly enhanced carbon sequestration potential and thus provide greater ecosystem services (Blair et al., 2014; Veldman et al., 2015), the grassland loss indicator weighs the losses of these grassland types equally.

Wetland cover is particularly difficult to resolve, especially in seasonally-flooded areas. Techniques cannot currently distinguish between natural and artificial wetlands, nor between wetlands characterized by native versus invasive species (Mahdavi et al., 2018). Newly restored wetlands can come with a climate penalty resulting from methane emissions (Hemes et al., 2018), although improved ecosystem engineering techniques can mitigate this penalty (Yang et al., 2020).

Focus 10.1

Google's Dynamic World: Toward More Accurate Land Cover Data

Land cover information is critical for many environmental applications, but climate and sustainability policies are currently held back by the lack of timely, accurate, and versatile data. Researchers at Google Earth, the World Resources Institute, and National Geographic have partnered to generate a cutting-edge dataset on land cover using remotely sensed imagery coupled with modern artificial intelligence. The upcoming Dynamic World dataset brings to the table a land cover analysis of unprecedented detail: land cover maps are available at a 10-meter spatial resolution and are updated daily.

Dynamic World uses satellite imagery from the European Space Agency's Sentinel-2 mission to construct maps of land cover as defined into 9 classes: water, flooded vegetation, built-up areas, trees, crops, bare ground, grass, shrubland, and snow/ice-covered areas. Advanced computing and machine learning techniques not only assign the most likely land cover to each pixel but also provide probabilities of what each pixel could be.

The Dynamic World dataset currently extends back to 2015, which is too recent to support an indicator tracking historical changes to ecosystem loss. As the dataset expands, however, it is of immense use to policymakers, business leaders, and researchers seeking to reduce greenhouse gas emissions from land-use change, track progress toward reducing deforestation, and help companies identify more sustainable supply chains.

Chapter 11. Fisheries

1. Introduction

The world depends on fish. An estimated 10% of the global population relies on fisheries for its livelihood (FAO, 2020). This population is concentrated in low- and middle-income countries, home to 50% of global fish catch (FAO, 2020). Around the world, fisheries are drivers of employment, economies, and simple subsistence. But even as increasing numbers of people catch, eat, and process fish, the health of global fisheries is in decline. In 1974, 90% of fisheries were fished at sustainable levels (FAO, 2020). In 2017, only 59.6% were (FAO, 2020). Ecologically harmful fishing practices, poor fisheries management, and climate stressors have been, and continue, to be responsible for much of this decrease (Barange et al., 2014).

For all the challenges fisheries face, sustainable fishing practices are within reach of countries that invest in effective management, permitting, and technologies. Policy changes implemented around the world in the last two decades have shown that better management can drive relatively rapid fishery recovery (Hegland and Raakjær, 2008; Kraak et al., 2013). This section highlights successful actors and poor performers, in addition to summing up global trends in a sector that is a critical source of nutrition and income to over three billion people around the world.

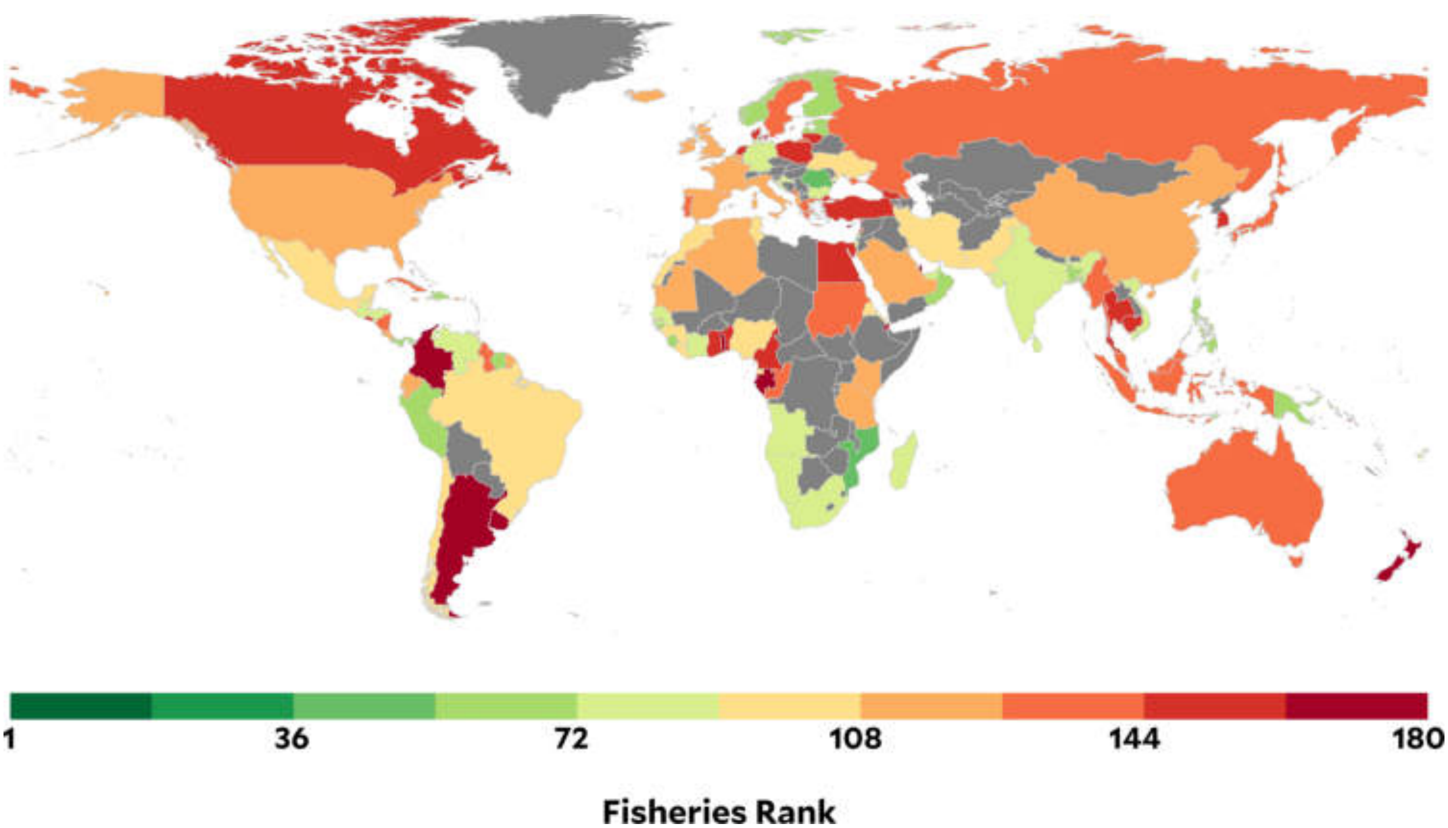
2. Indicators

Fish Stock Status (36% 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).

Marine Trophic Index (36% of issue category)
Marine Trophic Index captures ecological pressures on fish stocks. 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 — a scenario known as "fishing down the food web" (Pauly et al., 2008).

Fish Caught by Trawling and Dredging (28% of issue category)
Fish caught by trawling and dredging measures the percent of a country's fish caught by bottom trawling, in which a fishing net is pulled along the seafloor (NOAA, 2022), and by dredging, in which a dredge is pulled through seafloor sediment to collect bottom-dwelling species (NOAA, 2018). These techniques indiscriminately catch marine life and harm sensitive ecosystems along the seafloor.

Map 11-1. Global rankings on Fisheries.



Chapter 11

Table 11-1. Global rankings, scores, and regional rankings (REG) on Fisheries.

RANK	COUNTRY	SCORE	REG
1	Cabo Verde	100.0	1
1	Singapore	100.0	1
3	Comoros	78.4	2
4	St. Vincent and Grenadines	72.5	1
5	Romania	66.3	1
6	Mozambique	57.1	3
7	Maldives	56.7	1
8	Tonga	54.8	2
9	Dominican Republic	51.4	2
10	Malta	47.8	1
11	Peru	45.2	3
12	Marshall Islands	44.2	3
13	Finland	42.4	2
14	Suriname	40.9	4
15	Estonia	40.8	2
16	Norway	39.7	3
17	Latvia	38.4	3
18	Oman	35.6	1
19	Papua New Guinea	35.5	4
20	Bangladesh	35.1	2
21	Philippines	34.8	5
22	Sierra Leone	34.0	4
23	Haiti	33.5	5
24	Timor-Leste	33.3	6
25	Panama	33.2	6
26	Guinea-Bissau	33.0	5
27	Fiji	32.3	7
28	Sri Lanka	31.8	3
29	Madagascar	30.2	6
30	South Africa	29.9	7
31	Côte d'Ivoire	29.3	8
32	Venezuela	27.7	7
33	Israel	27.6	2
34	Germany	26.9	4
35	Honduras	26.8	8
36	Namibia	26.5	9
37	Saint Lucia	26.2	9
37	United Arab Emirates	26.2	3
39	Croatia	26.0	4
40	Guatemala	25.5	10
41	Taiwan	25.3	8
42	India	24.5	4
43	Angola	24.3	10
44	Viet Nam	24.2	9
45	Senegal	23.9	11
46	Bulgaria	23.8	5
47	Ukraine	23.7	1
48	Pakistan	23.6	5
49	Iran	23.4	4
50	Nigeria	23.3	12
50	Chile	23.3	11
52	Eritrea	22.7	13
53	Brazil	22.3	12
54	Tunisia	22.1	5
55	Guinea	22.0	14
56	Equatorial Guinea	21.9	15
57	Kiribati	21.5	10
58	Morocco	21.2	6
59	Vanuatu	21.0	11
60	Liberia	20.7	16
60	Belize	20.7	13
62	Seychelles	20.3	17
63	Mexico	19.8	14
64	São Tomé and Príncpe	19.7	18
64	Antigua and Barbuda	19.7	15
66	Saudi Arabia	19.5	7
66	France	19.5	5
68	Barbados	19.3	16
69	Ecuador	19.2	17
69	Iceland	19.2	6
71	Tanzania	19.1	19
72	Kuwait	18.6	8
73	Mauritius	18.5	20
73	Algeria	18.5	9
75	Mauritania	18.2	21
75	Ireland	18.2	7
77	China	17.7	12
78	Costa Rica	17.5	18
79	Albania	17.3	6
80	United States of America	17.2	8
81	United Kingdom	17.0	9
82	Jamaica	16.9	19
83	Italy	16.8	10
84	Trinidad and Tobago	16.5	20
85	Kenya	16.4	22
85	Belgium	16.4	11
85	Spain	16.4	11
88	Bahamas	16.3	21
88	Indonesia	16.3	13
90	Sudan	16.0	10
91	Greece	15.6	7
91	Japan	15.6	14
93	Samoa	15.5	15
94	Lebanon	15.4	11
95	Sweden	15.3	13
96	Myanmar	15.1	16
97	Republic of Congo	14.9	23
98	Portugal	14.7	14
99	Grenada	14.6	22
99	Guyana	14.6	22
99	Australia	14.6	15
102	Nicaragua	14.4	24
102	Montenegro	14.4	8
104	Malaysia	14.3	17
105	Cuba	13.9	25
106	Russia	13.7	2
107	Lithuania	13.4	9
108	Georgia	13.2	3
109	Netherlands	13.0	16
110	Bahrain	12.9	12
110	Thailand	12.9	18
112	Ghana	12.8	24
112	Canada	12.8	17
112	South Korea	12.8	19
115	Solomon Islands	12.7	20
116	Gambia	12.5	25
117	Dominica	12.4	26
118	El Salvador	12.0	27
119	Benin	11.3	26
119	Cambodia	11.3	21
121	Poland	11.0	10
122	Denmark	10.9	18
123	Egypt	10.6	13
124	Cameroon	10.4	27
125	Turkey	9.5	11
126	Brunei Darussalam	8.4	22
127	New Zealand	7.4	19
128	Togo	7.1	28
129	Gabon	7.0	29
130	Colombia	6.6	28
131	Djibouti	6.5	30
132	Cyprus	6.2	12
133	Argentina	5.8	29
134	Uruguay	5.7	30
134	Qatar	5.7	14
136	Micronesia	0.0	23
N/A	Botswana		N/A
N/A	Burkina Faso		N/A
N/A	Burundi		N/A
N/A	Central African Republic		N/A
N/A	Chad		N/A
N/A	Dem. Rep. Congo		N/A
N/A	Eswatini		N/A
N/A	Ethiopia		N/A
N/A	Lesotho		N/A
N/A	Malawi		N/A
N/A	Mali		N/A
N/A	Niger		N/A
N/A	Rwanda		N/A
N/A	Uganda		N/A
N/A	Zambia		N/A
N/A	Zimbabwe		N/A
N/A	Afghanistan		N/A
N/A	Bhutan		N/A
N/A	Nepal		N/A
N/A	Bolivia		N/A
N/A	Paraguay		N/A
N/A	Iraq		N/A
N/A	Jordan		N/A
N/A	Austria		N/A
N/A	Luxembourg		N/A
N/A	Switzerland		N/A
N/A	Armenia		N/A
N/A	Azerbaijan		N/A
N/A	Belarus		N/A
N/A	Kazakhstan		N/A
N/A	Kyrgyzstan		N/A
N/A	Moldova		N/A
N/A	Tajikistan		N/A
N/A	Turkmenistan		N/A
N/A	Uzbekistan		N/A
N/A	Bosnia and Herzegovina		N/A
N/A	Czech Republic		N/A
N/A	Hungary		N/A
N/A	North Macedonia		N/A
N/A	Serbia		N/A
N/A	Slovakia		N/A
N/A	Slovenia		N/A
N/A	Laos		N/A
N/A	Mongolia		N/A

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 and scores on Fisheries.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
St. Vincent and Grenadines	72.5	1
Dominican Republic	51.4	2
Peru	45.2	3
Suriname	40.9	4
Haiti	33.5	5
Panama	33.2	6
Venezuela	27.7	7
Honduras	26.8	8
Saint Lucia	26.2	9
Guatemala	25.5	10
Chile	23.3	11
Brazil	22.3	12
Belize	20.7	13
Mexico	19.8	14
Antigua and Barbuda	19.7	15
Barbados	19.3	16
Ecuador	19.2	17
Costa Rica	17.5	18
Jamaica	16.9	19
Trinidad and Tobago	16.5	20
Bahamas	16.3	21
Grenada	14.6	22
Guyana	14.6	22
Nicaragua	14.4	24
Cuba	13.9	25
Dominica	12.4	26
El Salvador	12.0	27
Colombia	6.6	28
Argentina	5.8	29
Uruguay	5.7	30
Bolivia	-	-
Paraguay	-	-

EASTERN EUROPE

Country	Score	Reg. Rank
Romania	66.3	1
Estonia	40.8	2
Latvia	38.4	3
Croatia	26.0	4
Bulgaria	23.8	5
Albania	17.3	6
Greece	15.6	7
Montenegro	14.4	8
Lithuania	13.4	9
Poland	11.0	10
Turkey	9.5	11
Cyprus	6.2	12
Bosnia and Herzegovina	-	-
Czech Republic	-	-
Hungary	-	-
North Macedonia	-	-
Serbia	-	-
Slovakia	-	-
Slovenia	-	-

SOUTHERN ASIA

Country	Score	Reg. Rank
Maldives	56.7	1
Bangladesh	35.1	2
Sri Lanka	31.8	3
India	24.5	4
Pakistan	23.6	5
Afghanistan	-	-
Bhutan	-	-
Nepal	-	-

GLOBAL WEST

Country	Score	Reg. Rank
Malta	47.8	1
Finland	42.4	2
Norway	39.7	3
Germany	26.9	4
France	19.5	5
Iceland	19.2	6
Ireland	18.2	7
United States of America	17.2	8
United Kingdom	17.0	9
Italy	16.8	10
Belgium	16.4	11
Spain	16.4	11
Sweden	15.3	13
Portugal	14.7	14
Australia	14.6	15
Netherlands	13.0	16
Canada	12.8	17
Denmark	10.9	18
New Zealand	7.4	19
Austria	-	-
Luxembourg	-	-
Switzerland	-	-

FORMER SOVIET STATES

Country	Score	Reg. Rank
Ukraine	23.7	1
Russia	13.7	2
Georgia	13.2	3
Armenia	-	-
Azerbaijan	-	-
Belarus	-	-
Kazakhstan	-	-
Kyrgyzstan	-	-
Moldova	-	-
Tajikistan	-	-
Turkmenistan	-	-
Uzbekistan	-	-

ASIA-PACIFIC

Country	Score	Reg. Rank
Singapore	100.0	1
Tonga	54.8	2
Marshall Islands	44.2	3
Papua New Guinea	35.5	4
Philippines	34.8	5
Timor-Leste	33.3	6
Fiji	32.3	7
Taiwan	25.3	8
Viet Nam	24.2	9
Kiribati	21.5	10
Vanuatu	21.0	11
China	17.7	12
Indonesia	16.3	13
Japan	15.6	14
Samoa	15.5	15
Myanmar	15.1	16
Malaysia	14.3	17
Thailand	12.9	18
South Korea	12.8	19
Solomon Islands	12.7	20
Cambodia	11.3	21
Brunei Darussalam	8.4	22
Micronesia	0.0	23
Laos	-	-
Mongolia	-	-

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Cabo Verde	100.0	1
Comoros	78.4	2
Mozambique	57.1	3
Sierra Leone	34.0	4
Guinea-Bissau	33.0	5
Madagascar	30.2	6
South Africa	29.9	7
Cote d'Ivoire	29.3	8
Namibia	26.5	9
Angola	24.3	10
Senegal	23.9	11
Nigeria	23.3	12
Eritrea	22.7	13
Guinea	22.0	14
Equatorial Guinea	21.9	15
Liberia	20.7	16
Seychelles	20.3	17
Sao Tome and Principe	19.7	18
Tanzania	19.1	19
Mauritius	18.5	20
Mauritania	18.2	21
Kenya	16.4	22
Republic of Congo	14.9	23
Ghana	12.8	24
Gambia	12.5	25
Benin	11.3	26
Cameroon	10.4	27
Togo	7.1	28
Gabon	7.0	29
Djibouti	6.5	30
Botswana	-	-
Burkina Faso	-	-
Burundi	-	-
Central African Republic	-	-
Chad	-	-
Dem. Rep. Congo	-	-
Eswatini	-	-
Ethiopia	-	-
Lesotho	-	-
Malawi	-	-
Mali	-	-
Niger	-	-
Rwanda	-	-
Uganda	-	-
Zambia	-	-
Zimbabwe	-	-

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Oman	35.6	1
Israel	27.6	2
United Arab Emirates	26.2	3
Iran	23.4	4
Tunisia	22.1	5
Morocco	21.2	6
Saudi Arabia	19.5	7
Kuwait	18.6	8
Algeria	18.5	9
Sudan	16.0	10
Lebanon	15.4	11
Bahrain	12.9	12
Egypt	10.6	13
Qatar	5.7	14
Iraq	-	-
Jordan	-	-

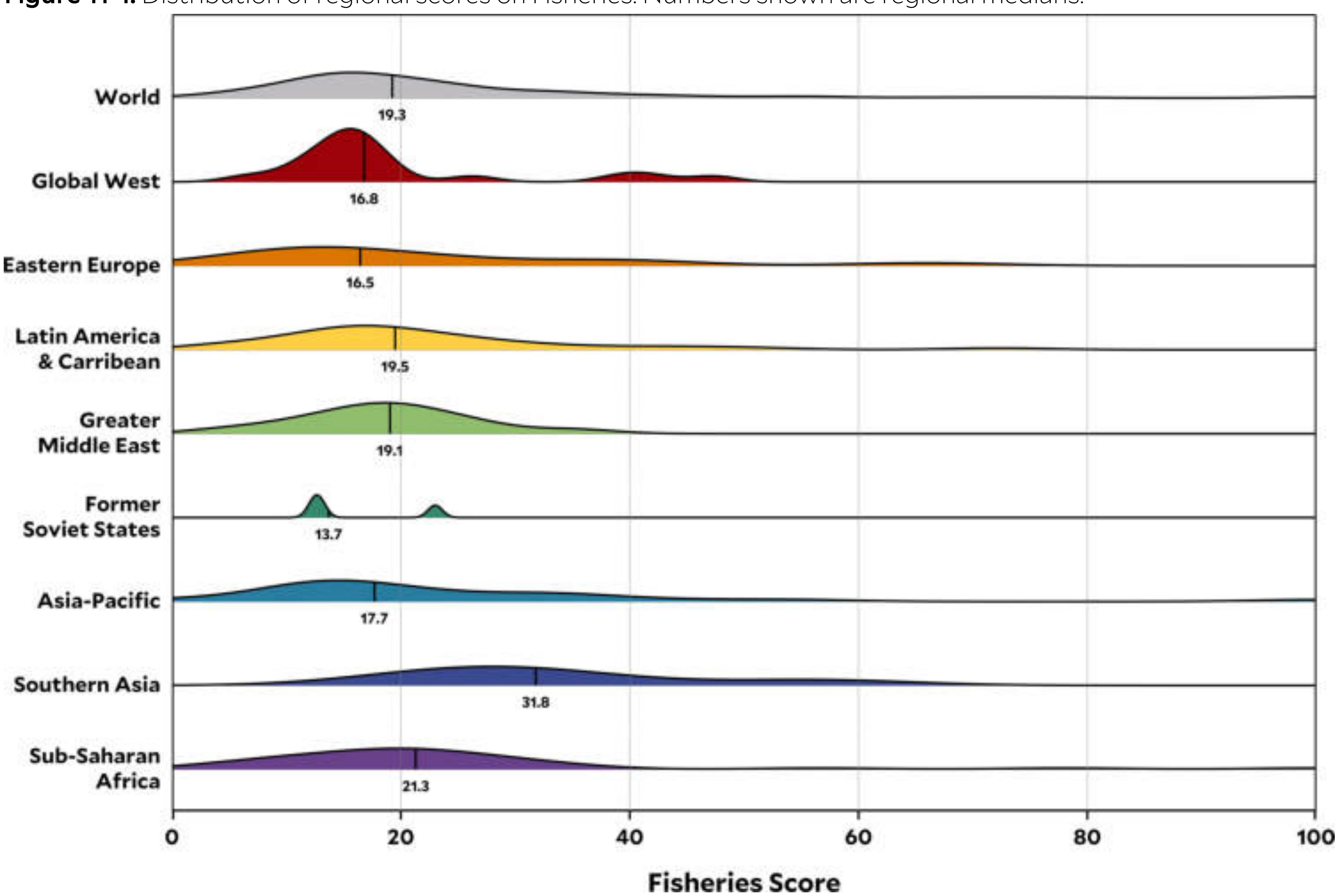
2. Global Trends

Global fish production has increased alongside population and economic growth over the past 50 years. For much of that period, consumption increased more substantially in developed than developing countries (FAO, 2022). That trend has reversed in recent years, and fish consumption is now growing most rapidly in developing countries, where it is a vital source of dietary protein. Of the 96.4 million tonnes of fish caught worldwide in 2018, the majority was consumed as food (FAO, 2020). The rising need for seafood protein has had adverse effects on the world's fish stocks, but the implementation of successful policies has kept the world from a completely unsustainable trajectory. Since 2010, the percentage of global fish stocks that are overexploited has stabilized around 33% (Figure 11-2). While fish stock biomass is declining around the world, the decline has been gradual, and, in some places, reversible. Hotspots of concern include the Mediterranean and Black Seas, South American Pacific and Atlantic coasts, and the Indian Ocean (FAO, 2020; Ricard et al., 2012). Species of concern include mackerel, and many shark and ray species, all of which are overfished or close to being so (RAM, 2021). One surprising global bright spot are tuna, three species of which have transitioned globally from being unsustainably to sustainably fished (FAO, 2020).

Despite the varied state of fisheries globally, most countries continue to perform poorly on all 2022 EPI Fisheries indicators. The maintenance of high catches in Asia has been the product of moving down the trophic index — a phenomenon that decreases marine biomass and reduces biodiversity (Liang and Pauly, 2017, 2020). Illegal and destructive practices like bottom trawling and dredging are also ecologically harmful, given that these practices reduce ecological diversity while also increasing carbon emissions (Epstein et al., 2022; Sala et al., 2021).

Better assessments of fish stocks and marine health are vital to increasing the sustainability of fisheries. The latest research suggests that better-monitored fisheries face less pressure from overfishing, are more likely to recover from depletion and degradation, and more rapidly

Figure 11-1. Distribution of regional scores on Fisheries. Numbers shown are regional medians.



recover biomass (Hilborn et al., 2020). Poorly assessed fisheries face stronger headwinds against recovery. Such fisheries are often located in developing countries in Asia, where coverage of fisheries data continues to lag Europe and the Americas (FAO, 2020). Research initiatives like the Sea Around Us have made major strides in providing more accurate data for fisheries regions around the world, but the continued support of such research is essential for accurately estimating global catch, the economic revenue of fisheries, and identifying the most urgent threats to fisheries. The results of this year's EPI highlight the need for better data collection in the Fisheries issue category. Even some of the world's biggest fish-producing countries are not fully represented across all three indicators, making it difficult to ascertain the condition of the world's fisheries.

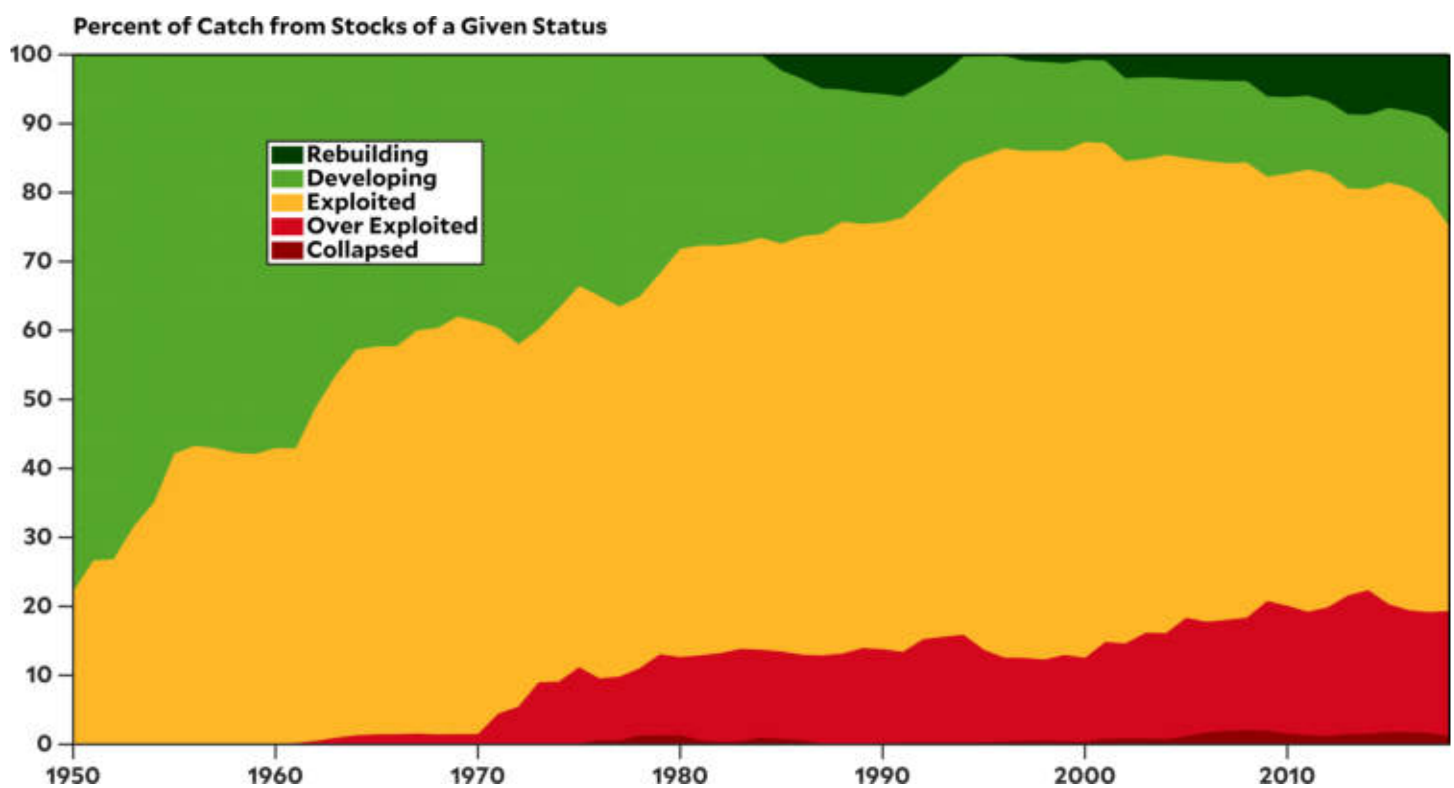
3. Leaders and Laggards

Only a few countries are responsible for the majority of global fish catch, of which China is by far the largest. It is also one of the poorest-performing countries in the Fisheries category in the 2022 EPI. China's share of global fish production, consumption, and fleets has grown with the rise of China's population and economy since 1990. In 2018, it produced 35% of global catch, more than the rest of Asia combined (FAO, 2020). Chinese vessels may now comprise half the world's fishing activity — and they increasingly fish outside of Chinese waters (Urbina, 2020). The country's distant-water fishing fleet is estimated to number almost 17,000 ships, over six times the official numbers, and it ranges across the Pacific in search of seafood species no longer found in China's overfished territorial waters (Gutiérrez et al., 2020). The size of the fleet and its unsustainable fishing practices pose a threat to vulnerable ocean ecosystems, complicating the already murky field of fisheries research.

Six countries, in addition to China, account for 50% of global fisheries catch: India, Peru, Indonesia, the United States, Russia, and Viet Nam. Nearly all of these countries receive low scores in the Fisheries issue category, with Viet Nam doing especially poorly. Its score in the *fish caught by trawling and dredging* indicator has decreased every year since 1995, tracking its economic growth and its fleets' increasing size and catch. Viet Namese fishing vessels have also begun to range further afield in search of catch, following China's trajectory (Teh and Pauly, 2018).

While most major fishing countries earn low scores in fish stock status, Peru emerges as an exception. Peru is the world's third-largest fish producer and accounts for 7% of global catch. Roughly 70% of that number is from a single

Figure 11-2. Global trends in *fish stock status*. Source: Sea Around Us.



fish: the Peruvian anchoveta, the most-caught fish in the world (RAM, 2021). First fished extensively in the 1960s, the anchoveta catch peaked in 1971 at 13 million metric tonnes (FAO, 2021; Oceana, 2022). By 1984, it had plunged to 22,000 metric tonnes (FAO, 2021). In 2021, five million metric tonnes of the fish were caught in Peru's waters. The rise, fall, and ongoing recovery of the anchoveta fishery demonstrates how Peru has turned one of the world's most overfished stocks into a model for sustainable fishery management. Even while catching between 4–8 million metric tonnes annually over the last 15 years, Peru has transformed the anchoveta fishery with regulations that mix a policy of "rational exploitation" with the need for economic and human development (Schreiber, 2012). One key to Peru's success has been its extensive use of licenses for vessels and the strict application of quotas to both fish producers and processes (Aranda, 2009). The continued use of such schemes, and an attention to the needs of the artisanal fishers who may have been left behind by prior versions of them, is essential to prevent the rollback of Peru's progress by its growing artisanal fleet, which has increasingly adopted illegal fishing gear (De la Puente et al., 2020).

Another high-performing country, especially in the fish stock status indicator, is Tuvalu. Tuvalu is one of the eight Parties to the Nauru Agreement, a fisheries management scheme that covers more than half of the global tuna supply (Yeeting et al., 2018). The central component of the agreement is the Vessel Day Scheme, a plan that licenses fishing rights to foreign fleets on a per diem basis, with revenues distributed among the Parties. Despite Nauru alone catching 50,000 tonnes of tuna a year, the Nauru Agreement's catch permissions and regulatory structure are considered sustainable in the long term (Bernadett, 2014). Fish protein is one of the few reliable and abundant sources of nutrition on the islands, with the average Tuvaluan consuming around 100 kg of fish a year (Preston et al., 2016). The agreement has also provided greater profits to its signatories (up to 12 times more, in some cases), who are small Pacific countries that had long faced adverse market pressure from buyers and international fleets (WEF, 2021).

While the Nauru Agreement has been mostly successful, the Parties do score poorly on some indicators. Micronesia scores especially poorly in the *fish stock status* indicator, while Tuvalu and Kiribati have some of the worst *marine trophic index* scores in the 2022 EPI. This may be attributable to a lag in the management of the islands' reef fisheries: while pelagic fishery conditions have greatly improved due to the Nauru Agreement, overfishing of reefs is common in countries across the Pacific (Chin et al., 2011). To counter these persistent problems, the Parties have taken several steps. Notable among them are Tuvalu's efforts to improve governance of its waters with better fishery monitoring, stricter attention to small-scale illegal fishing, and restructuring its fisheries ministry to serve both economic and sustainability objectives (Alefaio et al., 2018; RNZ, 2018). Some Micronesian islands are also attempting to expand marine aquaculture (Houk and Huynh Eller, 2010).

The best-scoring country in the Fisheries issue category is another island nation, Cabo Verde. Cabo Verde has seen its performance on the *fish stock status* and *marine trophic index* indicators climb each year since the early 1990s. The fishing industry constitutes around 3% of Cabo Verde's annual GDP and 5% of national employment (World Bank, 2022b). Cabo Verde has largely succeeded in balancing the economic development of the country with sustainability objectives. Since 2007, the European Union has paid Cabo Verde an annual fee to permit European fishing off its waters. A guaranteed portion of the payment is dedicated to sustainable fisheries management in the islands (EU, 2006). Another key policy for sustainable fishery management in the archipelago is the close monitoring of artisanal fishing, which makes up around half of the country's total catch. Stricter oversight has helped set depleted fisheries, like the local lobster fishery, on the path to recovery (González et al., 2020). Artisanal fishing in Cabo Verde also makes little use of environmentally destructive equipment, such as bottom trawls and dredges. Despite this, the country's fisheries may still be at risk. As the population of its main islands has increased, so have reports of overfishing. Without continued and careful sustainability policies, many of the archipelago's fisheries could be at high risk within a decade (Hammerschlag, 2021).

The poor scores most countries receive in the Fisheries issue category underscores the precarious state of the world's fisheries. From global, regional, and national perspectives, we are not fishing and preserving our fish stocks in a truly sustainable way. The effort to restore the world's fisheries back to health remains a long and arduous one.

4. Methods

Fisheries data has improved in coverage and accuracy over recent years as more fishing vessels become equipped with transponders recording their locations and catch reporting systems. Better monitoring and reporting of previously undisclosed fish catch can falsely suggest that fish populations are recovering — a so-called "presentist bias" (Zeller and Pauly, 2018). Fisheries data in many countries and regions is still reported by handwritten logs that are error-prone and easy to manipulate, and artisanal operations may not be incorporated into country-level statistics (Roberson et al., 2019; Rousseau et al., 2019).

The 2022 EPI Fisheries indicators are based on data from Sea Around Us, an initiative at the University of British Columbia. Sea Around Us synthesizes the best available data on catch, fishing methods, and ocean biome health, reconstructing missing and historical data through methods that rely on additional data sources from the scientific literature, expert consultation, and data interpolation (Pauly and Zeller, 2016; Zeller and Pauly, 2016).

Indicator Background

Fish stock status evaluates the percentage of a country's catch, by mass, that comes from stocks that are overexploited or collapsed. An overexploited fish stock is defined by landings that are 10% to 50% lower than the peak catch from a prior year (Pauly et al., 2008). A collapsed fish stock is characterized by catch falling below 10% of a prior year's peak (Kleisner and Pauly, 2015). For countries with multiple exclusive economic zones (EEZs) — and thus multiple data regions — the EPI calculates the weighted average percentage based on each EEZ's relative mass of fish catch. Since the continued exploitation of overfished stocks leads to progressively smaller catches, this indicator captures trends in the health of countries' fisheries.

Marine Trophic Index (MTI) captures how severely countries are depleting species at higher trophic levels, which are typically larger predator species like tuna and swordfish. This process — known as "fishing down the food web" —leads countries to target increasingly smaller and inherently different species (Essington et al., 2006; Pauly and Palomares, 2005). To account for the potential geographic expansion of fisheries and the development of operations farther offshore – which can mask overfishing near shore — Sea Around Us has developed the Regional MTI (Kleisner et al., 2014). The 2022 EPI uses the slope of change in MTI, reflecting the rate of change from the highest to current MTI values. This slope-based indicator captures how quickly countries are fishing down the food web.

The 2022 EPI introduces a modified fishing methods indicator, *fish caught by trawling and dredging*, reflecting the latest research into the ecological damage of demersal (occurring near the seabed) fishing practices. Bottom trawling and dredging methods of fishing are indiscriminate and wasteful, resulting in bycatch that is often discarded. These practices also harm sensitive ecosystems along the seafloor, like coral reefs (Clark et al., 2019; Victorero et al., 2018). Scores for this indicator are based on the percentage of fish by mass caught by bottom trawling and dredging.

Data Sources

Data for the EPI's three Fisheries indicators come from the Sea Around Us, a research initiative and member of the Global Fisheries Cluster at the University of British Columbia. This data is freely available for download from www.seaaroundus.org. Sea Around Us builds on FAO data for the years 1950 to 2018, using a multi-step process to obtain, verify, and augment datasets (Zeller and Pauly, 2016):

1. collect FAO and national data;
2. identify missing information;
3. seek alternative sources of information, such as national or agency fishing reports;
4. create and expand anchor points for missing data;
5. interpolate data for commercial and noncommercial fisheries;
6. combine reported and missing data; and
7. quantifying uncertainties.

Data Sources

Global fishing operations remain incompletely characterized, giving rise to uncertainties in fisheries datasets. Despite creative research in recent years — such as equipping seagoing birds with transponders that track illegal fishing vessels (Weimerskirch et al., 2020) — marine policymakers need improved data collection and reporting methods to gain a fuller picture of ocean and fishery health. The Sea Around Us data comes from FAO data supplemented by the scientific literature and expert judgment, which may not be as accurate as reliable fishing logs.

The EPI's three Fisheries Indicators seek to comprehensively monitor the sustainability of fisheries, although harmful practices not captured by these indicators continue to threaten marine health. These detrimental methods include dynamite and cyanide fishing, which indiscriminately kill or harm marine life (Bailey and Sumaila, 2015; Murray et al., 2020b).

Further, the EPI's indicators do not explicitly monitor the health of coral reefs, mangroves, and other regionally specific but globally important ecosystems. The EPI research team anticipates that more research and better data reporting on these critical fisheries issues will mark the advent of new indicators in subsequent iterations of the report.

Countries that import fish catch derived from unsustainable fishing practices in other countries may appear to perform well in fisheries indicators that fail to capture the outsourcing of environmental degradation. Many countries, such as the United States, rely heavily on imported seafood that has been caught via unsustainable practices elsewhere (Gephart et al., 2019). As consumption-based accounting of seafood improves (Guillen et al., 2019; West et al., 2019), EPI indicators may be able to track fisheries scores for inland and landlocked countries.

Chapter 12. Acid Rain

1. Introduction

Burning fossil fuels emits air pollutants — sulfur dioxide (SO_2) and nitrogen oxides (NO_X) — that cause precipitation to become more acidic. Rainwater acidification is among the most prevalent transboundary environmental issues: emissions in one region are blown downwind and can impact ecosystems continents away from the source (Grennfelt et al., 2020). Short but episodic periods of acid rain can eventually lead to a chronic decline in ecosystem vitality, by which the environment loses its ability to neutralize acid deposition (Singh and Agrawal, 2008), and adversely impact human health (Koplitz et al., 2017).

Acid rain contaminates drinking water (Speight, 2020), damages buildings and public infrastructure (Wang et al., 2020), affects plant growth (Shi et al., 2021), and harms wildlife (Singh and Agrawal, 2008). Although acid rain has largely been addressed in the Global West, it continues to produce debilitating impacts on environmental and public health in the developing world (Macaulay et al., 2020). Environmental researchers have devised many techniques to minimize the ecological impact of acidification (Rosi-Marshall et al., 2016), but there is no substitute for reducing SO_2 and NO_X emissions. The ultimate solution is to transition away from coal as a source of electricity and heat. In the meantime, smokestack scrubbers and low-sulfur coal can greatly reduce acid rain precursor emissions and help alleviate the acid rain problem in developing countries (Shammas et al., 2020).

2. Indicators

The 2022 EPI uses two indicators to track trends in countries' emissions of acid rain precursors:

Sulfur Dioxide (SO_2) Growth Rate (50% of issue category)

Nitrogen Oxides (NO_X) Growth Rate (50% of issue category)

We calculate the average annual rate of increase or decrease in emissions over the most recent ten years of data and adjust these rates for economic trends. Countries whose emissions are declining due to a downturn in economic activity receive scores based on adjusted emissions growth rates.

Map 12-1. Global rankings on Acid Rain.

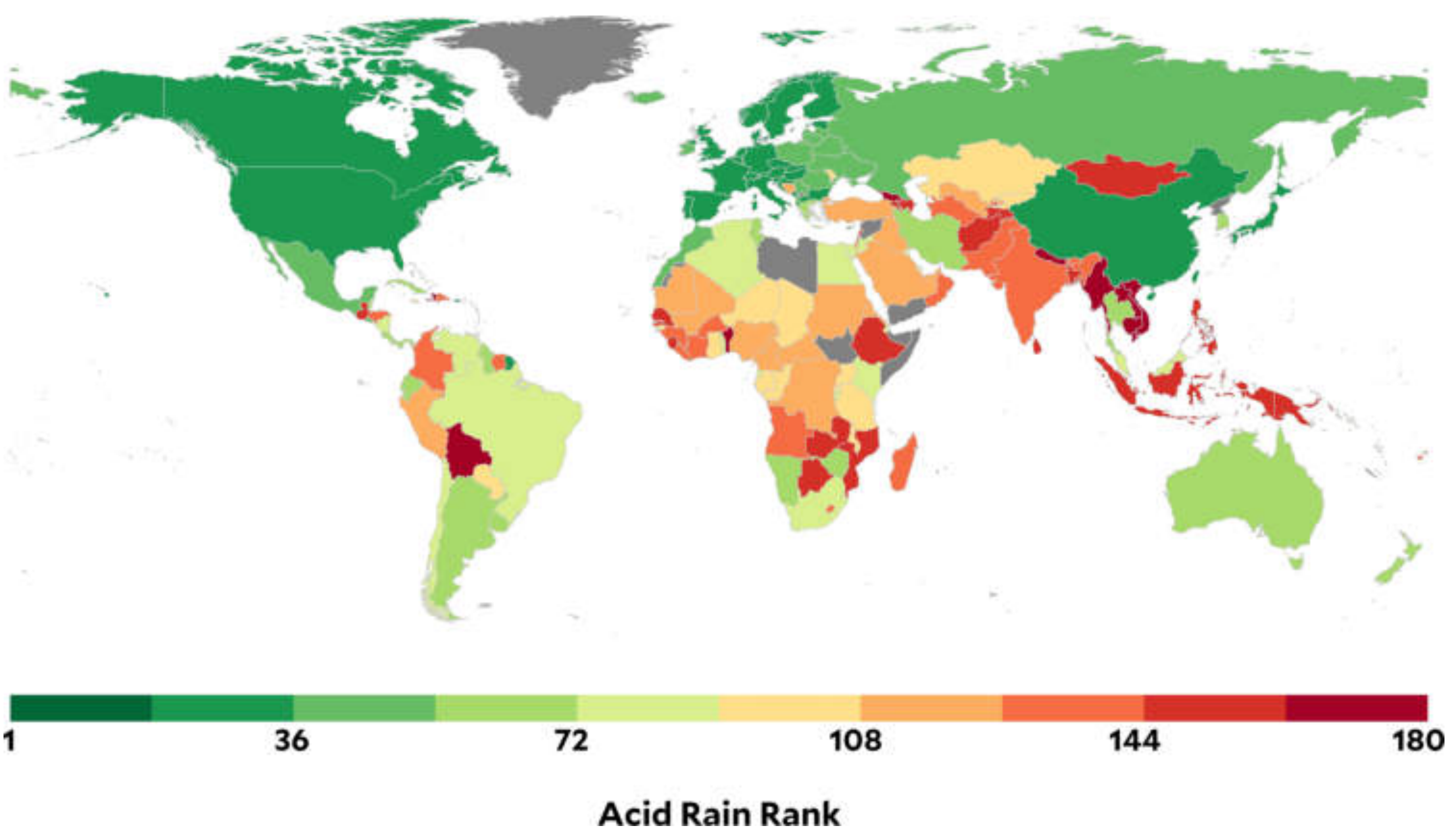


Table 12-1. Global rankings, scores, and regional rankings (REG) on Acid Rain.

RANK	COUNTRY	SCORE	REG
1	Austria	100.0	1
1	Belgium	100.0	1
1	Canada	100.0	1
1	Denmark	100.0	1
1	Finland	100.0	1
1	France	100.0	1
1	Germany	100.0	1
1	Italy	100.0	1
1	Luxembourg	100.0	1
1	Malta	100.0	1
1	Netherlands	100.0	1
1	Norway	100.0	1
1	Portugal	100.0	1
1	Spain	100.0	1
1	Sweden	100.0	1
1	Switzerland	100.0	1
1	United Kingdom	100.0	1
1	United States of America	100.0	1
1	Bulgaria	100.0	1
1	Croatia	100.0	1
1	Czech Republic	100.0	1
1	Estonia	100.0	1
1	Hungary	100.0	1
1	Montenegro	100.0	1
1	North Macedonia	100.0	1
1	Slovakia	100.0	1
1	Slovenia	100.0	1
1	China	100.0	1
1	Japan	100.0	1
1	Singapore	100.0	1
1	Taiwan	100.0	1
32	Poland	99.6	10
33	Serbia	99.3	11
34	Belarus	97.8	1
35	Romania	95.9	12
36	Iceland	95.8	19
37	Lithuania	95.5	13
38	Ireland	95.4	20
39	Latvia	95.0	14
40	Ukraine	94.6	2
41	Antigua and Barbuda	93.2	1
42	El Salvador	92.8	2
43	Cyprus	92.5	15
44	Barbados	92.2	3
45	Russia	91.9	3
46	St. Vincent and Grenadines	91.5	4
47	Morocco	90.9	1
48	Albania	90.2	16
49	Mexico	90.1	5
50	Saint Lucia	89.8	6
51	Panama	89.6	7
52	Iran	89.4	2
53	Australia	88.6	21
54	Bahamas	88.1	8
55	Zimbabwe	87.8	1
56	Dominica	87.7	9
57	Grenada	87.4	10
58	Belize	85.9	11
59	Argentina	85.4	12
60	South Korea	84.3	5
61	Costa Rica	84.2	13
62	Cuba	81.3	14
63	Guyana	81.2	15
64	Tunisia	80.6	3
65	Ecuador	79.9	16
66	Thailand	79.8	6
67	Uruguay	79.7	17
68	Greece	78.7	17
69	Namibia	76.7	2
70	New Zealand	76.0	22
71	Eswatini	75.5	3
72	Jordan	75.3	4
73	Burundi	74.8	4
74	Djibouti	74.6	5
74	South Africa	74.6	5
74	Chile	74.6	18
77	Venezuela	74.0	19
78	Egypt	73.8	5
79	Togo	72.6	7
80	Seychelles	72.4	8
81	Kuwait	71.6	6
82	Kenya	71.0	9
82	Malaysia	71.0	7
84	Algeria	70.8	7
85	Tonga	70.5	8
86	Brazil	70.4	20
86	Brunei Darussalam	70.4	9
88	Equatorial Guinea	69.8	10
89	Trinidad and Tobago	69.4	21
90	Nicaragua	69.2	22
91	Jamaica	69.1	23
92	Rwanda	67.8	11
93	Solomon Islands	67.7	10
94	Kyrgyzstan	66.5	4
95	Gabon	66.1	12
96	Niger	65.4	13
97	Ghana	65.3	14
98	Kiribati	64.9	11
99	Mauritius	64.8	15
100	Kazakhstan	64.7	5
101	Paraguay	64.5	24
102	Tanzania	64.4	16
103	Qatar	64.3	8
104	Chad	63.9	17
104	Vanuatu	63.9	12
106	Moldova	63.3	6
107	Uganda	63.2	18
108	Guinea-Bissau	62.9	19
109	Malawi	62.7	20
109	Republic of Congo	62.7	20
111	Cameroon	62.5	22
112	Nigeria	62.2	23
113	Turkey	61.8	18
114	Central African Republic	61.1	24
114	Mali	61.1	24
116	Sudan	60.5	9
117	Bahrain	59.7	10
118	Comoros	59.2	26
118	United Arab Emirates	59.2	11
120	Israel	58.5	12
121	Gambia	58.2	27
122	Eritrea	58.1	28
123	Saudi Arabia	57.4	13
124	Uzbekistan	56.6	7
125	Dem. Rep. Congo	56.4	29
126	Iraq	56.3	14
127	Mauritania	56.1	30
128	Peru	56.0	25
128	Bosnia and Herzegovina	56.0	19
130	São Tomé and Príncpe	55.6	31
131	Dominican Republic	54.9	26
132	India	54.4	1
133	Lesotho	53.1	32
134	Madagascar	52.6	33
135	Côte d'Ivoire	52.5	34
136	Suriname	52.1	27
137	Colombia	52.0	28
138	Marshall Islands	51.4	13
139	Honduras	51.1	29
140	Angola	50.5	35
140	Micronesia	50.5	14
142	Samoa	48.6	15
143	Pakistan	48.0	2
144	Guinea	47.6	36
145	Fiji	46.9	16
146	Turkmenistan	46.7	8
147	Burkina Faso	45.6	37
148	Liberia	45.5	38
149	Bhutan	45.4	3
150	Oman	45.2	15
151	Sierra Leone	44.1	39
152	Indonesia	43.9	17
153	Ethiopia	43.6	40
154	Timor-Leste	42.1	18
155	Armenia	39.2	9
156	Tajikistan	38.5	10
157	Lebanon	37.9	16
158	Botswana	37.2	41
159	Maldives	36.0	4
160	Afghanistan	35.5	5
161	Philippines	34.8	19
162	Papua New Guinea	33.7	20
163	Guatemala	33.5	30
164	Mongolia	32.6	21
165	Zambia	32.2	42
166	Azerbaijan	31.9	11
167	Sri Lanka	29.5	6
168	Senegal	28.0	43
169	Bangladesh	25.8	7
170	Mozambique	25.6	44
171	Bolivia	22.3	31
172	Cabo Verde	21.4	45
173	Haiti	19.8	32
174	Viet Nam	19.3	22
175	Cambodia	17.6	23
176	Georgia	17.3	12
177	Laos	13.3	24
178	Nepal	11.2	8
179	Benin	6.0	46
180	Myanmar	0.0	25

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 and scores on Acid Rain.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Antigua and Barbuda	93.2	1
El Salvador	92.8	2
Barbados	92.2	3
St. Vincent and Grenadines	91.5	4
Mexico	90.1	5
Saint Lucia	89.8	6
Panama	89.6	7
Bahamas	88.1	8
Dominica	87.7	9
Grenada	87.4	10
Belize	85.9	11
Argentina	85.4	12
Costa Rica	84.2	13
Cuba	81.3	14
Guyana	81.2	15
Ecuador	79.9	16
Uruguay	79.7	17
Chile	74.6	18
Venezuela	74.0	19
Brazil	70.4	20
Trinidad and Tobago	69.4	21
Nicaragua	69.2	22
Jamaica	69.1	23
Paraguay	64.5	24
Peru	56.0	25
Dominican Republic	54.9	26
Suriname	52.1	27
Colombia	52.0	28
Honduras	51.1	29
Guatemala	33.5	30
Bolivia	22.3	31
Haiti	19.8	32

EASTERN EUROPE

Country	Score	Reg. Rank
Bulgaria	100.0	1
Croatia	100.0	1
Czech Republic	100.0	1
Estonia	100.0	1
Hungary	100.0	1
Montenegro	100.0	1
North Macedonia	100.0	1
Slovakia	100.0	1
Slovenia	100.0	1
Poland	99.6	10
Serbia	99.3	11
Romania	95.9	12
Lithuania	95.5	13
Latvia	95.0	14
Cyprus	92.5	15
Albania	90.2	16
Greece	78.7	17
Turkey	61.8	18
Bosnia and Herzegovina	56.0	19

SOUTHERN ASIA

Country	Score	Reg. Rank
India	54.4	1
Pakistan	48.0	2
Bhutan	45.4	3
Maldives	36.0	4
Afghanistan	35.5	5
Sri Lanka	29.5	6
Bangladesh	25.8	7
Nepal	11.2	8

GLOBAL WEST

Country	Score	Reg. Rank
Austria	100.0	1
Belgium	100.0	1
Canada	100.0	1
Denmark	100.0	1
Finland	100.0	1
France	100.0	1
Germany	100.0	1
Italy	100.0	1
Luxembourg	100.0	1
Malta	100.0	1
Netherlands	100.0	1
Norway	100.0	1
Portugal	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
Iceland	95.8	19
Ireland	95.4	20
Australia	88.6	21
New Zealand	76.0	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Belarus	97.8	1
Ukraine	94.6	2
Russia	91.9	3
Kyrgyzstan	66.5	4
Kazakhstan	64.7	5
Moldova	63.3	6
Uzbekistan	56.6	7
Turkmenistan	46.7	8
Armenia	39.2	9
Tajikistan	38.5	10
Azerbaijan	31.9	11
Georgia	17.3	12

ASIA-PACIFIC

Country	Score	Reg. Rank
China	100.0	1
Japan	100.0	1
Singapore	100.0	1
Taiwan	100.0	1
South Korea	84.3	5
Thailand	79.8	6
Malaysia	71.0	7
Tonga	70.5	8
Brunei Darussalam	70.4	9
Solomon Islands	67.7	10
Kiribati	64.9	11
Vanuatu	63.9	12
Marshall Islands	51.4	13
Micronesia	50.5	14
Samoa	48.6	15
Fiji	46.9	16
Indonesia	43.9	17
Timor-Leste	42.1	18
Philippines	34.8	19
Papua New Guinea	33.7	20
Mongolia	32.6	21
Viet Nam	19.3	22
Cambodia	17.6	23
Laos	13.3	24
Myanmar	0.0	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Zimbabwe	87.8	1
Namibia	76.7	2
Eswatini	75.5	3
Burundi	74.8	4
Djibouti	74.6	5
South Africa	74.6	5
Togo	72.6	7
Seychelles	72.4	8
Kenya	71.0	9
Equatorial Guinea	69.8	10
Rwanda	67.8	11
Gabon	66.1	12
Niger	65.4	13
Ghana	65.3	14
Mauritius	64.8	15
Tanzania	64.4	16
Chad	63.9	17
Uganda	63.2	18
Guinea-Bissau	62.9	19
Malawi	62.7	20
Republic of Congo	62.7	20
Cameroon	62.5	22
Nigeria	62.2	23
Central African Republic	61.1	24
Mali	61.1	24
Comoros	59.2	26
Gambia	58.2	27
Eritrea	58.1	28
Dem. Rep. Congo	56.4	29
Mauritania	56.1	30
Sao Tome and Principe	55.6	31
Lesotho	53.1	32
Madagascar	52.6	33
Cote d'Ivoire	52.5	34
Angola	50.5	35
Guinea	47.6	36
Burkina Faso	45.6	37
Liberia	45.5	38
Sierra Leone	44.1	39
Ethiopia	43.6	40
Botswana	37.2	41
Zambia	32.2	42
Senegal	28.0	43
Mozambique	25.6	44
Cabo Verde	21.4	45
Benin	6.0	46

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Morocco	90.9	1
Iran	89.4	2
Tunisia	80.6	3
Jordan	75.3	4
Egypt	73.8	5
Kuwait	71.6	6
Algeria	70.8	7
Qatar	64.3	8
Sudan	60.5	9
Bahrain	59.7	10
United Arab Emirates	59.2	11
Israel	58.5	12
Saudi Arabia	57.4	13
Iraq	56.3	14
Oman	45.2	15
Lebanon	37.9	16

2. Global Trends

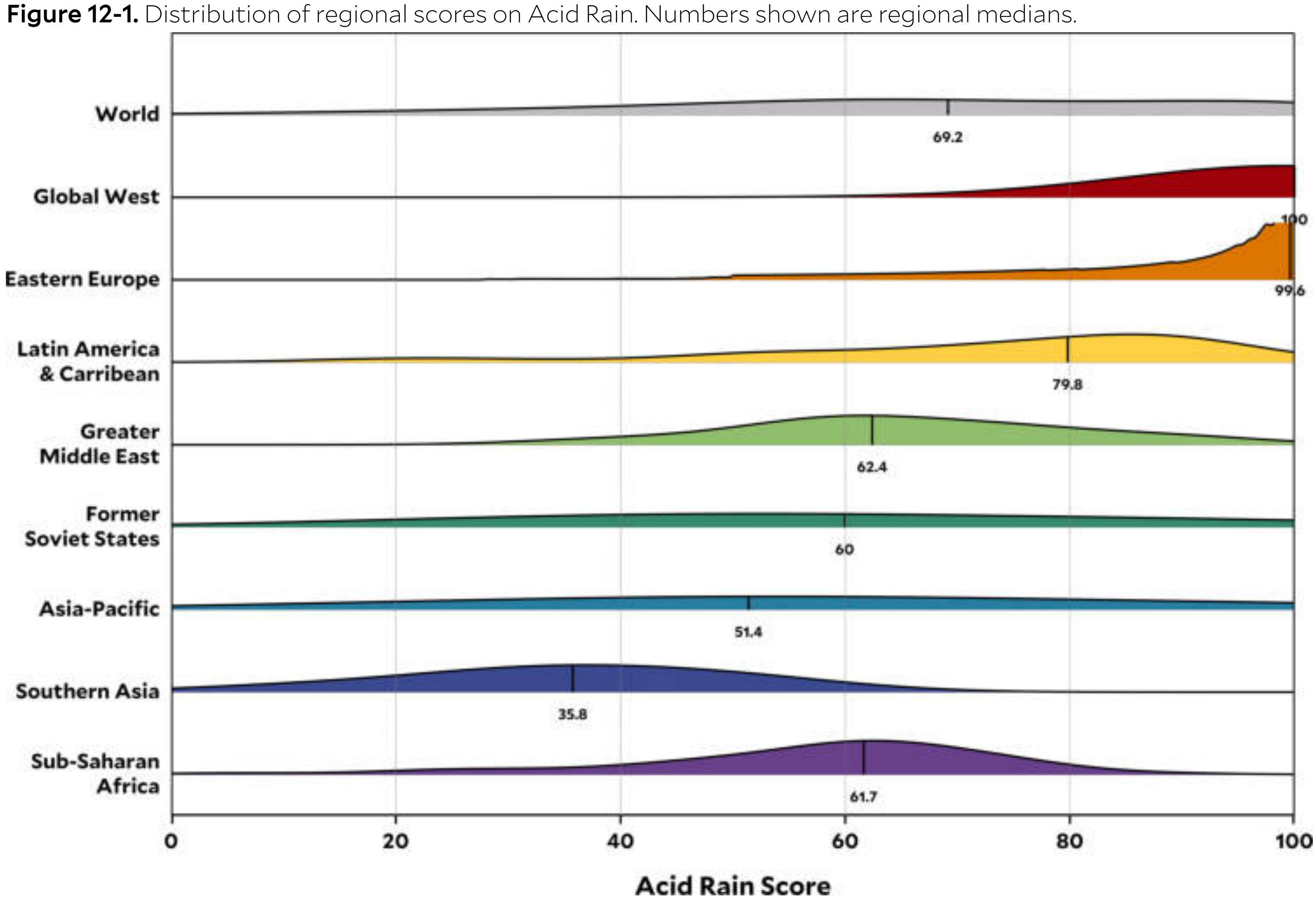
After increasing since the 19th century, global SO_2 and NO_x emissions have stabilized in recent decades. SO_2 emissions peaked in 1979, while NO_x emissions began to plateau over the last 15 years. These promising trends mask striking differences in performance between world regions. Most countries in the Global West and Eastern Europe have enacted policies that successfully reduced (but did not eliminate) SO_2 and NO_x emissions. The developing world, however, has seen increasing emissions. Between 2010 and 2019, the Global West's SO_2 emissions fell 58% while Southern Asia's emissions increased by 33% (Figure 12-2). During this same period, NO_x emissions declined by 33% in the Global West while increasing 20% in Southern Asia (Figure 12-3).

Uneven global performance in this issue category reflects two worlds of acid rain policy. In one, wealthy developed nations have enacted rigorous pollution control strategies. But in the developing world, growing vehicle use and fossil fuel consumption coupled with a lack of emissions regulations mean acid rain continues to harm environmental and human health (Macaulay et al., 2020).

Of the 180 countries included in this report, 107 realized improved Acid Rain scores over the past decade, and 56 regressed. 17 countries, mainly wealthy countries in the Global West, have consistently achieved top scores in this issue category because of their longstanding acid rain mitigation policies. The overall positive global trends reflect efforts on the parts of major countries like the United States and China to decrease SO_2 and NO_x emissions.

The EPI team emphasizes here the contrast between globally-declining acid rain precursor emissions and increasing greenhouse gas emissions. Although global fossil fuel consumption is still on the rise, the world has successfully managed to decouple SO_2 and NO_x emissions from fossil fuel — and economic — growth. The lessons learned from acid rain policies may therefore serve as a useful blueprint for policymakers seeking to mitigate greenhouse gas emissions (Hansjürgens, 2011;

Figure 12-1. Distribution of regional scores on Acid Rain. Numbers shown are regional medians.



Reis et al., 2012; Solomon, 1995). Scale and technological differences between the two environmental issues, however, makes acid rain policy an imperfect analog for climate policy.

3. Leaders and Laggards

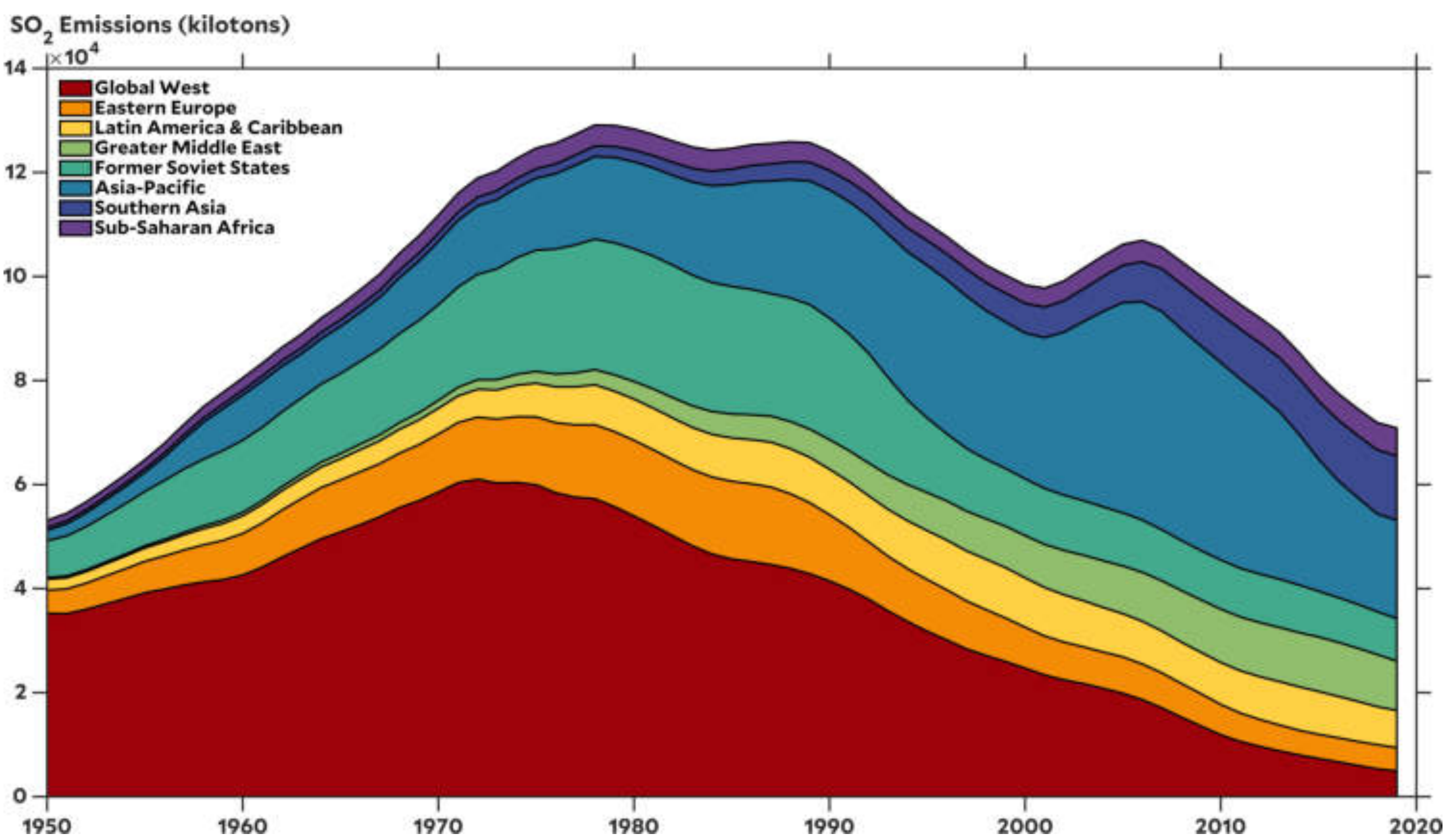
Most high-performing countries in Acid Rain fall within the Global West. Denmark, France, Germany, the United Kingdom, and several other European countries have witnessed declining SO_2 and NO_X emissions for over a decade, earning top scores in the 2022 EPI as well as in the backcasted scores. This success partly stems from the Convention on Long-range Transboundary Air Pollution (CLRTAP). The Convention and its 2012 amendment, the Gothenburg Protocol, required reduced air pollution emissions and has largely mitigated the acid rain problem across Europe (EEA, 2021). Europe has also reduced acid rain precursor emissions through a series of policies, namely the Ambient Air Quality Directives of 2004 and 2008, and the 2016 National Emissions Ceilings Directive, which codified commitments made under CLRTAP to reduce SO_2 and NO_X emissions.

Cap and trade policies implemented in the United States as part of the 1990 Clean Air Act amendments have also propelled the country to a top score. Under this design, policymakers set a ceiling on emissions (the "cap") and allocate emissions allowances that polluters can buy and sell (the "trade"). Researchers point to the success of this program as evidence that market-based mechanisms can be a cost-effective and flexible policy choice for alleviating large-scale air pollution problems (Napolitano et al., 2007).

China has achieved one of the most dramatic improvements in ACD score in the past decade, rising from a score of 21.2 to a score of 100 in the 2022 EPI, in large part due to a series of clean air policies implemented starting in 2005. Nation-wide efforts to better regulate coal-fired power plants have successfully reduced SO_2 emissions by about 70% between 2006 and 2017 through flue gas desulfurization technology (Zheng et al., 2020). Although EPI indicators do not capture spillover emissions, we note that China pledged in 2021 to stop financing coal power as part of its Belt and Road Initiative (Ma, 2022). Research suggests that this policy choice will improve acidification trends in Southeast Asia and Sub-Saharan Africa (Schiermeier, 2021).

While China and other countries have made remarkable strides in mitigating acid rain, the Philippines' score in this issue category fell by over 60 points over the past decade. The Philippines' growing demand for energy has largely

Figure 12-2. Trends in regional SO_2 emissions. Source: Community Emissions Data System (CEDS).



been met by fossil fuels. Coal accounts for about 36% of energy production nationwide, where it powers new power plants and is also used for household cooking and heating (EIA, 2020). Lacking effective emissions control policies (Koplitz et al., 2017), the Philippines' reliance on coal and other fossil fuels has sent SO_2 and NO_X emissions skyrocketing in recent years. The Philippine's SO_2 emission limits for new coal power plants (700 mg m^{-3}) sorely lag those of peers and top-performers: China's limit is 50 mg m^{-3} and the European Union's is 150 mg m^{-3}, although many stations outperform these limits (Greenpeace, 2016). As developing countries begin to transition away from fossil fuel energy sources, they will realize co-benefits for both environmental and human health as greenhouse gas and toxic air pollutants are reduced (Karlsson et al., 2020).

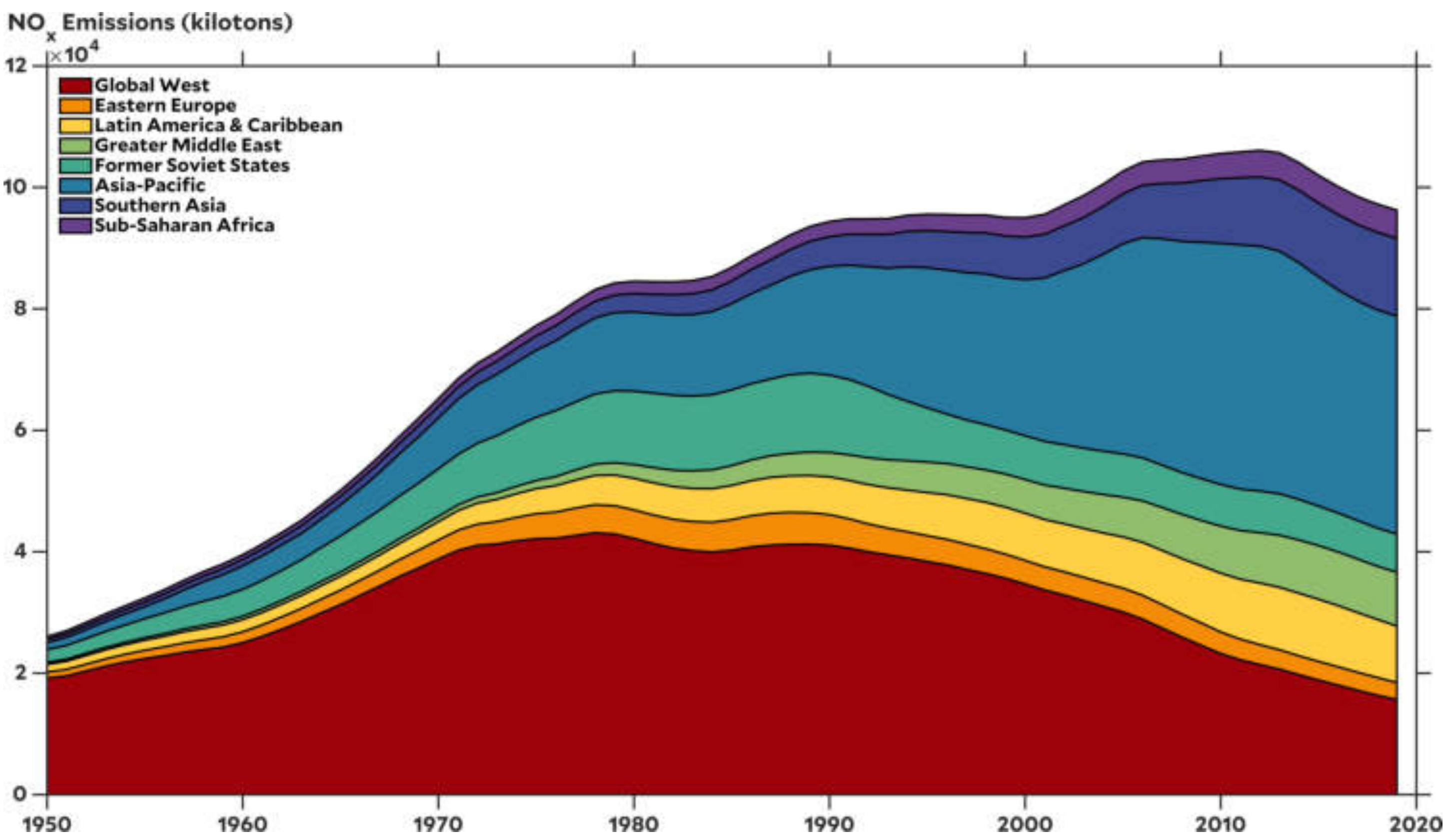
4. Methods

Accurate metrics tracking acid rain precursor emissions help policymakers evaluate their current emissions policies and highlight best practices for mitigating environmental acidification. Technological advances in ground-based and remote sensing have improved our ability to estimate emissions, but current methods still struggle to track pollution flows as they migrate away from sources and are ultimately deposited into remote ecosystems. Atmospheric dispersion and deposition are difficult to model, muddying countries' overall contribution to transboundary acid rain events. Emissions factors data can fill gaps in datasets where actual SO_2 and NO_X emissions are unreported, allowing us to extend indicators through time and across the world. These emissions factors leverage data on fuel consumption and fuel type to estimate emissions.

Indicator Background

To track country performance in mitigating acid rain, 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. Where SO_2 and NO_X emissions are falling, we inspect whether the decrease results from economic decline or the decoupling of pollution emissions from economic growth. Several countries have both decreasing SO_2 emissions and shrinking economies (Figure 12-5), suggesting their progress could be due to depressed economic activity rather than effective policies.

Figure 12-3. Trends in regional NO_X emissions. Source: Community Emissions Data System (CEDS).

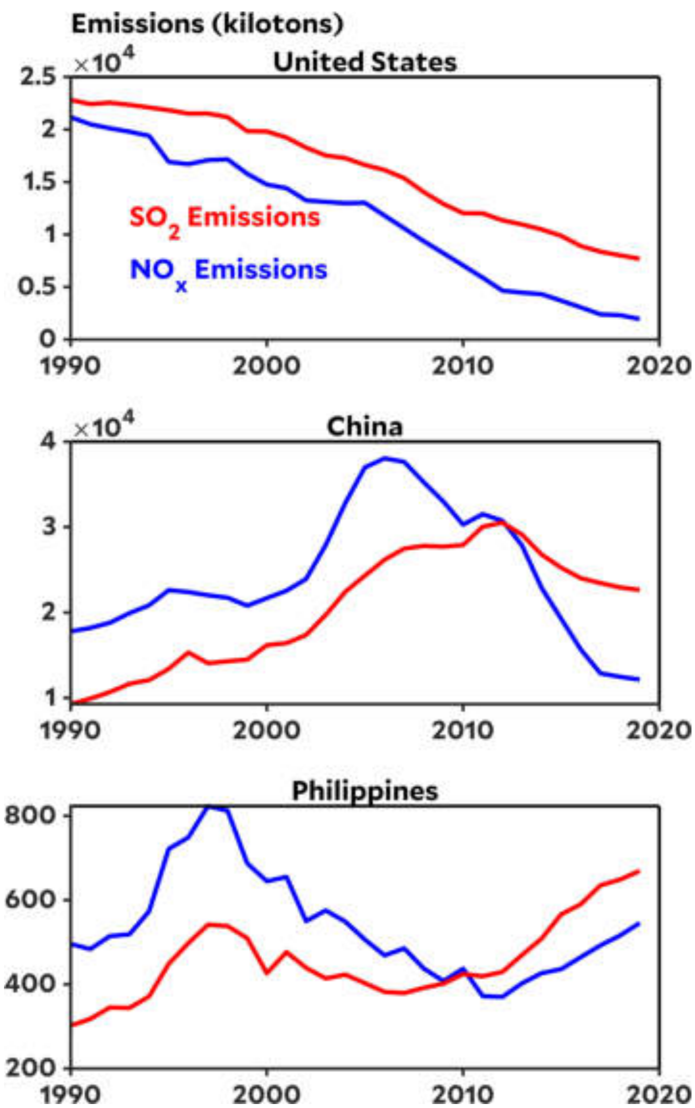


Rewarding countries that have successfully decoupled SO_2 and NO_X emissions from economic growth while ensuring that countries do not earn high scores for unsustainability trends, we adjust the emission growth rates for countries with declining emissions as follows:

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 (Figure 12-5).

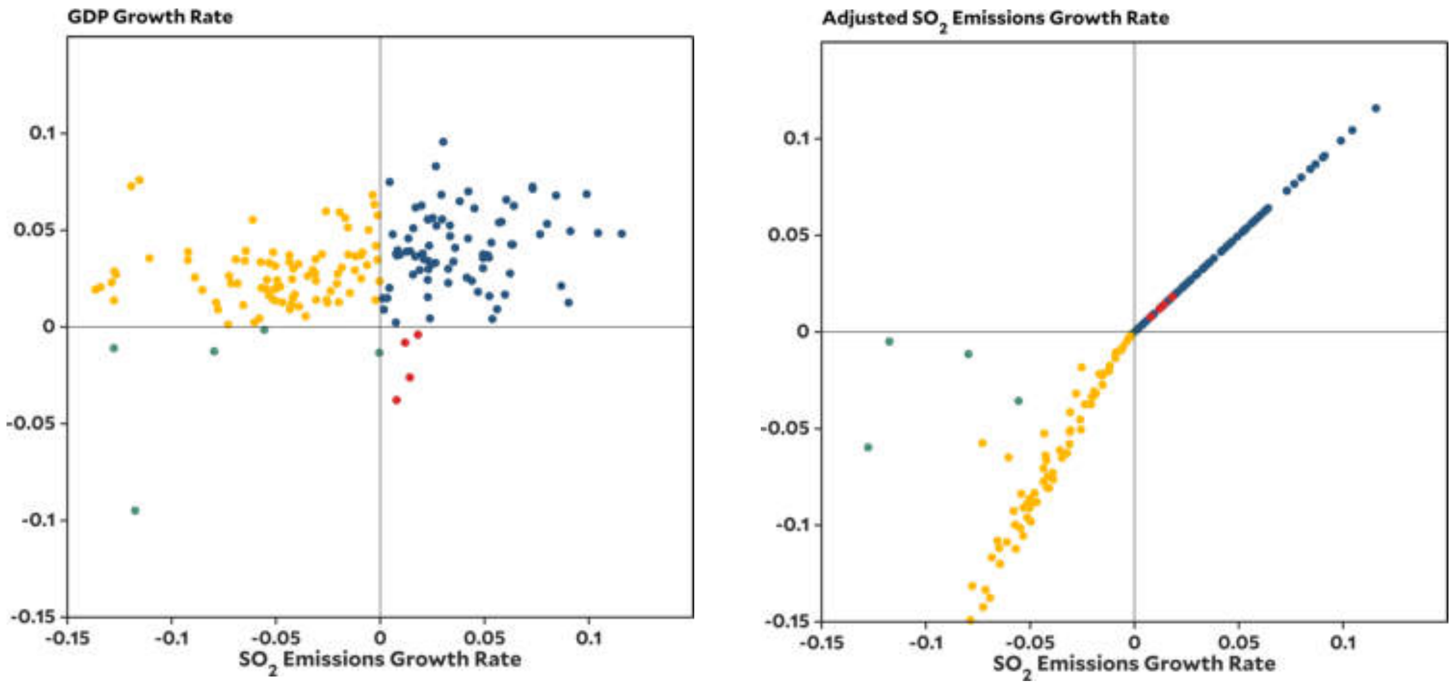
Figure 12-4. Country trends in acid rain precursor emissions. Source: CEDS.



Data Sources
The Joint Global Change Research Institute and the Pacific Northwest National Laboratory collaborate on the Community Emissions Data System (CEDS) to produce data that undergirds the Acid Rain indicators. 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; McDuffie et al., 2020). 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 *adjusted emission growth rate* indicators for SO_2 and NO_X are based on CEDS data covering the years 2010–2019. CEDS data are publicly available for download from the CEDS public GitHub repository: https://github.com/JGCRI/CEDS/.

Limitations
Due to limited data availability and inherent uncertainties in emissions inventories, data are more reliable in higher-income countries with more transparent and robust data reporting protocols. Improvements in satellite observation methods, combined with deposition maps, will allow scientists to more accurately estimate pollution emissions in areas with previous incomplete data (Fu et al., 2022). Finally, the EPI indicators treat SO_2 and NO_X emissions as proxies for acid rain severity. The paucity of global data prevent the EPI's indicators from monitoring the pH of rainwater or from tracking the ecological and public health impacts of acid rain.

Figure 12-5. Adjusting declining SO_2 emissions growth rate based on correlation with economic growth rate, 2010–2019. Sources: SO_2 emissions from CEDS; GDP from World Bank and IMF.



Chapter 13. Agriculture

1. Introduction

As Earth's population grows, agricultural demand rises to keep pace. Chemical inputs can increase yields and prevent infestations, helping farmers raise enough crops to feed the nearly 7.7 billion people now living on the planet (Hunter et al., 2017). Agrochemical mismanagement, however, makes food systems inefficient and threatens ecosystem vitality (Gomiero et al., 2011). Both fertilizers and pesticides have a role to play in sustaining the planet, but countries must properly manage them to avoid adverse environmental effects, including soil erosion, damaged ecosystems, and water pollution (Alexandratos and Bruinsma, 2012). Pesticide and nutrient mismanagement pose a risk of driving agricultural systems beyond the limits of sustainability.

Fertilizers rich in reactive nitrogen are vital to maximizing agricultural yields, but nitrogen pollution can result in widespread environmental damage (Bodirsky et al., 2014; Zhang et al., 2015). Runoff into rivers, lakes, and oceans can cause eutrophication and algal blooms that threaten animal life (Liu et al., 2021). Pesticide misuse degrades soil health and can also pollute waterways through runoff (Tang and Maggi, 2021). Policies and education programs that result in the more efficient use of agrochemicals will be critical to moving the world toward more sustainable agricultural systems. The 2022 EPI's agricultural indicators allow countries to assess whether their agricultural policies are producing improvements in ecosystem vitality.

2. Indicators

Sustainable Nitrogen Management Index (SNMI) (50% of issue category)

The *Sustainable Nitrogen Management Index* (SNMI) seeks to balance efficient application of nitrogen fertilizer with maximizing crop yield as a measure of the sustainability of agricultural production (Zhang and Davidson, 2019).

Sustainable Pesticide Use (50% of issue category)

The 2022 EPI introduces a pilot indicator on sustainable pesticide use. This indicator considers the gains in food security from responsible pesticide use while recognizing that over-application damages the environment. The sustainable pesticide use indicator adjusts a newly-developed metric called the "pesticide risk score" (Tang et al., 2021) based on a country's pesticide use rate (Maggi et al., 2019).

Map 13-1. Global rankings on Agriculture.

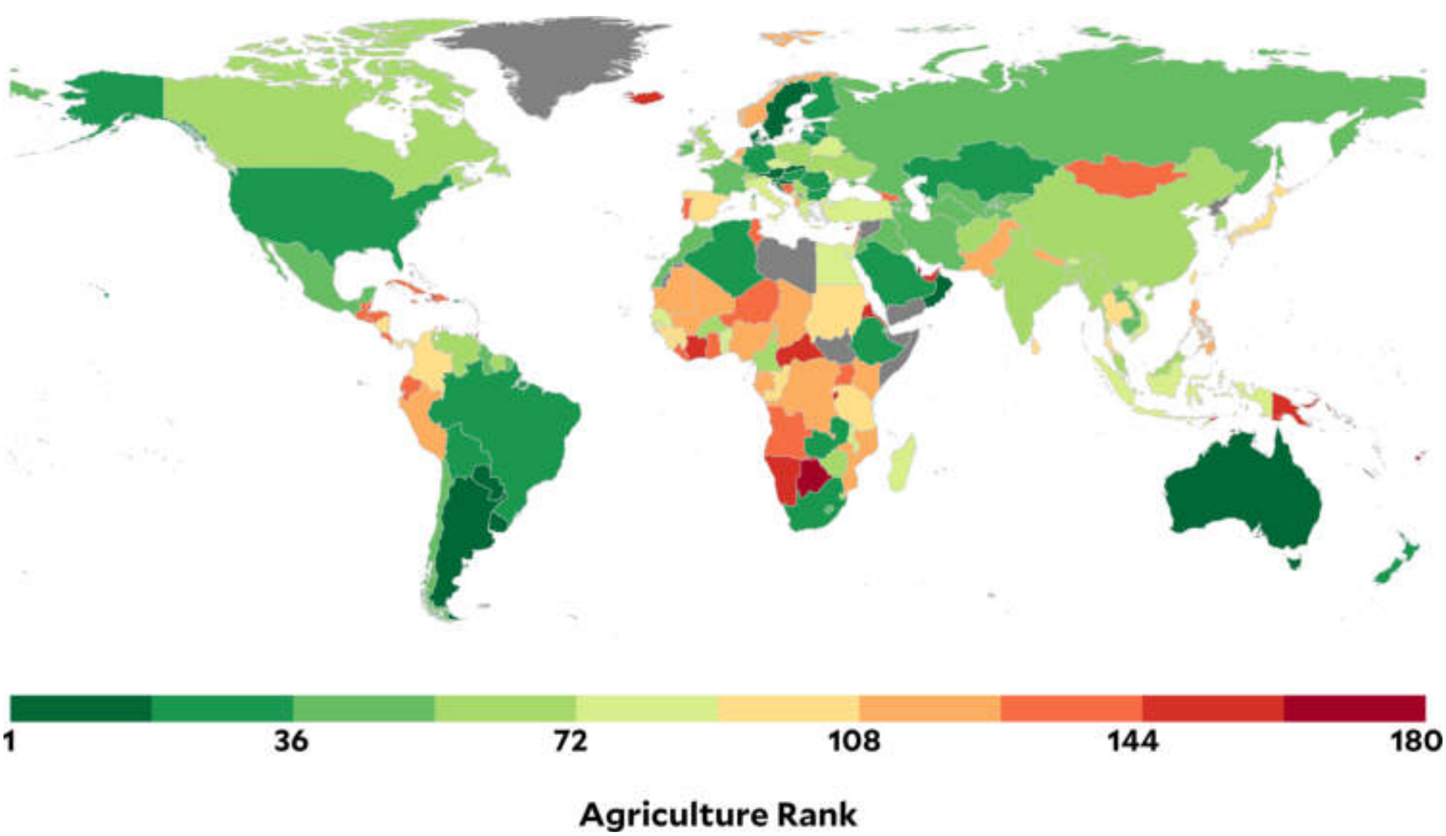


Table 13-1. Global rankings, scores, and regional rankings (REG) on Agriculture.

RANK	COUNTRY	SCORE	REG	RANK	COUNTRY	SCORE	REG	RANK	COUNTRY	SCORE	REG
1	Denmark	75.7	1	61	Poland	42.7	11	121	Malta	28.3	19
2	Argentina	74.1	1	62	China	42.4	5	122	Samoa	27.7	15
3	Sweden	74.0	2	63	Suriname	42.2	10	123	Mauritania	27.2	27
4	Uruguay	70.7	2	64	Canada	42.1	13	124	Kenya	27.1	28
5	Austria	70.6	3	65	North Macedonia	41.9	12	124	Nepal	27.1	7
6	Paraguay	69.4	3	66	Bangladesh	41.4	2	126	Kiribati	26.5	16
7	Croatia	68.9	1	67	Switzerland	41.1	14	127	Dem. Rep. Congo	26.4	29
8	Slovakia	68.0	2	68	Burkina Faso	40.6	9	128	Gabon	26.2	30
9	Australia	67.9	4	69	Malaysia	40.5	6	129	Norway	25.5	20
10	Oman	67.3	1	70	India	40.0	3	130	Equatorial Guinea	25.4	31
11	Bolivia	66.1	4	71	Senegal	39.9	10	131	Jamaica	25.3	17
12	Lithuania	65.6	3	72	Viet Nam	39.6	7	132	Angola	24.9	32
13	New Zealand	64.9	5	73	Kuwait	39.5	8	133	Tunisia	24.8	13
14	Latvia	64.4	4	74	Togo	39.2	11	134	Honduras	24.2	18
15	Algeria	63.3	2	75	Turkey	39.1	13	135	Guatemala	23.7	19
16	Finland	62.7	6	76	Greece	38.9	14	136	Portugal	23.5	21
17	Estonia	61.8	5	77	Italy	38.8	15	137	Dominican Republic	23.3	20
18	United States of America	61.4	7	78	Egypt	38.6	9	138	Ecuador	23.1	21
19	South Africa	61.1	1	79	Czech Republic	37.4	15	139	Cuba	22.7	22
20	Germany	60.9	8	80	Comoros	37.3	12	139	Mongolia	22.7	17
21	Kazakhstan	60.5	1	80	Bhutan	37.3	4	141	Liberia	22.4	33
22	Saudi Arabia	59.4	3	82	Malawi	36.7	13	142	Ghana	22.1	34
23	Ethiopia	56.9	2	82	Indonesia	36.7	8	143	Georgia	22.0	12
24	Brazil	56.5	5	84	Gambia	36.4	14	143	Singapore	22.0	18
25	Luxembourg	55.9	9	84	Belarus	36.4	10	145	Costa Rica	21.8	23
26	Bulgaria	55.8	6	86	Moldova	36.0	11	146	Niger	21.6	35
27	Slovenia	55.0	7	87	Madagascar	35.9	15	147	Belize	21.5	24
28	Romania	53.8	8	88	St. Vincent and Grenadines	35.4	11	148	Uganda	21.3	36
29	Zambia	53.2	3	89	Benin	35.3	16	148	Bosnia and Herzegovina	21.3	18
30	Hungary	53.0	9	90	Montenegro	34.7	16	150	El Salvador	20.6	25
31	Guyana	52.6	6	91	Republic of Congo	34.5	17	151	Mauritius	20.0	37
32	Turkmenistan	51.8	2	92	Guinea-Bissau	34.1	18	152	Côte d'Ivoire	19.7	38
33	Iraq	51.4	4	92	Tonga	34.1	9	153	Micronesia	19.4	19
33	Azerbaijan	51.4	3	94	Taiwan	33.8	10	154	Burundi	18.5	39
35	Mexico	50.6	7	95	Japan	33.4	11	154	Iceland	18.5	22
36	Tajikistan	50.1	4	96	Sierra Leone	33.2	19	154	Timor-Leste	18.5	20
37	France	49.5	10	96	Panama	33.2	12	157	São Tomé and Príncpe	18.2	40
38	Laos	49.1	1	96	Bahrain	33.2	10	158	Dominica	17.8	26
39	Djibouti	49.0	4	99	Sudan	33.1	11	159	Lebanon	17.5	14
39	Morocco	49.0	5	99	Belgium	33.1	16	160	United Arab Emirates	17.4	15
39	Kyrgyzstan	49.0	5	101	Thailand	33.0	12	161	Cabo Verde	16.7	41
42	Jordan	48.9	6	101	Vanuatu	33.0	12	162	Central African Republic	15.9	42
42	Russia	48.9	6	103	Nicaragua	31.9	13	163	Haiti	15.7	27
44	Ireland	48.7	11	104	Spain	31.8	17	164	Papua New Guinea	15.6	21
45	Iran	47.7	7	105	Sri Lanka	31.6	5	165	Eritrea	14.9	43
46	Chile	47.4	8	106	Rwanda	31.5	20	166	Namibia	14.8	44
47	Uzbekistan	47.2	7	107	Guinea	31.2	21	166	Brunei Darussalam	14.8	22
48	Cambodia	45.9	2	107	Colombia	31.2	14	168	Maldives	14.1	8
49	Lesotho	45.5	5	109	Tanzania	31.1	22	169	Bahamas	14.0	28
49	Armenia	45.5	8	110	Mali	30.7	23	170	Cyprus	13.9	19
51	Serbia	45.3	10	110	Peru	30.7	15	171	Qatar	13.3	16
52	United Kingdom	45.0	12	112	Mozambique	30.4	24	172	Barbados	11.9	29
53	Ukraine	44.7	9	113	Philippines	29.6	14	173	Fiji	11.1	23
54	Cameroon	44.2	6	114	Netherlands	29.3	18	174	Botswana	10.7	45
54	Afghanistan	44.2	1	115	Grenada	28.9	16	175	Seychelles	8.8	46
56	South Korea	44.1	3	115	Albania	28.9	17	176	Solomon Islands	8.6	24
57	Venezuela	43.6	9	117	Israel	28.8	12	177	Saint Lucia	6.4	30
58	Eswatini	43.2	7	118	Nigeria	28.6	25	178	Antigua and Barbuda	5.1	31
59	Myanmar	43.0	4	118	Pakistan	28.6	6	179	Trinidad and Tobago	4.1	32
60	Zimbabwe	42.8	8	120	Chad	28.4	26	180	Marshall Islands	1.7	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 rankings and scores on Agriculture.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Argentina	74.1	1
Uruguay	70.7	2
Paraguay	69.4	3
Bolivia	66.1	4
Brazil	56.5	5
Guyana	52.6	6
Mexico	50.6	7
Chile	47.4	8
Venezuela	43.6	9
Suriname	42.2	10
St. Vincent and Grenadines	35.4	11
Panama	33.2	12
Nicaragua	31.9	13
Colombia	31.2	14
Peru	30.7	15
Grenada	28.9	16
Jamaica	25.3	17
Honduras	24.2	18
Guatemala	23.7	19
Dominican Republic	23.3	20
Ecuador	23.1	21
Cuba	22.7	22
Costa Rica	21.8	23
Belize	21.5	24
El Salvador	20.6	25
Dominica	17.8	26
Haiti	15.7	27
Bahamas	14.0	28
Barbados	11.9	29
Saint Lucia	6.4	30
Antigua and Barbuda	5.1	31
Trinidad and Tobago	4.1	32

EASTERN EUROPE

Country	Score	Reg. Rank
Croatia	68.9	1
Slovakia	68.0	2
Lithuania	65.6	3
Latvia	64.4	4
Estonia	61.8	5
Bulgaria	55.8	6
Slovenia	55.0	7
Romania	53.8	8
Hungary	53.0	9
Serbia	45.3	10
Poland	42.7	11
North Macedonia	41.9	12
Turkey	39.1	13
Greece	38.9	14
Czech Republic	37.4	15
Montenegro	34.7	16
Albania	28.9	17
Bosnia and Herzegovina	21.3	18
Cyprus	13.9	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Afghanistan	44.2	1
Bangladesh	41.4	2
India	40.0	3
Bhutan	37.3	4
Sri Lanka	31.6	5
Pakistan	28.6	6
Nepal	27.1	7
Maldives	14.1	8

GLOBAL WEST

Country	Score	Reg. Rank
Denmark	75.7	1
Sweden	74.0	2
Austria	70.6	3
Australia	67.9	4
New Zealand	64.9	5
Finland	62.7	6
United States of America	61.4	7
Germany	60.9	8
Luxembourg	55.9	9
France	49.5	10
Ireland	48.7	11
United Kingdom	45.0	12
Canada	42.1	13
Switzerland	41.1	14
Italy	38.8	15
Belgium	33.1	16
Spain	31.8	17
Netherlands	29.3	18
Malta	28.3	19
Norway	25.5	20
Portugal	23.5	21
Iceland	18.5	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Kazakhstan	60.5	1
Turkmenistan	51.8	2
Azerbaijan	51.4	3
Tajikistan	50.1	4
Kyrgyzstan	49.0	5
Russia	48.9	6
Uzbekistan	47.2	7
Armenia	45.5	8
Ukraine	44.7	9
Belarus	36.4	10
Moldova	36.0	11
Georgia	22.0	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Laos	49.1	1
Cambodia	45.9	2
South Korea	44.1	3
Myanmar	43.0	4
China	42.4	5
Malaysia	40.5	6
Viet Nam	39.6	7
Indonesia	36.7	8
Tonga	34.1	9
Taiwan	33.8	10
Japan	33.4	11
Thailand	33.0	12
Vanuatu	33.0	12
Philippines	29.6	14
Samoa	27.7	15
Kiribati	26.5	16
Mongolia	22.7	17
Singapore	22.0	18
Micronesia	19.4	19
Timor-Leste	18.5	20
Papua New Guinea	15.6	21
Brunei Darussalam	14.8	22
Fiji	11.1	23
Solomon Islands	8.6	24
Marshall Islands	1.7	25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
South Africa	61.1	1
Ethiopia	56.9	2
Zambia	53.2	3
Djibouti	49.0	4
Lesotho	45.5	5
Cameroon	44.2	6
Eswatini	43.2	7
Zimbabwe	42.8	8
Burkina Faso	40.6	9
Senegal	39.9	10
Togo	39.2	11
Comoros	37.3	12
Malawi	36.7	13
Gambia	36.4	14
Madagascar	35.9	15
Benin	35.3	16
Republic of Congo	34.5	17
Guinea-Bissau	34.1	18
Sierra Leone	33.2	19
Rwanda	31.5	20
Guinea	31.2	21
Tanzania	31.1	22
Mali	30.7	23
Mozambique	30.4	24
Nigeria	28.6	25
Chad	28.4	26
Mauritania	27.2	27
Kenya	27.1	28
Dem. Rep. Congo	26.4	29
Gabon	26.2	30
Equatorial Guinea	25.4	31
Angola	24.9	32
Liberia	22.4	33
Ghana	22.1	34
Niger	21.6	35
Uganda	21.3	36
Mauritius	20.0	37
Cote d'Ivoire	19.7	38
Burundi	18.5	39
Sao Tome and Principe	18.2	40
Cabo Verde	16.7	41
Central African Republic	15.9	42
Eritrea	14.9	43
Namibia	14.8	44
Botswana	10.7	45
Seychelles	8.8	46

GREATER MIDDLE EAST

Country	Score	Reg. Rank
Oman	67.3	1
Algeria	63.3	2
Saudi Arabia	59.4	3
Iraq	51.4	4
Morocco	49.0	5
Jordan	48.9	6
Iran	47.7	7
Kuwait	39.5	8
Egypt	38.6	9
Bahrain	33.2	10
Sudan	33.1	11
Israel	28.8	12
Tunisia	24.8	13
Lebanon	17.5	14
United Arab Emirates	17.4	15
Qatar	13.3	16

2. Global Trends

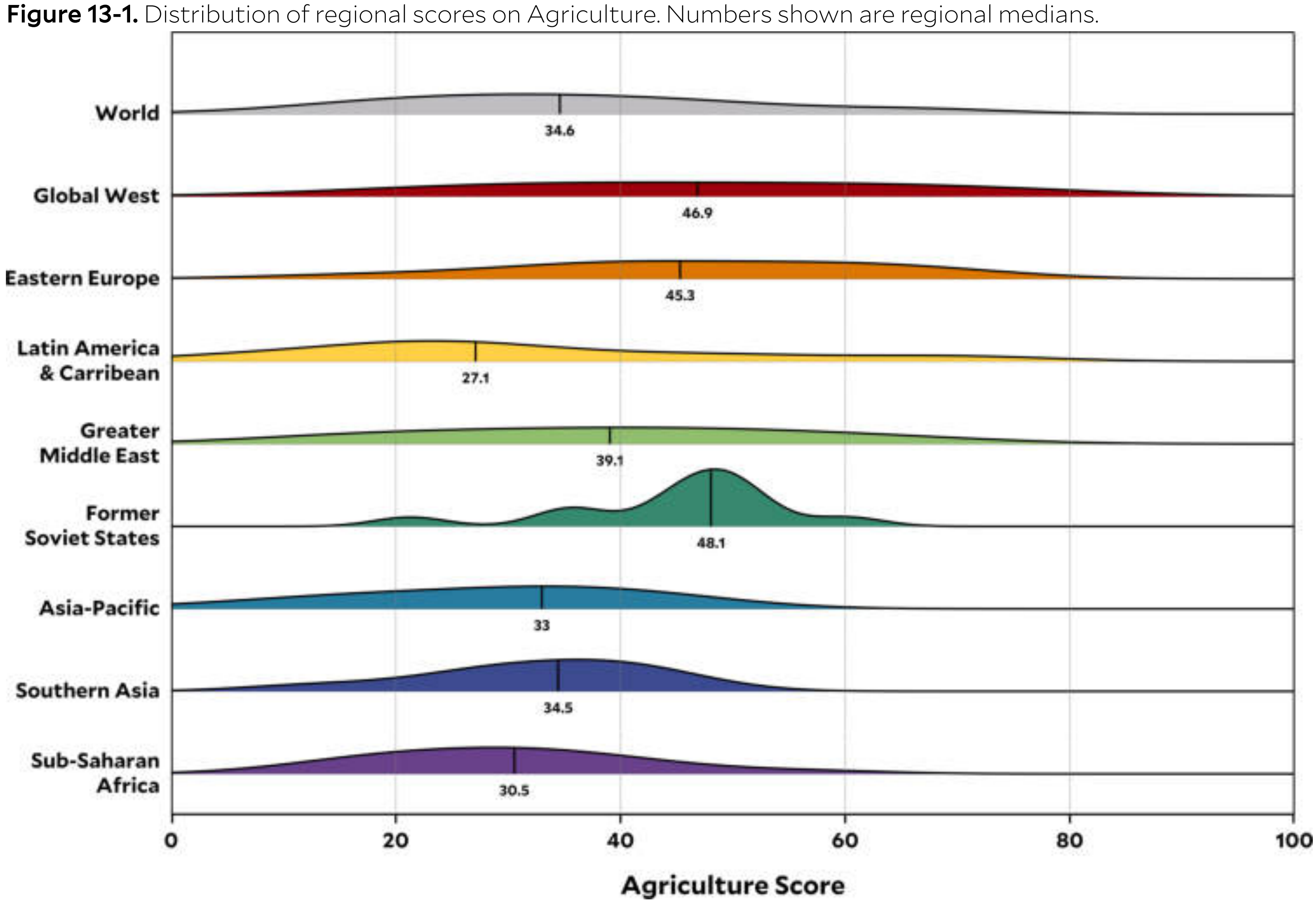
The world's agricultural lands are suffering from agrochemical mismanagement. About 64% of global agricultural land is at risk of pollution by more than one active pesticide ingredient, and 31% of land is at high-risk of pesticide pollution (Tang et al., 2021). Many high-risk areas are adjacent to biodiversity hotspots, illustrating the danger of pesticide mismanagement. The median unadjusted pesticide risk score is 3.16 across all countries for which the EPI has data (Tang et al., 2021), meaning that farmland in over 50% of countries is at risk of environmental and human degradation due to pesticide misuse. Research suggests that educational programs will be key to helping farmers manage pesticide applications more sustainably (Sapbamrer, 2018; Sharifzadeh and Abdollahzadeh, 2021).

Global scores in the sustainable nitrogen management index increased gradually between 1961 and 2015, but the world has seen little improvement in the most recent decade's data. The latest global SNMI score is 53.5. Although 95 countries' scores improved in the most recent decade's data, 81 countries saw worsening nitrogen management. China and India together produce over half of the world's nitrogen pollution, despite making up only 36% of the global population (Zhang et al., 2015). To reduce nitrogen pollution, developed and transitioning economies — including China and India — will need to sharply increase nitrogen use efficiency. Maintaining current yields, a global SNMI of zero could be reached by 2050 if nitrogen use efficiency increases by 30% (Zhang et al., 2015).

3. Leaders and Laggards

The top-performing countries in Agriculture are several European nations (Austria, Denmark, Sweden), as well as a group of developing countries in South America (Argentina, Paraguay, Uruguay). Higher-income countries are more capable of achieving high crop yields with efficient nitrogen use, as financial resources can improve soil health and weather forecasting to prevent runoff (Zhang et al., 2015). Not all wealthy countries, however, score well. Among those falling behind are Singapore (22), Iceland

Figure 13-1. Distribution of regional scores on Agriculture. Numbers shown are regional medians.



(18.5), and Qatar (13.3). More effective grazing management could help alleviate Iceland's fertilizer inefficiency (Mulloy et al., 2021).

Denmark earns the highest score in the 2022 EPI's Agriculture issue category. Over the past decade, Denmark has enacted several policies for pesticides and fertilizers which have increased efficiency and reduced pollution. After a pesticide smuggling operation was revealed in 2012 (CPH Post, 2012), policymakers moved to place more stringent bans on harmful pesticides across the country (ARC2020, 2012). A 2017 action plan tightened the authorizations required to use pesticides (Ministry of Environment and Food of Denmark, 2017). The plan also developed targeted inspection efforts and reduced authorizations for pesticide use on non-agricultural land, including golf courses and private gardens. Despite its strong performance, Denmark can still improve its agricultural practices. For instance, recent experts have called on the Danish government to mitigate pesticide residue in drinking water (Sonne et al., 2018).

Argentina, another top performer in this issue category, has enacted policies to reduce the environmental impact of its agricultural systems. In 2018, Argentina's farming organization, Asociación de Cooperativas Argentinas, created a software program to help farmers minimize water and fertilizer inputs while still maintaining yields (Meyerhoff, 2019). The country has also developed an opt-in certification system for farmers to market to customers that they have adopted environmentally friendly agricultural practices (Peiretti and Dumanski, 2014). Policymakers in other countries could leverage similar green certifications to provide market incentives for improving performance.

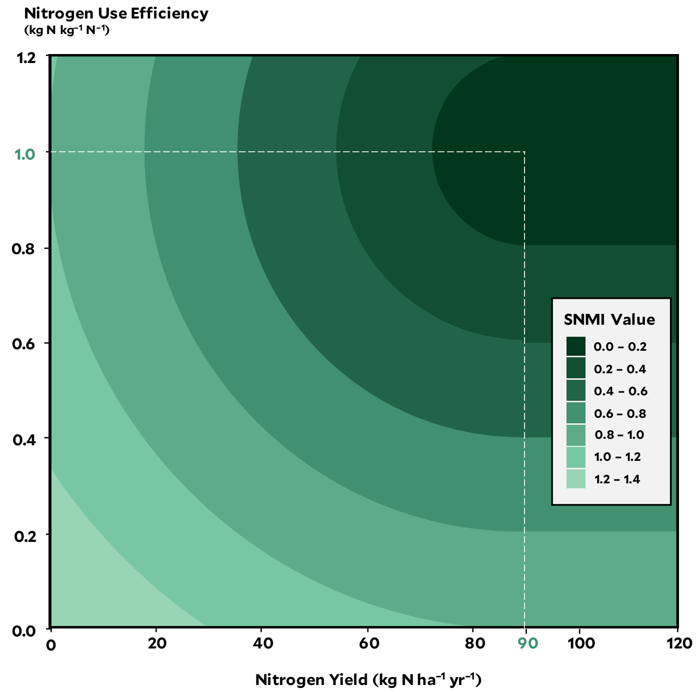


Figure 13-2. Sustainable Nitrogen Management Index (SNMI) values are based on the Euclidean distance from an ideal point defined by Nitrogen Use Efficiency = 1, indicating that nitrogen is neither over-applied nor removed from the soil, and Yield ≥ 90 kg N ha^{-1} yr^{-1}, a universal standard for sufficient production of harvested nitrogen. The greater the distance from the ideal point, the worse the performance on the SNMI. Source: based on Zhang and Davidson, 2019.

4. Methods

In 2014, the World Resources Institute (WRI) published Indicators of Sustainable Agriculture: A Scoping Analysis. In that analysis, WRI identified five areas in which agricultural indicators are needed, according to a survey of past and potential measurements (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 to 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.

Six years later, the world still lacks the global data systems necessary to support all of these critical agricultural issues. Many existing studies are limited in geographical scope, infrequently updated, or methodologically inconsistent, resulting in their exclusion from the EPI. The importance of agriculture to society and the range of its potential environmental impacts have made the data gaps a pressing priority for the EPI.

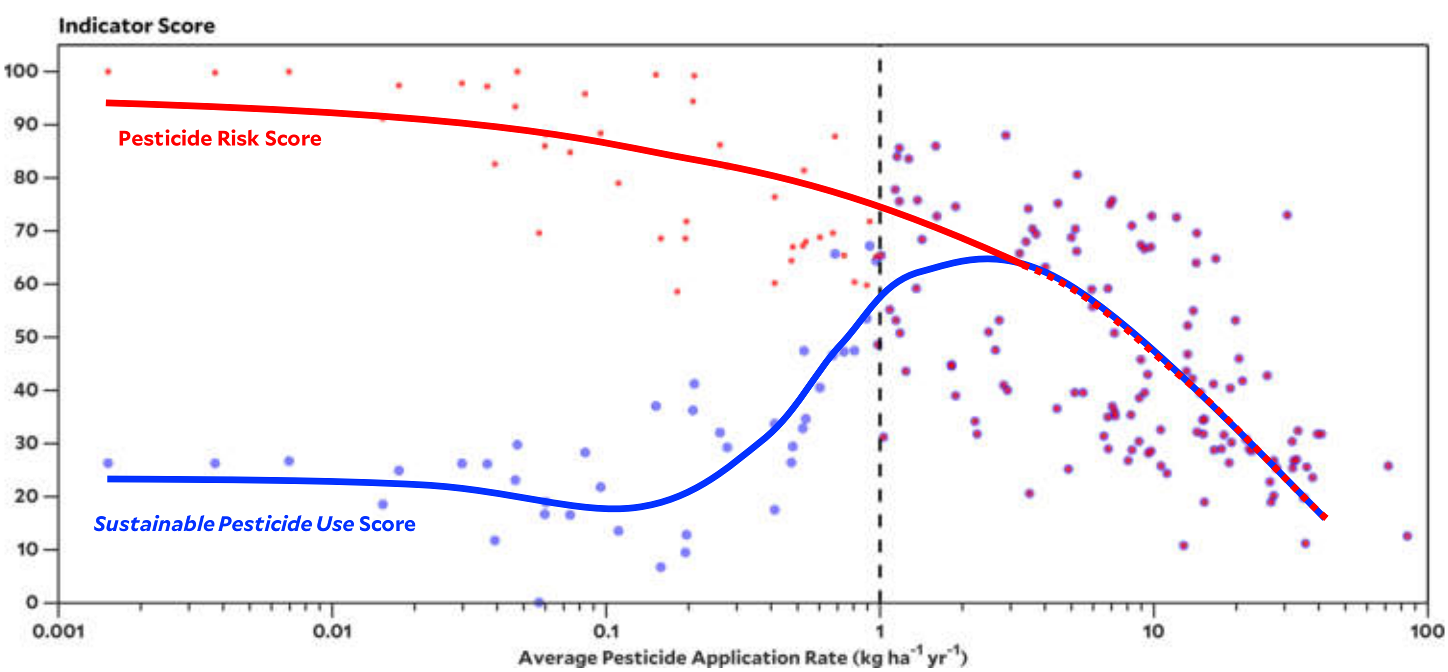
Recent groundbreaking research, however, has allowed the EPI to include a pilot indicator on sustainable pesticide use. Like the SNMI, this indicator captures dimensions of soil health by starting with country pesticide risk scores. The pesticide risk scores, developed by Tang et al. 2021, track 92 of the common active ingredients in pesticides, and juxtapose their use against water scarcity, biodiversity, and national income. The unadjusted risk score is representative of the ratio of the predicted environmental concentration of active ingredients (PEC) and the predicted no-effect environmental concentration (PNEC). The risk of pollution is classified as negligible (0-1), medium (1.01-3), or high (3.01+). The EPI's indicator adjusts pesticide risk scores by penalizing countries that use too little pesticides and thus may suffer from food insecurity. When countries do not use pesticides, crops bear a greater risk of attracting pests and disease vectors. This results in less efficient agricultural practices and, consequently, excess agricultural land use.

The EPI team emphasizes that this indicator is a first step toward a more accurate gauge of country performance, and welcomes feedback on how to improve the indicator moving forward.

The SNMI, a 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 (Zhang et al., 2015; Zhang and Davidson, 2019). Second, countries are assessed on annual nitrogen yield, which is the amount of nitrogen bound up in crops every year. The ideal NUE level is 1. Excess fertilizer use, where nitrogenous nutrients are not used by crops and can pollute waterways through runoff, corresponds to NUE levels above 1. NUE levels below 1 indicate nitrogen is being depleted in the soil and crops will be less healthy and productive.

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 the threshold for sustainable yield at 90 kg N/ha/yr based on the NAO's estimate of the "required nitrogen yield, averaged globally, to meet 2050 crop production targets without expanding the current crop land" (Alexandratos and Bruinsma, 2012).

Figure 13-3. Derivation of *sustainable pesticide use* from pesticide risk score and application rates. Source: risk score from Tang et al. 2021; application rates from Maggi et al. 2019 with analysis by EPI.



Data Sources
Sustainable pesticide use data for 166 countries in 2021 come from the recent scientific literature (Tang et al., 2021). Global georeferenced pesticide application rates, used to adjust the raw pesticide risk score, are derived from the USGS Pesticide National Synthesis Project and FAOSTAT (Maggi et al., 2019).

Sustainable nitrogen use data for 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 (Zhang et al., 2015). The SNMI is the Euclidean distance of a country's normalized NUE and nitrogen yield from an ideal point (Figure 13.2). The methodology for SNMI is described in further detail in Zhang and Davidson (2019).

Limitations
The two indicators monitor just two aspects of complex agricultural systems. Data limitations prevent a more comprehensive assessment of agriculture's environmental impacts.

Sustainable pesticide use leverages two inputs — pesticide risk score and pesticide application rates — both of which are highly variable within countries. Variability similarly affects the two axes of the SNMI, nitrogen use efficiency and yield. Regions vary in the nutrient content in their soil and require different amounts of chemical input to support agricultural yields. Nations can be in nitrogen excess and deficiency at the same time (X. Zhang & Davidson, 2019).

As agricultural data grows more comprehensive, one priority should be to establish country-specific benchmarks for nitrogen and pesticide use so that findings can be normalized (Reytar et al., 2014). The optimal pesticide use for a specific country might different from the approximately 1 kg/ha level used for the pilot sustainable pesticide use indicator. Likewise, a country's target nitrogen yield might differ from the FAO's established target of 90 kg N ha^{-1} yr^{-1} used in the SNMI (Zhang and Davidson, 2019).

Focus 13.1

The Variable Potential for Agricultural Sectors to Mitigate Climate Change

Though agriculture is vital to human existence, it is also a major driver of land-use change and a source of greenhouse gas emissions (GHGs). The imperative to mitigate climate change under the Paris Agreement encourages countries to set targets for reduction of their GHG emissions, including those from the agricultural sector. There are significant opportunities for agriculture to lessen negative climate impacts and even help mitigate climate change, but these opportunities are highly variable across different agricultural activities and countries.

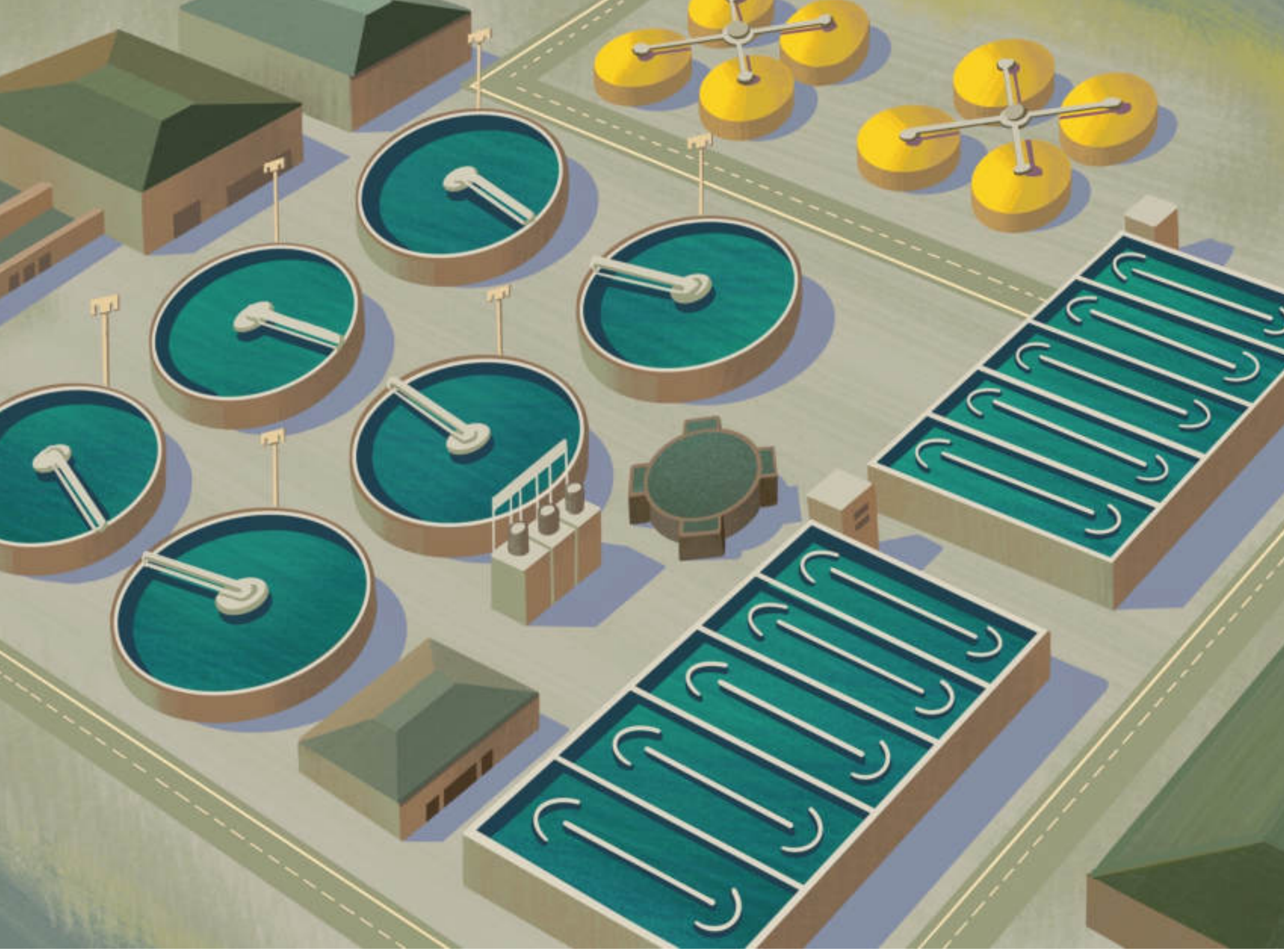
Food systems contribute over a third of all anthropogenic emissions annually. Seventy-one percent of these emissions stem from agricultural activities and land use clearing, while supply chain production contributes 29% of emissions (Crippa et al., 2021). The types, sources, intensities, and drivers of emissions vary from country to country. For example, Kenya's agricultural GHGs contribute to 63% of its national emissions but less than 0.08% to global agricultural emissions, while China's agricultural sector is only 5.7% of its national emissions yet contributes to 11.6% of global emissions.

Changes to agricultural systems can not only mitigate emissions but also enhance carbon sinks. Better soil management may sequester enough carbon to offset yearly agricultural GHG emissions by 31%. Feedstock supplements for cattle and genetically modified rice varieties offer options to reduce methane emissions. More effective fertilizer application can help reduce nitrous oxide emissions. Countries can harness numerous policies to reduce the climatic impact of their agriculture sectors. One policy pathway involves payments to incentivize cover crops or reduced tillage, both of which promote sequestration and retention of CO_2 in soils. Carbon offset markets are also a burgeoning opportunity to incentivize the reduction and removal of GHGs.

The adequacy of these policies will vary from country to country. This variable capacity, and desire, to mitigate GHG emissions factors into countries' Nationally-Determined Contributions under the Paris Climate Agreement. To stay aligned with the Paris Agreement, countries such as the USA, Australia, and China may not need to prioritize action in their agriculture sectors even though they contribute proportionally more to global agriculture emissions than the bottom 147 lowest emitting countries in the world. Conversely, those lower-emitting countries may feel more urgency to mitigate agricultural emissions because they make up a proportionally larger share of their national emissions.

Policymakers must navigate these complex policy choices to enhance the sustainability of agricultural systems worldwide. Regulating commodities associated with deforestation may, for instance, curb agriculturally driven land-use change and make supply chains greener. Countries that both contribute significantly to global agricultural emissions and have the capacity to mitigate these emissions should pursue soil fertility and sequestration, better manage agricultural byproducts (such as repurposing manure to produce biochar or biodigester energy), and reverse socio-economic drivers of land degradation.

Agriculture represents an array of practices, purposes, and meanings beyond its climate impacts. It is inextricably and complexly linked to human survival, and yet in this century, adds another link to that survival through its climate impacts.



Chapter 14. Water Resources

1. Introduction

From groundwater to seawater, water plays a complex and underappreciated role in global environmental, economic, and public health. Access to water underpins food production (Rosegrant et al., 2009), industrial sectors like mining and manufacturing (Hamilton, 2019), and urban growth (Aivazidou et al., 2021). Water sources, especially groundwater, sustain biodiversity in the world's terrestrial and wetland biomes. These ecosystems form bulwarks against climate shocks and natural disasters, and serve as important sources of food and cultural heritage (UNESCO, 2022). Human activities emit pollutants including organics, nutrients, synthetic compounds, pathogens, heat, and large litter into the world's waters. Crucially for human life, wetlands and water bodies protect groundwater and surface water from contamination by naturally processing and taking in contaminants produced by homes, business, and farms (Xu et al., 2020). Pollution puts aquatic life at risk and reduces global water access, in addition to reducing the health of terrestrial and aquatic ecosystems.

This issue category focuses on one issue: wastewater treatment. Poor wastewater management poses long-term risks to public welfare and ecosystem vitality. Wastewater treatment technologies, from primary treatment (comminutors and first degree sedimentation) to tertiary treatment (chlorination and dechlorination), make waters safe for discharge and reuse by removing pollutants from wastewater (Crini and Lichtfouse, 2019; Gallego-Schmid and Tarpani, 2019). Connecting people to wastewater collection and treatment systems, and improving global wastewater treatment standards, offers a net benefit to the built and natural environment and is an important sustainable development target.

Research consistently demonstrates that a robust understanding of water resources is essential to maintaining both public health and ecosystem vitality (Daigger, 2007). But monitoring sustainable management of water sources is difficult due to the regionally variable conditions of different water bodies and hydrological processes. In an ideal world, every country would be able to track water quality reliably and consistently as water moves from springs to deltas, in and out of the sphere of human use. But there are currently no internationally standardized gauges of drinking water quality, aquifer depletion, and pollution levels in groundwater or surface levels across the countries covered by the EPI (Bare, 2014; Fienen and Arshad, 2016). For that reason, the 2022 EPI relies on wastewater treatment as a proxy metric for water resources. The EPI team emphasizes that this indicator covers only a small part of the human relationship with water resources, and encourages the development of more robust water quality and quantity metrics across countries. A key obstacle to progress, especially in low- and middle-income countries, is a lack of data access (UNESCO, 2022). Policymakers can do more to improve data collection and promote development by sharing data with international organizations.

2. Indicators

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.

Map 14-1. Global rankings on Water Resources.

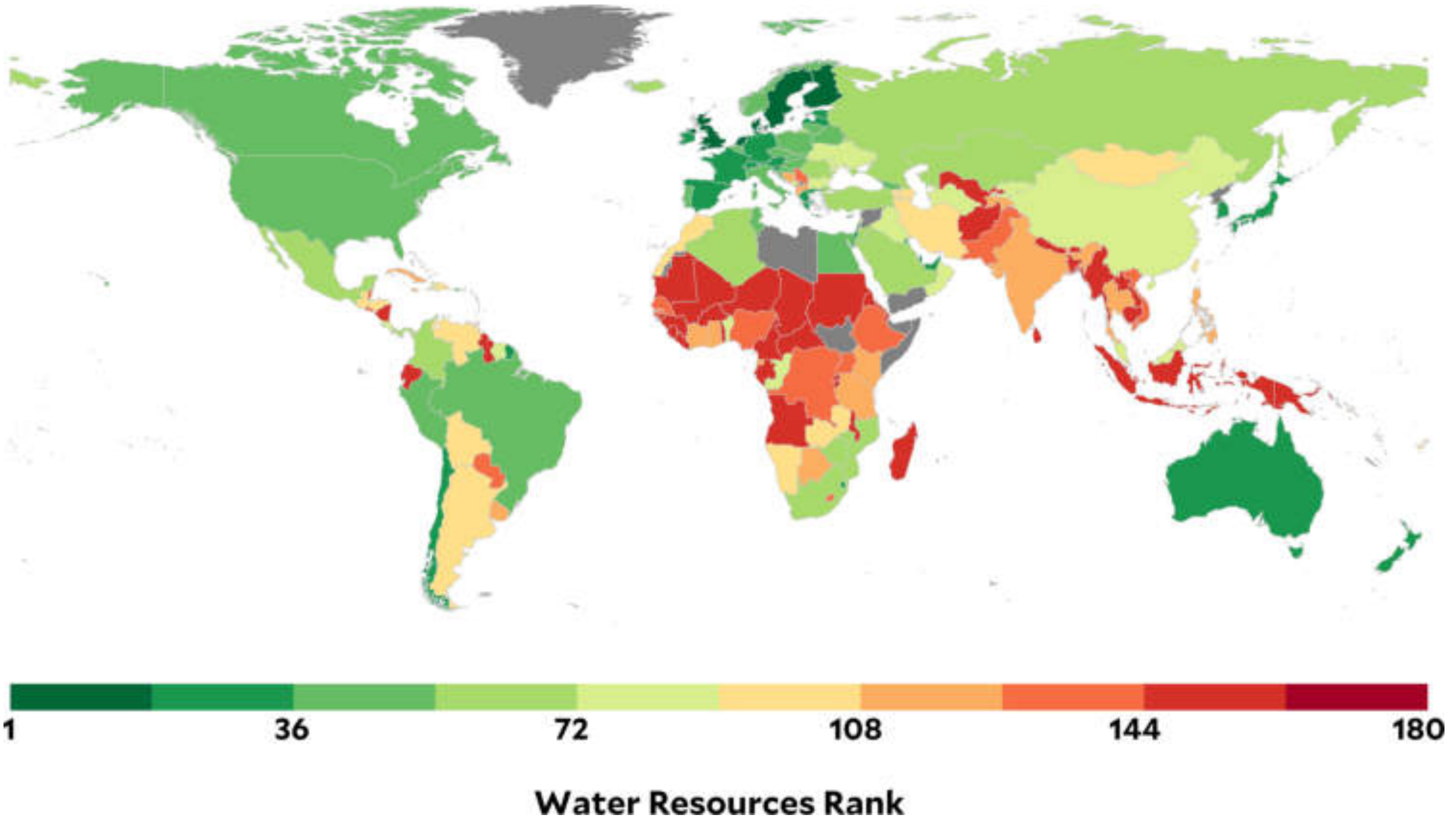


Table 14-1. Global rankings, scores, and regional rankings (REG) on Water Resources.

RANK	COUNTRY	SCORE	REG
1	Denmark	100.0	1
1	Finland	100.0	1
1	Netherlands	100.0	1
1	Sweden	100.0	1
1	Singapore	100.0	1
6	United Kingdom	99.0	5
7	Luxembourg	98.0	6
8	Germany	97.0	7
8	Switzerland	97.0	7
10	Austria	94.0	9
11	Australia	92.9	10
12	Slovenia	92.2	1
13	United Arab Emirates	92.1	1
14	Spain	91.1	11
15	Latvia	90.7	2
16	Bahrain	88.0	2
16	France	88.0	12
18	Ireland	87.0	13
19	Israel	81.7	3
19	Greece	81.7	3
21	New Zealand	79.9	14
22	South Korea	76.8	2
23	Japan	74.8	3
24	Chile	71.9	1
25	Estonia	70.4	4
26	Eswatini	70.0	1
26	Qatar	70.0	4
28	Croatia	69.0	5
29	Belgium	68.2	15
30	Canada	67.4	16
31	Norway	64.3	17
32	Czech Republic	61.5	6
32	Poland	61.5	6
34	Portugal	59.2	18
35	United States of America	58.9	19
36	Italy	58.8	20
37	Belarus	55.8	1
38	Hungary	55.3	8
39	Brazil	52.4	2
40	Lithuania	52.3	9
41	Cyprus	50.0	10
42	Georgia	46.6	2
43	Slovakia	44.7	11
44	Kuwait	43.1	5
45	Tunisia	43.0	6
46	Egypt	42.0	7
47	Peru	41.0	3
48	Lebanon	38.2	8
49	Saudi Arabia	37.7	9
50	Zimbabwe	37.2	2
51	Algeria	33.1	10
52	Turkey	30.5	12
53	Kazakhstan	27.5	3
54	Colombia	25.9	4
55	Romania	25.7	13
56	Mexico	25.2	5
57	Cabo Verde	24.7	3
58	Panama	23.1	6
59	South Africa	21.7	4
60	Mozambique	20.0	5
61	Seychelles	19.5	6
62	Jordan	18.6	11
63	Russia	18.5	4
64	Bahamas	17.4	7
65	Antigua and Barbuda	15.7	8
66	Iceland	15.3	21
67	Grenada	15.1	9
68	Ukraine	14.1	5
69	Saint Lucia	14.0	10
69	St. Vincent and Grenadines	14.0	10
71	Bulgaria	13.9	14
72	Oman	13.4	12
73	Suriname	13.2	12
74	Iraq	13.1	13
75	Malaysia	12.6	4
76	São Tomé and Príncpe	10.9	7
77	Comoros	10.1	8
78	Turkmenistan	9.8	6
79	Benin	9.6	9
80	China	9.4	5
81	Moldova	9.2	7
82	Republic of Congo	8.8	10
83	Kyrgyzstan	8.6	8
84	Montenegro	8.4	15
85	Gambia	7.9	11
86	Costa Rica	7.2	13
87	Haiti	7.1	14
88	Guatemala	6.8	15
89	Taiwan	6.5	6
90	Venezuela	6.4	16
91	Argentina	5.9	17
92	Dominican Republic	5.8	18
92	Brunei Darussalam	5.8	7
94	Morocco	5.4	14
95	Namibia	5.0	12
96	Zambia	4.5	13
96	Armenia	4.5	9
96	Kiribati	4.5	8
96	Vanuatu	4.5	8
100	Azerbaijan	3.9	10
100	Fiji	3.9	10
102	Maldives	3.8	1
103	Iran	3.7	15
104	Bolivia	3.5	19
105	Mongolia	3.3	11
106	Honduras	3.1	20
107	Ghana	3.0	14
107	Jamaica	3.0	21
107	Trinidad and Tobago	3.0	21
110	Tanzania	2.9	15
111	Mauritius	2.8	16
112	India	2.2	2
112	Tajikistan	2.2	11
114	Uruguay	2.1	23
115	Albania	1.9	16
116	Thailand	1.8	12
117	Cuba	1.7	24
118	Côte d'Ivoire	1.2	17
118	Equatorial Guinea	1.2	17
118	Solomon Islands	1.2	13
121	Kenya	1.1	19
121	Bosnia and Herzegovina	1.1	17
123	Botswana	0.9	20
123	Dominica	0.9	25
123	Samoa	0.9	14
126	North Macedonia	0.8	18
126	Philippines	0.8	15
128	Paraguay	0.7	26
128	Serbia	0.7	19
130	Timor-Leste	0.6	16
131	Senegal	0.5	21
132	Uganda	0.4	22
132	Belize	0.4	27
134	Lesotho	0.3	23
134	Viet Nam	0.3	17
136	Nigeria	0.2	24
137	Dem. Rep. Congo	0.1	25
137	Ethiopia	0.1	25
137	Pakistan	0.1	3
137	El Salvador	0.1	28
141	Angola	0.0	27
141	Burkina Faso	0.0	27
141	Burundi	0.0	27
141	Cameroon	0.0	27
141	Central African Republic	0.0	27
141	Chad	0.0	27
141	Djibouti	0.0	27
141	Eritrea	0.0	27
141	Gabon	0.0	27
141	Guinea	0.0	27
141	Guinea-Bissau	0.0	27
141	Liberia	0.0	27
141	Madagascar	0.0	27
141	Malawi	0.0	27
141	Mali	0.0	27
141	Mauritania	0.0	27
141	Niger	0.0	27
141	Rwanda	0.0	27
141	Sierra Leone	0.0	27
141	Togo	0.0	27
141	Afghanistan	0.0	4
141	Bangladesh	0.0	4
141	Bhutan	0.0	4
141	Nepal	0.0	4
141	Sri Lanka	0.0	4
141	Barbados	0.0	29
141	Ecuador	0.0	29
141	Guyana	0.0	29
141	Nicaragua	0.0	29
141	Sudan	0.0	16
141	Malta	0.0	22
141	Uzbekistan	0.0	12
141	Cambodia	0.0	18
141	Indonesia	0.0	18
141	Laos	0.0	18
141	Myanmar	0.0	18
141	Papua New Guinea	0.0	18
N/A	Marshall Islands		N/A
N/A	Micronesia		N/A
N/A	Tonga		N/A

- 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 and scores on Water Resources.

LATIN AMERICA & CARIBBEAN

Country	Score	Reg. Rank
Chile	71.9	1
Brazil	52.4	2
Peru	41.0	3
Colombia	25.9	4
Mexico	25.2	5
Panama	23.1	6
Bahamas	17.4	7
Antigua and Barbuda	15.7	8
Grenada	15.1	9
Saint Lucia	14.0	10
St. Vincent and Grenadines	14.0	10
Suriname	13.2	12
Costa Rica	7.2	13
Haiti	7.1	14
Guatemala	6.8	15
Venezuela	6.4	16
Argentina	5.9	17
Dominican Republic	5.8	18
Bolivia	3.5	19
Honduras	3.1	20
Jamaica	3.0	21
Trinidad and Tobago	3.0	21
Uruguay	2.1	23
Cuba	1.7	24
Dominica	0.9	25
Paraguay	0.7	26
Belize	0.4	27
El Salvador	0.1	28
Barbados	0.0	29
Ecuador	0.0	29
Guyana	0.0	29
Nicaragua	0.0	29

EASTERN EUROPE

Country	Score	Reg. Rank
Slovenia	92.2	1
Latvia	90.7	2
Greece	81.7	3
Estonia	70.4	4
Croatia	69.0	5
Czech Republic	61.5	6
Poland	61.5	6
Hungary	55.3	8
Lithuania	52.3	9
Cyprus	50.0	10
Slovakia	44.7	11
Turkey	30.5	12
Romania	25.7	13
Bulgaria	13.9	14
Montenegro	8.4	15
Albania	1.9	16
Bosnia and Herzegovina	1.1	17
North Macedonia	0.8	18
Serbia	0.7	19

SOUTHERN ASIA

Country	Score	Reg. Rank
Maldives	56.7	1
Bangladesh	35.1	2
Sri Lanka	31.8	3
India	24.5	4
Pakistan	23.6	5
Afghanistan	-	-
Bhutan	-	-
Nepal	-	-

GLOBAL WEST

Country	Score	Reg. Rank
Denmark	100.0	1
Finland	100.0	1
Netherlands	100.0	1
Sweden	100.0	1
United Kingdom	99.0	5
Luxembourg	98.0	6
Germany	97.0	7
Switzerland	97.0	7
Austria	94.0	9
Australia	92.9	10
Spain	91.1	11
France	88.0	12
Ireland	87.0	13
New Zealand	79.9	14
Belgium	68.2	15
Canada	67.4	16
Norway	64.3	17
Portugal	59.2	18
United States of America	58.9	19
Italy	58.8	20
Iceland	15.3	21
Malta	0.0	22

FORMER SOVIET STATES

Country	Score	Reg. Rank
Belarus	55.8	1
Georgia	46.6	2
Kazakhstan	27.5	3
Russia	18.5	4
Ukraine	14.1	5
Turkmenistan	9.8	6
Moldova	9.2	7
Kyrgyzstan	8.6	8
Armenia	4.5	9
Azerbaijan	3.9	10
Tajikistan	2.2	11
Uzbekistan	0.0	12

ASIA-PACIFIC

Country	Score	Reg. Rank
Singapore	100.0	1
South Korea	76.8	2
Japan	74.8	3
Malaysia	12.6	4
China	9.4	5
Taiwan	6.5	6
Brunei Darussalam	5.8	7
Kiribati	4.5	8
Vanuatu	4.5	8
Fiji	3.9	10
Mongolia	3.3	11
Thailand	1.8	12
Solomon Islands	1.2	13
Samoa	0.9	14
Philippines	0.8	15
Timor-Leste	0.6	16
Viet Nam	0.3	17
Cambodia	0.0	18
Indonesia	0.0	18
Laos	0.0	18
Myanmar	0.0	18
Papua New Guinea	0.0	18
Marshall Islands		24
Micronesia		23
Tonga		25

SUB-SAHARAN AFRICA

Country	Score	Reg. Rank
Eswatini	70.0	1
Zimbabwe	37.2	2
Cabo Verde	24.7	3
South Africa	21.7	4
Mozambique	20.0	5
Seychelles	19.5	6
Sao Tome and Principe	10.9	7
Comoros	10.1	8
Benin	9.6	9
Republic of Congo	8.8	10
Gambia	7.9	11
Namibia	5.0	12
Zambia	4.5	13
Ghana	3.0	14
Tanzania	2.9	15
Mauritius	2.8	16
Cote d'Ivoire	1.2	17
Equatorial Guinea	1.2	17
Kenya	1.1	19
Botswana	0.9	20
Senegal	0.5	21
Uganda	0.4	22
Lesotho	0.3	23
Nigeria	0.2	24
Dem. Rep. Congo	0.1	25
Ethiopia	0.1	25
Angola	0.0	27
Burkina Faso	0.0	27
Burundi	0.0	27
Cameroon	0.0	27
Central African Republic	0.0	27
Chad	0.0	27
Djibouti	0.0	27
Eritrea	0.0	27
Gabon	0.0	27
Guinea	0.0	27
Guinea-Bissau	0.0	27
Liberia	0.0	27
Madagascar	0.0	27
Malawi	0.0	27
Mali	0.0	27
Mauritania	0.0	27
Niger	0.0	27
Rwanda	0.0	27
Sierra Leone	0.0	27
Togo	0.0	27

GREATER MIDDLE EAST

Country	Score	Reg. Rank
United Arab Emirates	92.1	1
Bahrain	88.0	2
Israel	81.7	3
Qatar	70.0	4
Kuwait	43.1	5
Tunisia	43.0	6
Egypt	42.0	7
Lebanon	38.2	8
Saudi Arabia	37.7	9
Algeria	33.1	10
Jordan	18.6	11
Oman	13.4	12
Iraq	13.1	13
Morocco	5.4	14
Iran	3.7	15
Sudan	0.0	16

2. Global Trends

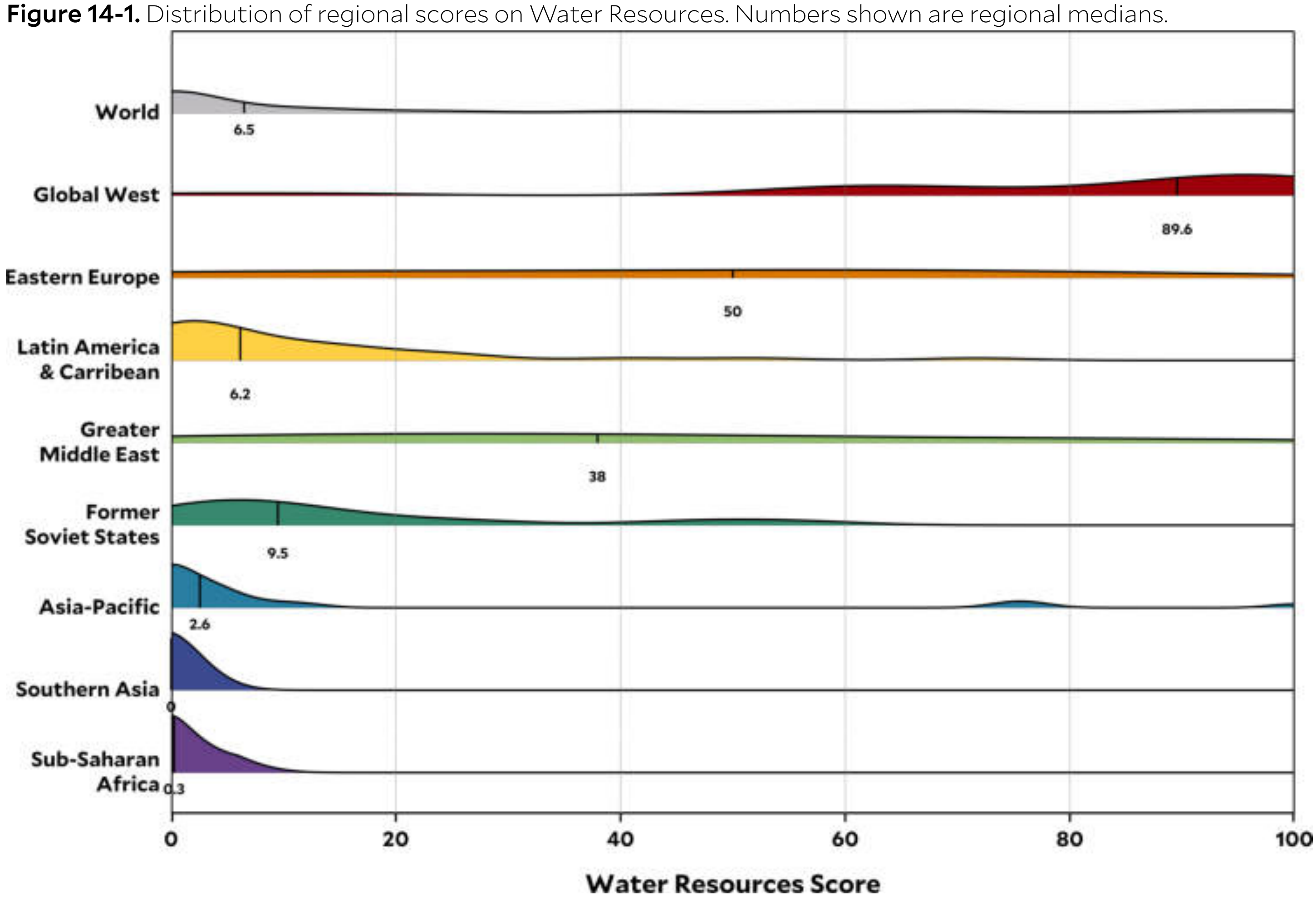
Entire regions of the world have serious shortcomings in their wastewater treatment levels. A total of 120 countries — two-thirds of those in the 2022 EPI — fall below the global average category score of 24.4. Although some countries, mostly European, do significantly better, the world's major population centers struggle to improve their performance in the Water Resources issue category. Both South Asia and Sub-Saharan Africa have median scores of 0.0, while the Asia-Pacific has a marginally higher median score of 0.3.

Robust wastewater treatment systems often require substantial infrastructure investments, particularly in urban centers. The costs of infrastructure, and the amount of time it takes to implement wastewater treatment, may explain the low performance of developing countries in the Global South. Rapid levels of urbanization, combined with unprecedented demands on already stressed water sources, make it difficult for government authorities to quickly implement and expand wastewater treatment. In the developed world, wastewater treatment rates are high, especially in Europe and North America. Many countries in the Greater Middle East also do better than the mean in this category, pointing to a synchronization of policy objectives with environmental realities: the region is already the most water-insecure in the world, and climate change is only making life more precarious for its inhabitants (Hofste et al., 2019b).

3. Leaders and Laggards

While many countries perform poorly in the Water Resources issue category, the EPI data spotlights countries that rise above their peers. Northern European countries, as well as several countries in the Greater Middle East, score highly in this category. Three of the best-performing countries for the indicator are Bahrain, the United Arab Emirates (UAE), and Israel, all of which are located in the highly water-stressed regions (Hofste et al., 2019a). Despite growing population loads and scarce access to natural groundwater and surface water sources, Bahrain,

Figure 14-1. Distribution of regional scores on Water Resources. Numbers shown are regional medians.



the UAE, and Israel have worked to rapidly improve their wastewater treatment infrastructure over the last two decades.

In Bahrain, as the population and water usage have increased, the demands placed on its limited wastewater treatment capacity have seen a corresponding rise. Bahrain's wastewater treatment system was centralized during the early stages of its urbanization, in the 1970s (Shakespeare, 2014). Today, the island's sewage networks service nearly 100% of the population. But the country's main wastewater treatment plant, the Tubli sewage treatment plant, was routinely handling treatment loads 50% higher than its 200,000 cm^3/day capacity by the late 2000s. Bahrain is now working to expand wastewater treatment by doubling the Tubli plant's capacity, and constructing two new wastewater treatment plants, slated for completion in 2022 (Fanack Water, 2020). The emphasis on constructing new wastewater treatment facilities and expanding old ones is crucial to water security in Bahrain, which is projected by the World Resources Institute to be one of the 11 most water-stressed countries in the world by 2040 (Luo et al., 2015).

The UAE, Israel, and Singapore are also water-stressed countries that earn top scores in Water Resources. While wastewater treatment is a bright spot for these countries as they prepare for an increasingly water insecure future, sustainability researchers remain concerned by excess water consumption and the cost and byproducts of desalination (Hsien et al., 2019; Miller et al., 2015). The proximity of wastewater treatment plants to fragile ecosystems (as in Bahrain, where the Tubli plant currently discharges minimally treated sewage into nearby Tubli Bay) points to the challenges of optimizing for intensified climate risks, limited water resources, and a challenging water access landscape.

Bahrain and Singapore are rare strong performers among island nations in this issue category. Island nations around the world rank poorly in this issue category, as many lack effective wastewater treatment infrastructure and discharge untreated or barely treated wastewater into nearby bodies of water, polluting marine habitats and threatening marine life (Kereseka, 2021; Wear and Thurber, 2015). Even wealthy island countries like Malta, Iceland, and Mauritius do poorly in this area due to the high costs of constructing treatment infrastructure, though Mauritius is taking important steps to move beyond primary treatment into consistent tertiary treatment of wastewater (Muller, 2021).

Malta is the only European Union member country to score a 0 in this category. The island struggles with limited access to water — it has low groundwater supplies and desalination is the main form of drinking water production — and is in an already heat-stressed part of Southern Europe. While the EU has subsidized sewage treatment facilities on the island, Malta continues to lag its peer nations in wastewater treatment. Until 2011, 80% of wastewater generated in Malta was discharged untreated into the sea, and the country has failed to abide by the EU's landmark Urban Wastewater Treatment Directive (European Commission, 2019). It was recently reprimanded by the European Commission, alongside laggards like Poland, Slovakia, and Greece, for consistent failures in wastewater treatment (Water News Europe, 2022).

In Africa, no Sub-Saharan African country performs well in the wastewater treatment indicator. A total of 20 countries in the region receive scores of 0 in this category. The highest performing nation in the region is Eswatini, where a network of 10 wastewater treatment plants has put the country's performance on the wastewater treatment indicator ahead of wealthier nations like Belgium and Norway (Eswatini Ministry of Health, 2019). Eswatini's success points to the possibility of improving water resources in developing countries under the right conditions, despite the challenges posed by geographical diversity, rapid urbanization, and poorly monitored pollution.

4. Methods

As we note earlier in this chapter, the ideal water resources category would provide rankings based not just on wastewater treatment, but also on the household, industrial, and agricultural use of water, the level of treatment wastewater receives, and the sites into which it discharges. Unfortunately, this ideal appears distant, and the costs and effort of data gathering on water resources remain too much for many countries. To provide the most useful information to policymakers, we hope that future wastewater metrics will be able to leverage a wider variety of data to inform more sustainable water resources policy. The EPI calls for the adoption of internationally standardized data collection processes and reporting mechanisms, overseen by international bodies.

Indicator Background
The wastewater treatment indicator was introduced to the EPI in 2014, together with an article describing its methodology, results, and limitations (Malik et al., 2015). In the ensuing eight years, a lack of data has held the indicator back from developing in scope and sophistication. The EPI defines the indicator as the percentage of wastewater generated in a country that receives at least primary treatment. Primary treatment is the removal of large solids found in raw wastewater through screening, comminution (the reduction of material into smaller fragments), grit removal, and primary sedimentation (the settling out of sludge from wastewater). Subsequent treatment stages, like secondary and tertiary treatment,

are not included in this indicator. The primary treatment rate is multiplied by the connection rate—the proportion of the country's population that is connected to a centralized sewage system—to generate the wastewater treatment metric.

Data Sources

The 2022 EPI estimates treatment and connection rates using data from the United Nations Statistics Division (UNSD), the Organization for Economic Co-operation and Development (OECD), and Eurostat.
Every country outside of the OECD and the EU has an opportunity to report relevant data on their treatment of wastewater and connection rate to the United Nations Environment Programme (UNEP) in a 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 (Masons, 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 the indicator in some countries. For the 2022 EPI, we impute missing data on wastewater treatment rates and connection rates using country wealth and population as inputs into a predictive model. We apply a 25% penalty to imputed estimates for failing to report information to UNSD, OECD, or Eurostat. Additional details about the EPI's imputation methods and data sources are available in the online Technical Appendix, as well as in the Malik et al. (2015).

Limitations

When the EPI first introduced the wastewater treatment indicator, we intended it to be a pilot metric that would encourage standardized data collection and efforts to expand data availability on water resources. Unfortunately, many of the limitations of this metric that the 2014 EPI report highlighted persist today. The wastewater indicator is an imperfect metric for gauging performance on water resources, and we urge both better data coverage for the indicator and research that builds other indicators useful to the water resources issue area.

Data reporting for both components of the wastewater treatment indicator is scattered. The EPI team assembles the indicator from a variety of sources that includes international organizations' reports, government statistics, and commercial publications. Few countries regularly update their wastewater treatment figures, and some nations do not report their metrics to international bodies, making it difficult to construct comprehensive wastewater treatment estimates for many countries (Sato et al., 2013). This problem is further complicated by the lack of standardized measurements of wastewater treatment and water quality and quantity across data sources, which sometimes results in different values for wastewater treatment for the same country. The limitations imposed by a lack of data availability and standardizations points to the urgent need for improved data collection and measurement to support more robust water resources metrics.

An additional challenge posed by the datasets that are available is that many do not distinguish between different grades of wastewater treatment. A key problem is that in most reports, no distinction is drawn between filtration and primary treatment when reporting wastewater treatment rates. While some developed countries provide more detailed wastewater treatment reports, the information they hold is not standardized or accessible enough to be usefully applied to cross-country comparisons. Data reporting problems are worse in developing countries, where there is a lack of capacity for monitoring and reporting wastewater treatment metrics.

When attempting to standardize monitoring approaches when performing cross-country comparisons, we face the additional challenge of losing original data sources in the process of data aggregation (Hering, 2017). Regional or municipal data is sometimes used as a proxy for national data when national-level values are unavailable. However, these proxy figures may not be representative of a country's overall wastewater treatment rate, causing gaps and inaccuracies in our data (Malik et al., 2015). Even when municipalities collect comprehensive data, they make infrequent updates, such that tracking progress on wastewater treatment across time is highly challenging. Greater efforts by countries to build wastewater treatment reporting frameworks are essential to future water resources protection efforts.

Chapter 15. Methodology

1. Introduction

The Environmental Performance Index is a composite index, combining and distilling data on 40 critical sustainability issues into a single number summarizing country level performance. This process involves several carefully coördinated and calibrated steps — identifying and cleaning data, translating data into metrics of success, and aggregating individual metrics into an overall composite score — which are described in greater detail in this chapter. For a broader and authoritative explanation of the best practices for developing a composite indicator, the EPI team refers readers to the Organisation for Economic Co-operation and Development (OECD) handbook on constructing composite indicators (OECD, 2008).

A guiding principle of the EPI is to create data-driven, analytically rigorous, and easily understandable metrics of environmental performance. In this spirit, the methodologies described here seek to explain the 2022 EPI's process and clarify the assumptions behind its results. The online Technical Appendix — available for download from our website at epi.yale.edu — provides even further details on data sources and the specific calculations undergirding each indicator. As with past reports, we have invited the European Commission Joint Research Centre to audit the 2022 EPI, the results of which are also available on our website. Every iteration of the EPI seeks to use the latest advances in environmental science and statistical analyses to deliver robust environmental policy insights. To that end, we recognize that each report reflects a continual process of improvement. We welcome feedback from the global research and policymaking community on our data sources and methodological choices.

2. Data Selection

Every iteration of the EPI is grounded in the latest scientific understanding of our natural environment. Advances in sustainability research, remote sensing methods, and data reporting mean that the world's access to information on the health of the environment has never been richer. This section describes the criteria the EPI research team uses to identify reliable and relevant data. Only the best global data ultimately inform the EPI's analyses.

Inclusion Criteria

Each indicator in the EPI tracks a specific sustainability issue. Data underlying these indicators should allow the EPI team and policymakers to monitor country-level performance in environmental outcomes over time. To enable comparison of performance between countries, data should ideally track the same variables using consistent methods across the world. Seeking information that advances our understanding of real-world environmental performance and enhances the credibility of our analyses, the EPI team uses the following criteria to select data:

- **Relevance**: Data should measure environmental issues that pertain to most countries at any point in time.

- **Performance orientation**: Data should measure environmental issues that policy interventions can improve. Key to this criterion is that the EPI does not penalize countries for environmental trends and resource endowments beyond their control. Policy interventions are not always successful. The data underlying indicators should measure real-world environmental outcomes rather than policymakers' intentions or other policy inputs. When the direct measurement of environmental variables is not possible, proxy measurements that are causally linked to those variables can be acceptable substitutes. All of the 2022 EPI indicators conform to the System or Impact categories of the Driving Force-Pressure-State-Impact-Response framework (Bradley and Yee, 2015; Carr et al., 2007).

- **Established methodology**: As environmental research advances, scientists and policymakers may develop diverging methods for quantifying the same environmental issues. Different units and incompatible protocols result in datasets that are not comparable across countries or time. The EPI seeks data derived using established and uniform methodology that has been peer reviewed or endorsed by an international scientific organization.

- **Verified results**: The EPI uses data that are independently verified by third party scientific organizations, or data that have been submitted through a transparent reporting system amenable to audit. This criterion stipulates that the EPI team does not accept data directly from countries' environmental ministries as a basis for EPI rankings.

- **Spatial completeness**: Ideal data applies the same methodology to measure environmental variables in the same way around the globe. Many data reporting systems span only a subset of countries, e.g., OECD countries. In such cases, the EPI team looks for compatible datasets spanning different regions. Sometimes, important environmental issues are thoroughly monitored in only a handful of countries. In such cases, the EPI report highlights how better monitoring networks would enhance policymaking by providing decision-makers with data-driven insights.

- **Temporal completeness**: Metrics are most powerful when they capture trends instead of snapshots at single points in time. The EPI prefers to use temporally complete data that provides longitudinal records of country performance. To this end, it is also important that data producers and curators demonstrate a commitment to extending analyses into the future.

- **Recency**: Newer data better supports the needs of decision-makers as they implement new environmental policies and monitor the adequacy of existing policies. The EPI strives to use the most recent and high-quality data available.

- **Open source**: The EPI carries a strong preference for data that is freely accessible. Open-source data builds credibility among users and researchers and holds the strongest potential for driving transformative policy change. All of the data used as inputs to the 2022 EPI indicators are freely available for download from our website at epi.yale.edu.

These criteria ensure that only the most accurate and fair data inform the EPI's policy insights. The EPI occasionally uses data that falls short of these criteria for two reasons. First, an environmental issue may be so critical to track that it becomes preferable to develop a qualified metric rather than leave policymakers with no insight whatsoever. When including an imperfect metric, the EPI is careful to clearly state its limitations and call for better data. Second, the EPI may rely on pilot metrics to monitor important environmental issues where global datasets are still evolving. These pilot metrics — such as the *sustainable pesticide use* indicator introduced in the 2022 EPI — leverage the latest environmental research while calling for continued investments in monitoring.

Data Sources

Data that meet the above quality criteria typically come from international organizations, research institutions, academia, and government agencies. These sources use a variety of methods to collect, curate, and verify global scale datasets, including:

- Remotely sensed data from satellite observations
- Observations from surface-based monitoring stations
- Surveys and questionnaires;
- Estimates derived from both on-the-ground measurements and statistical models;
- Industry reports on resource consumption and emissions; and
- Government statistics, reported either individually or through international organizations like the United Nations Environment Programme.

We detail each indicator's data source or sources in the 2022 EPI Technical Appendix, freely available for download from epi.yale.edu.

3. Country Level Data

The EPI places special emphasis on issues of sovereignty when constructing rankings of country performance. As the data inclusion criteria above describe, we seek out global data with enough spatial detail to track the performance of countries and their territories when possible. Datasets often contain entries in tabular form, with countries and territories designated by an official ISO 3166 code. Country definitions and boundaries evolve over time, and time series data may contain entries for countries that no longer exist or currently exist in smaller forms, such as Yugoslavia or Sudan. In such cases, we assign the historical values from these countries to all successor states. For example, data for Sudan prior to 2011 are assigned to South Sudan. Policymakers should exercise caution when comparing indicator trends across times of geographic restructuring.

Data on territories controlled or protected by other countries pose a unique challenge. Although the EPI measures country-level trends in environmental performance, we recognize that policy is formed within several levels of government, from national to local scales. When deciding whether certain territories merit separate inclusion in our datasets, the EPI team considers several criteria. Most critically, we scrutinize the degree to which a territory exercises control over its own policies, reports data through their own government agencies, or is usually aggregated into another country's data reporting systems. When possible, the EPI attempts to include most major territories as separate countries within the EPI database, even though many do not have sufficient data coverage across all 40 indicators to calculate an EPI score. Raw data files including information for many territories are available for download from the EPI website. A full list of how territories are treated within the EPI database is available in the online Technical Appendix.

The EPI team recognizes that judgements on territorial sovereignty carry significant importance. Nothing about the 2022 EPI report's country-level data aggregation or illustrations should be interpreted as an endorsement or rejection of claims of autonomy or recognition. Rather, we make these choices as a practical matter for the purposes of our statistical calculations, and do so with caution.

4. Indicator Construction

Data can make policymaking more effective and efficient — but only if information is conveyed clearly to decision-makers, researchers, the media, and the general public. To facilitate data-driven policymaking, the EPI transforms complex environmental datasets into simple metrics that gauge sustainability progress. These metrics, or indicators, give each country a score, with 0 denoting worst performance and 100 denoting best performance. Some datasets come to the EPI team as metrics that already intuitively score countries. Most datasets, however, require additional calculations and processing to convert their information into indicators. Chapters 4 through 14 of this report describe each of the 40 performance indicators in greater detail, and the online Technical Appendix provides additional information on their specific underlying calculations. The sections below provide a broad overview of the 2022 EPI data framework, illustrating the methodological choices made to construct indicators from raw data.

Standardization

Metrics are most useful when policymakers and researchers can use them to compare performance between countries. Standardizing data by dividing them by a common denominator is a common way to achieve this goal, resulting in proportions or per capita units rather than raw units. For example, we control for country size and population in our pilot *recycling rates* indicator by dividing the mass of recyclable materials recycled by the total mass generated, yielding a proportion. Data on environmental health risks from the Global Burden of Disease (GBD) project express performance as a rate per 100,000 people. The GBD data also consider the demographics of each country's population to produce age-standardized measures, allowing the data from countries with older populations to be compared with data from countries with younger populations. Trend-based indicators also allow for fairer comparison between countries, scoring them based on rates of change rather than, e.g., total emissions alone. The 2022 EPI indicators reflect the team's latest understanding of the fairest and most accurate standardization techniques. We invite comments and suggestions for further improvements in how we standardize indicators in subsequent iterations.

Transformation

On some environmental issues, most countries tend to perform very well or very poorly, leaving other countries spread across the rest of the range of data values. This creates skewed distributions that can introduce biases into composite indices. In such cases, the EPI uses logarithmic transformations to improve our interpretation of results. These transformations spread out the scores of countries at one end of the range, allowing indicators to better score countries whose relative performance would otherwise appear indistinguishable. Without logarithmic transformation, only the countries at the extremes of the data range can easily be compared, and making distinctions between leaders or laggards would be infeasible.

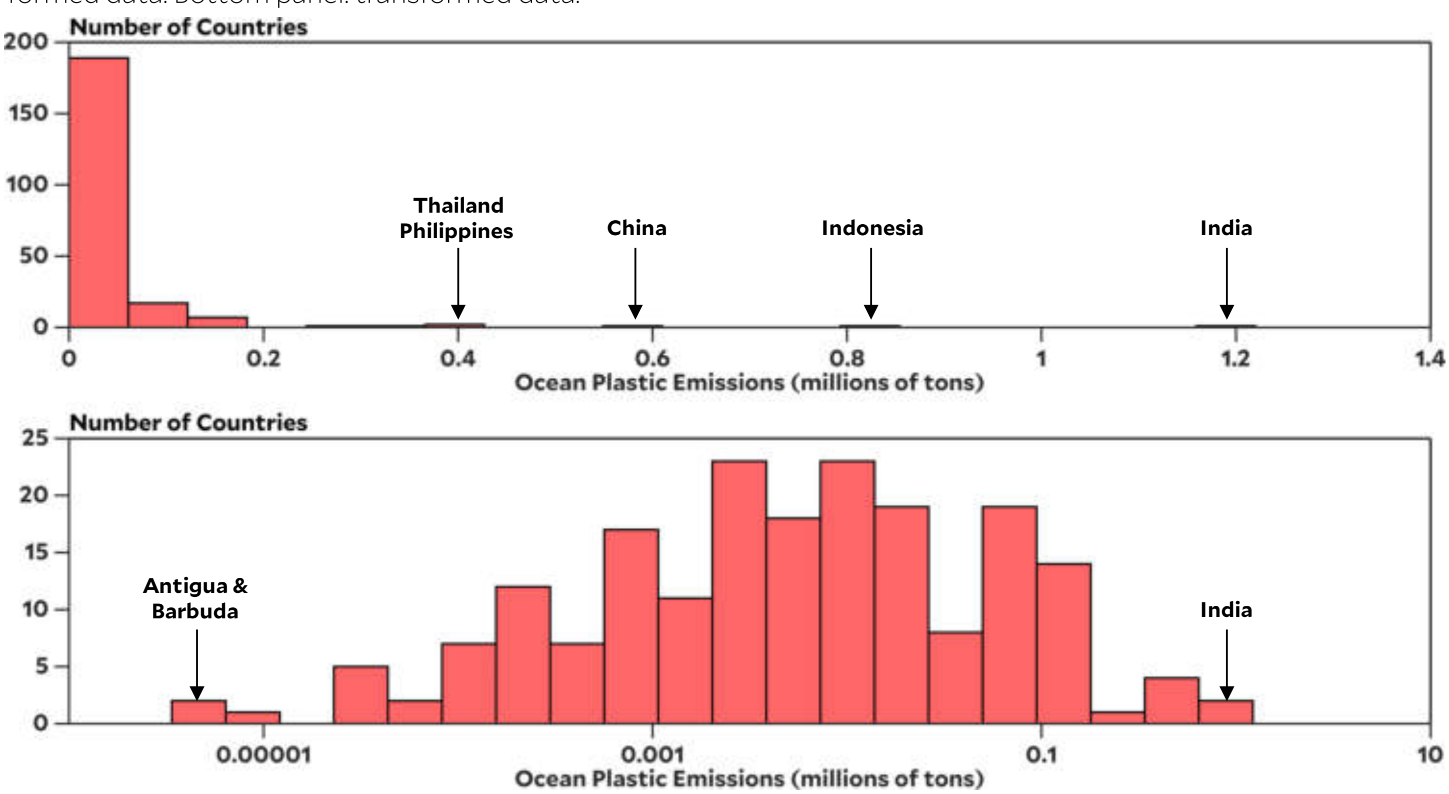
Scoring

Once the EPI team obtains, verifies, and transforms the data, the final step is to rescale the data into a 0 to 100 score. This process puts all indicators on a common scale, allowing them to be compared and aggregated into a composite index. The EPI uses the distance-to-target approach for indicator scoring. Each country's score is scaled according to where it falls relative to targets for best and worst performance. The general formula for calculating the indicator is:

$$\text{Indicator Score} = (X - W) / (B - W) \times 100$$

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. Similarly, if a country's value is less than W, we set its indicator score to zero. These ceilings and floors prevent outliers from having an undue influence on other well-performing or poorly performing countries' scores.

Figure 15-1. Transforming skewed data on *ocean plastic pollution* using the natural logarithm. Top panel: untransformed data. Bottom panel: transformed data.



The EPI team takes seriously the process of identifying good and bad performance targets for each indicator. The targets arise according to the following hierarchy:

- Performance targets set forth in international agreements, treaties, or institutions. If there are no such targets, the EPI uses:

- Performance targets based on the recommendation of expert judgment. If no such recommendations are available, the EPI uses:

- Performance targets based on percentiles of country scores. Good performance targets are usually set at either the 95th or 99th percentile, while bad performance is usually set at the 1st or 5th percentile, depending on the distribution of the indicator data.

We note that international agreements or expert judgment rarely define standards of bad performance, so the EPI most often uses percentiles for bad performance targets. When the 2022 EPI uses percentile-based targets, we calculate percentiles using data across all available years and countries for each indicator — not just the data from the most recent year or from countries included in the EPI. The online Technical Appendix details each indicator's performance targets.

5. 2022 EPI Framework

As a composite index, the Environmental Performance Index integrates data on 40 sustainability indicators into 11 broad issue categories, three policy objectives, and ultimately into a single overall EPI score for each country. The 2022 EPI organizes issue categories by familiar topics of sustainability:

- Climate Change Mitigation
- Air Quality
- Sanitation & Drinking Water
- Heavy Metals
- Waste Management
- Biodiversity & Habitat
- Ecosystem Services
- Fisheries
- Acid Rain
- Agriculture
- Water Resources

For the first time, the 2022 EPI introduces Climate Change as a coequal policy objective alongside Environmental Health and Ecosystem Vitality. These objectives capture the dominant policy domains within which policymakers and researchers compartmentalize environmental issues, although the EPI research team recognizes the overlap between them. Environmental Health measures the impacts of environmental pollution on human wellbeing. Ecosystem Vitality measures natural resources, habitat conservation, and ecosystem services. Climate Change measures countries' trends in climate pollutant emissions and gauges whether countries are on track to successfully mitigate these emissions.

These three policy objectives are aggregated into a single overall EPI score. As the framework demonstrates, 2022 EPI scores serve as a starting point for deeper analyses into a country's sustainability performance. Scores at each level of the framework are available throughout this report and from our website, epi.yale.edu.

6. Weighting and Aggregation

All 40 performance indicators, 11 issue categories, and three policy objectives are aggregated to calculate a country's overall EPI score. This aggregation step requires the EPI team to assign a weight to each indicator, issue category, and policy objective. There are various methods for determining weighting schemes in composite indicators (Munda, 2012; Munda and Nardo, 2009; OECD, 2008). Some authorities on composite indexing advocate using geometric sums as a way to more robustly account for varied performance between indicators. The EPI forgoes this method for the sake of transparency, using simple arithmetic weighted sums. The weights used by the 2022 EPI (Figure 15-2) reflect multiple factors, including: the importance of the issue; data quality; timeliness of data; and statistical analyses to balance the spread of scores. We encourage readers to treat these weights as suggestions, recognizing that users may prefer different weights and encouraging them to explore alternative weighting schemes. The 2022 EPI's data are available for download from epi.yale.edu for readers interested in researching alternative weights and aggregation methods.

Policy Objectives

Policy objectives are not weighted equally (Figure 15-2). Placing 1/3rd of the overall weight on each policy objective would give Environmental Health too much influence in determining overall EPI scores, since the range and standard deviation in country scores for this objective is much larger than for Ecosystem Vitality and Climate Change. Without adjustment, countries that score well on Environmental Health would perform well on the EPI, with less input from their performance on Ecosystem Vitality or Climate Change. To account for this potential imbalance, the 2022 EPI gives a weight of 20% to Environmental Health, 42% to Ecosystem Vitality, and 38% to Climate Change. This framework does not reflect a prioritization of some environmental issues over others. Instead, the choice of weights is guided by robust statistical analyses that aim to provide policymakers with useful insights into their country's overall sustainability performance. We further detail each policy objective below.

Environmental Health

Performance in the Environmental Health policy objective is correlated (R^2 = 0.62) with overall EPI scores. Weights assigned to issue categories and individual indicators within Environmental Health largely reflect impact. Performance in Air Quality, Sanitation & Drinking Water, and Heavy Metals are all measured in terms of health outcomes, and weights are derived from relative disability-adjusted life year (DALY) rates. Aggregated to the global level, we find that most DALYs lost result from poor ambient air quality and unsafe sanitation and drinking water. Within Waste Management, the 2022 EPI introduces two new pilot indicators on recycling rates and ocean plastic pollution. The lower weights given to these indicators reflects their novelty and the EPI team's preference for soliciting feedback on pilot indicators before their weights are increased.

Climate Change

Scores in Climate Change are correlated (R^2 = 0.62) with overall EPI scores. With just one issue category, the weighting nuances in this policy objective fall to determining indicator weights. The weights assigned to the

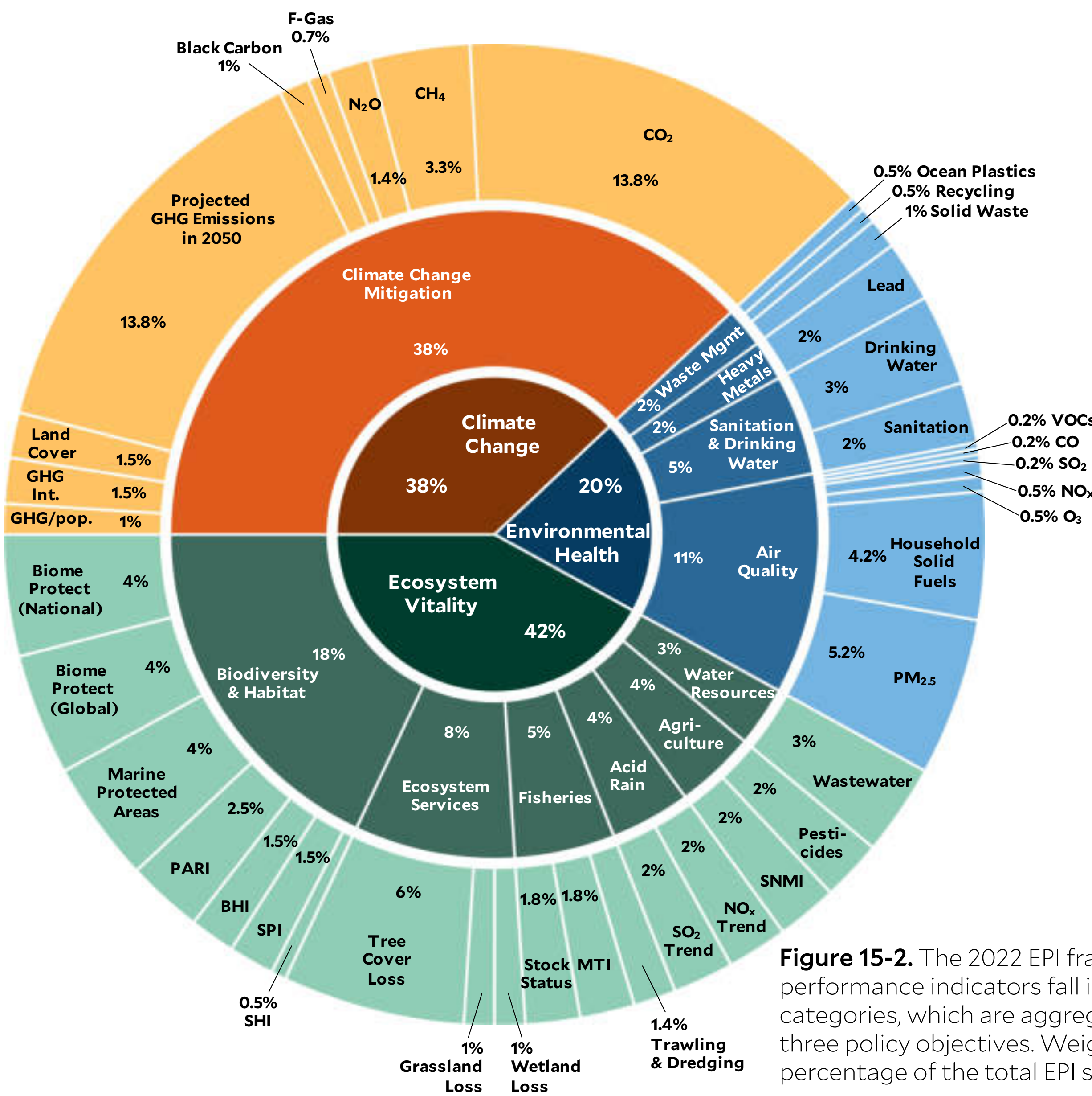


Figure 15-2. The 2022 EPI framework. 40 performance indicators fall into 11 issue categories, which are aggregated into three policy objectives. Weights show the percentage of the total EPI score.

Climate Mitigation indicators reflect a balance of scientific empiricism and policy realism. Climate pollutant trends — CO_2, CH_4, N_2O, F-gas, and black carbon — are weighted by considering their relative contribution to recent climate change while also considering the ease of reducing their emissions. The new projected GHG emissions in 2050 indicator has substantial weight at 13.8% of the overall EPI score. This choice reflects the importance of getting countries on track to meet their climate commitments and successfully mitigating climate change. First introduced as a pilot indicator in the 2020 EPI, the *CO_2 emissions from land cover change* indicator has now been afforded greater weight at 1.5%.

Ecosystem Vitality
Ecosystem Vitality scores are correlated ($R^2 = 0.61$) with overall EPI scores. While weights in Environmental Health and Climate Change are more empirically determined, the selection of weights in Ecosystem Vitality is more subjective. The 2022 EPI weighting framework reflects input from sustainability experts, data quality and timeliness, and the perceived relative importance of each issue. Biodiversity & Habitat takes the majority of the weight in this policy objective at 18%. Ecosystem Services, which reflects country performance in preserving critical biomes, is weighted at 8%. The remaining weight is distributed almost evenly between Fisheries (5%), Acid Rain (4%), Agriculture (4%), and Water Resources (3%). Although each of these environmental issues is critically important for maintaining planetary health, the low weights given to them here reflect a lack of good global data, recent measurements, and relevant indicators. As new environmental data and insights become available to monitor these issue categories, the EPI team will adjust weights accordingly.

6. Materiality

Not every indicator is applicable to every country. In the 2022 EPI, countries that are landlocked or have very short coastlines (specifically, a coastline-to-land area ratio of less than 0.01) are not scored in the Fisheries issue category or the *marine protected areas* indicator. The weights normally given to these indicators are redistributed to other indicators proportional to these other indicators' base weights.

7. Missing Data

The EPI strives to use the most spatially and temporally complete data available. Realities in environmental data science, however, often require us to make do with datasets that have missing entries or do not cover all countries. This sometimes results due to materiality, as with landlocked countries and the Fisheries indicators. Other indicators may not pertain to certain countries, such as tree cover loss in countries with no starting tree cover in the year 2000. In other cases, such as the *Species Protection Index* and *Species Habitat Index*, the metric cannot be reliably calculated for small countries. When data is missing, the EPI team assigns a weight of zero to these indicators and redistributes their weight to other indicators within each issue category during the aggregation step. Water Resources, however, has only one indicator. Missing data in this issue category introduces a unique challenge, leading the EPI team to impute missing values through a statistical model. We describe the assumptions behind this imputation in the online Technical Appendix.

8. Backcasting EPI Performance

Performance trends are useful to policymakers seeking to understand whether investments in sustainability programs are paying off, and for calling attention to issues where a country's performance is deteriorating over time. To support these insights, the 2022 EPI provides current scores in addition to backcasted scores using data approximately ten years prior to 2022.

Current datasets do not support the calculation of annual EPI scores for two reasons. First, not all data exists as a time series. Several indicators, such as *municipal solid waste* and *wastewater treatment* have data for only a single year. Second, EPI metrics have disparate beginning and end years. Deriving synchronized time series for all datasets is beyond the scope of the EPI's analysis and would likely produce misleading results, as they could reflect our extrapolation method rather than on-the-ground conditions. Where data is infrequently updated, 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 online Technical Appendix describes data coverage for all 40 indicators, many of which have time series data.

9. Global Scorecard

The 2022 EPI provides a scorecard of global environmental performance in addition to country-level scorecards. Where possible, EPI researchers aggregate data to the global level and construct indicator scores using the same methods as for country scores. The global scorecard is most useful for assessing the world's progress toward meeting international sustainability targets.

10. Changes from the 2020 EPI

Since its inception, the EPI has aimed to use the latest advancements in environmental science to inform data-driven sustainability policy. We include in the 2022 EPI several additional innovations to support empirically-founded sustainability policymaking. In the interest of continued improvement, we welcome feedback on our indicator and data choices from the global sustainability community.

The 2022 EPI introduces a major methodological advancement to monitor progress toward meeting climate policy commitments. Leveraging the latest data, the new *projected GHG emissions in 2050* indicator captures whether countries are on track to achieve net-zero greenhouse gas emissions by mid-century. For over 20 years, the EPI's innovative metrics have framed policy discussions with analytically rigorous insights, and informing more effective climate policy remains a top priority of our work. We offer the new metric as a tool that policymakers, the media, non-governmental organizations, and the public can use to gauge the adequacy of climate policies and hold their nations accountable to meeting their emissions pledges.

Recognizing the severity of air pollution around the world, we also introduce several new indicators on exposure to toxic air pollutants in the hopes that this information will help decision-makers more holistically improve ambient air quality. To support new emissions control policies and ensure implemented solutions realize meaningful gains in environmental health, the 2022 EPI tracks exposure to four additional air pollutants: nitrogen oxides, sulfur dioxide, carbon monoxide, and volatile organic compounds. These pilot indicators demonstrate that even wealthy countries have a long way to go toward cleaning up their air.

We further expand the scope of The Waste Management issue category, introducing new indicators on *recycling rates* and *ocean plastic pollution*. These indicators will help policymakers reduce and reuse their waste — and, when this is not possible, dispose of it in a controlled and safe way. Recognizing the critical role of agricultural systems in healthy societies, we also introduce a pilot indicator on *sustainable pesticide use*. Pesticide mismanagement contaminates drinking water and harms environmental health, yet until now countries have lacked data on the impacts of their pesticide use. The 2022 EPI's innovative metrics promise to deliver high-impact policy insights to decision-makers as they strive to keep ahead of emerging sustainability trends.

With each iteration of the EPI, we refresh our data sources, survey the literature, and engage with leading sustainability researchers to ensure cutting-edge scientific insights support the EPI's results and policy insights. The 2022 EPI leverages the latest data on *wetland* and *grassland loss*, extending coverage on these indicators to 2020. In Fisheries, we now account for the environmental impacts of dredging. And in the Biodiversity & Habitat indicators, we incorporate significantly updated data on the extent of protected areas. These and other changes are further described in the report's issue category chapters and in the online Technical Appendix. As always, the EPI team welcomes feedback on how we can enhance our analyses and methodologies as we continue to monitor sustainability performance into the future.

Chapter 16. References

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Links

Data Sources

Institute for Health Metrics and Evaluation

Copernicus Air Quality

Copernicus Land https://cds.climate.copernicus.eu/Cover

World Database of Protected Areas

WWF Terrestrial Ecoregions of the World

Marine Regions

CSIRO Data Access Portal

Map of Life Indicators

Global Forest Watch

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

2020 Index of Economic Freedom

Expert Contributors

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Institute for Health Metrics and Evaluation

Commonwealth Scientific and Industrial Research Organisation

Map of Life

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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

McCall MacBain Foundation

The McCall MacBain Foundation is based in Geneva, Switzerland and was founded by John and Marcy McCall MacBain. Its mission is to improve the welfare of humanity by providing scholarships and other educational opportunities that nurture transformational leadership, and by investing in evidence-based strategies to address climate change, preserve our natural environment, and improve health outcomes. www.mccallmacbain.org

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