Environmental
Performance
Index

Environmental Performance Index 2024

Technical Appendix

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2024 Environmental Performance Index

Technical Appendix

This technical appendix is a companion document to the 2024 Environmental Performance Index (EPI) report. It contains additional details about the methods used in the 2024 EPI. Along with the files available online, which include all the data used in the EPI analyses, the purpose of this technical appendix is to provide all information necessary for replicating the EPI results or re-running the analysis using different choices and assumptions.

Note: Throughout this appendix, TLA is used to refer to the three letter abbreviations of the input data sources and resulting indicators, issue categories, and policy objectives.

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1. Indicator and Data Overview

Table TA-1. Organization of the 2024 EPI, with three-letter abbreviations (TLAs) and percent weights (Wt.) of overall EPI. Note that weights are rounded and may not add up to 100%. The "Weights.csv" file available for download from the EPI website contains the exact weights.

Policy Objective	Issue Category	TLA	Wt. (%)	Indicator	TLA	Wt. (%)
Ecosystem Vitality ECO (45%)	Biodiversity & Habitat	BDH	25	Marine KBA Protection	MKP	12.0
				Marine Habitat Protection	MHP	12.0
				Marine Protection Stringency	MPE	2.0
				Protected Areas Representativeness Index	PAR	12.0
				Species Protection Index	SPI	16.0
				Terrestrial Biome Protection	TBN	10.0
				Terrestrial KBA Protection	TKP	10.0
				Protected Area Effectiveness	PAE	2.0
				Protected Human Land	PHL	2.0
				Red List Index	RLI	12.0
				Species Habitat Index	SHI	8.0
				Bioclimatic Ecosystem Resilience	BER	2.0
	Forests	ECS	5	Primary Forest Loss	PFL	30.0
				Intact Forest Landscape Loss	IFL	30.0
				Tree cover loss weighted by permanency	FCL	25.0
				Net change in tree cover	TCG	10.0
				Forest Landscape Integrity	FLI	5.0
	Fisheries	FSH	2	Fish Stock Status	FSS	15.0
				Fish Catch Discarded	FCD	20.0
				Bottom Trawling in EEZ	BTZ	25.0
				Bottom Trawling in Global Ocean	BTO	35.0
				Regional Marine Trophic Index	RMS	5.0
	Air Pollution	APO	6	Ozone exposure KBAs	OEB	8.3
				Ozone exposure croplands	OEC	8.3
				Adj. emissions growth rate for nitrous oxides	NXA	41.7
				Adj. emissions growth rate for sulfur dioxide	SDA	41.7
	Agriculture	AGR	3	Sustainable Nitrogen Management Index	SNM	40.0
				Phosphorus Surplus	PSU	3.3
				Pesticide Pollution Risk	PRS	16.7
				Relative Crop Yield	RCY	40.0
	Water Resources	WRS	5	Wastewater generated	WWG	10.0
				Wastewater collected	WWC	40.0
				Wastewater treated	WWT	40.0
				Wastewater reused	WWR	10.0

(Continues on the next page).

Table TA-1 (continuation). Organization of the 2024 EPI, with three-letter abbreviations (TLAs) and percent weights (Wt.) of overall EPI. Note that weights are rounded and may not add up to 100%. To reproduce the results exactly, use the weights in the "Weights.csv" file available for download from the EPI website.

Policy Objective	Issue Category	TLA	Wt. (%)	Indicator	TLA	Wt. (%)
Environmental Health HLT (25%)	Air Quality	AIR	17	Anthropogenic PM2.5 exposure	HPE	38.2
				Household solid fuels	HFD	38.2
				Ozone exposure	OZD	8.8
				NOx exposure	NOD	5.9
				SO2 exposure	SOE	2.9
				CO exposure	COE	2.9
				VOC exposure	VOE	2.9
	Sanitation & Drinking Water	H2O	5	Unsafe sanitation	USD	40.0
				Unsafe drinking water	UWD	60.0
	Heavy Metals	HMT	2	Lead exposure	LED	100.0
	Waste Management	WMG	1	Waste generated per capita	WPC	40.0
				Controlled solid waste	SMW	20.0
				Waste recovery rate	WRR	40.0
Climate Change PCC (30%)	Climate Change Mitigation	CCH	30	Adjusted emissions growth rate for carbon dioxide	CDA	25.0
				CO_2 growth rate (country-specific targets)	CDF	1.7
				Adjusted emissions growth rate for methane	CHA	10.0
				Adjusted emissions growth rate for F-gases	FGA	6.7
				Adjusted emissions growth rate for nitrous oxide	NDA	3.3
				Adjusted emissions growth rate for black carbon	BCA	5.0
				Net carbon fluxes due to land cover change	LUF	3.3
				GHG growth rate adjusted by emissions intensity	GTI	20.0
				GHG growth rate adjusted by per capita emissions	GTP	20.0
				Projected emissions in 2050	GHN	3.3
				Projected cumulative emissions to 2050 relative to carbon budget	CBP	1.7

2. Data Sources

The 2024 EPI draws on data from a wide variety of sources. This section of the Technical Appendix describes the sources of data used in the EPI, using the following template.

TLA	Three letter abbreviation for the variable.
Source	The organization that produces the dataset.
URL	Where the dataset may be found on the Internet. If the dataset is not publicly available online, the URL points to the source institution.
Date received	The date on which the dataset used in the 2024 EPI came into the possession of the EPI team.
Instructions	Any special instructions for navigating the data source website or other means of retrieving the dataset.
Citation	Formal citation for the dataset, source organization, or other relevant published materials that are helpful in understanding the dataset.
Reference	Reference to a peer-reviewed publication documenting the dataset.
Documentation	Additional documents that describe the dataset.
Note	Additional details for understanding how to retrieve or use the dataset.

Due to the variety of data sources, not every field is applicable to every dataset. Each entry below provides the fullest account possible.

ATY	Country-specific attainable yields of 17 major crops
Source	Mueller et al. 2012
URL	https://doi.org/10.1038/nature11420
Date received	2023-05-22
Instructions	In the "Supplementary information" section, click "Supplementary Data."
Reference	Mueller, N., Gerber, J., Johnston, M. et al. (2012). Closing yield gaps through nutrient and water management. Nature 490: 254–257

BER	Bioclimatic Ecosystem Resilience Index
Source	Commonwealth Scientific and Industrial Research Organisation (CSIRO)
URL	https://doi.org/10.25919/437m-8b91
Date received	2024-03-12
Instructions	Under the Files pane, download everything except BERI_v2_Map_images
Citation	Harwood, Tom; Ware, Chris; Hoskins, Andrew; Ferrier, Simon; Bush, Alex; Golebiewski, Maciej; Hill, Samantha; Ota, Noboru; Perry, Justin; Purvis, Andy; Williams, Kristen (2022): BERI v2: Bioclimatic Ecosystem Resilience Index: 30s global time series. v1. CSIRO. Data Collection. https://doi.org/10.25919/437m-8b91
Reference	Ferrier et al. 2020. A globally applicable indicator of the capacity of terrestrial ecosystems to retain biological diversity under climate change: The bioclimatic ecosystem resilience index. Ecological Indicators 117, October 2020, 106554. https://doi.org/10.1016/j.ecolind.2020.106554

BLC	Black carbon emissions [Gg]
Source	Community Emissions Data Systems
URL	https://zenodo.org/records/10904361
Date received	2024-05-01
Instructions	Download CEDS_v_2024_04_01_aggregate.zip
Citation	Hoesly, R., & Smith, S. (2024). CEDS v_2024_04_01 Release Emission Data (v_2024_04_01) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.10904361
Reference	Hoesly et al. 2018. Historical (1750–2014) anthropogenic emissions of reactive gases and aerosols from the Community Emissions Data System (CEDS). Geosci. Model Dev. 11, 369-408. https://doi.org/10.5194/gmd-11-369-2018

BTO	Bottom trawling and dredging on the global ocean
Source	Sea Around Use
URL	https://www.seaaroundus.org/
Date received	2023-05-31
Instructions	1. Navigate to Tools & Data 2. Select "Global" 3. On the chart's menu "Dimension", select "Gear" 4. Click "Download Data" button on the top-right

BTZ	Bottom trawling and dredging on a country's EEZ
Source	Sea Around Use
URL	https://www.seaaroundus.org/
Date received	2024-02-28
Instructions	1. Navigate to Tools & Data 2. Under "Search Type", select "EEZ" 3. Select on EEZ on the map or from the dropdown menu 4. On the chart's menu "Dimension", select "Gear" 5. Click "Download Data" button on the top-right 6. Repeat for each EEZ.

CDO	CO_2 emissions [Gg], excluding land use and forestry
Source	Global Carbon Budget
URL	https://globalcarbonbudgetdata.org/latest-data.html
Date received	2024-02-02
Instructions	Download National Fossil Carbon Emissions v2023
Citation	Friedlingstein et al. 2023 Earth System Science Data https://doi.org/10.5194/essd-15-5301-2023

CH4	Methane emissions [Gg]
Source	PRIMAP-hist national historical emissions time series
URL	https://zenodo.org/records/10705513
Date received	2024-02-28
Instructions	Under Files, click to download Guetschow_et_al_2024-PRIMAP-hist_v2.5.1_final_27-Feb-2024.csv (73.1 MB)
Citation	Gütschow, J.; Pflüger, M.; Busch, D. (2023): The PRIMAP-hist national historical emissions time series v2.5.1 (1750-2022). Zenodo. doi:10.5281/zenodo.10705513
Reference	Gütschow, J.; Jeffery, L.; Gieseke, R.; Gebel, R.; Stevens, D.; Krapp, M.; Rocha, M. (2016): The PRIMAP-hist national historical emissions time series, Earth Syst. Sci. Data, 8, 571-603, doi:10.5194/essd-8-571-2016

COC	Global distribution of cold-water corals
Source	UNEP - World Conservation Monitoring Center
URL	https://doi.org/10.34892/72x9-rt61
Date received	2024-03-27
Citation	Freiwald A, Rogers A, Hall-Spencer J, Guinotte JM, Davies AJ, Yesson C, Martin CS, Weatherdon LV (2021). Global distribution of cold-water corals (version 5.1). Fifth update to the dataset in Freiwald et al. (2004) by UNEP-WCMC, in collaboration with Andre Freiwald and John Guinotte. Cambridge (UK): UN Environment Programme World Conservation Monitoring Centre.
Reference	Freiwald A, Fosså JH, Grehan A, Koslow T, Roberts JM (2004). Cold-water coral reefs: out of sight – no longer out of mind. Biodiversity Series 22. Cambridge (UK): UNEP World Conservation Monitoring Centre. 86 pp. URL: https://archive.org/details/coldwatercoralre04frei

COE	CO exposure
Source	Copernicus Atmosphere Monitoring Service
URL	https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly
Date received	2023-07-10
Instructions	Variable: Multi Level; Carbon monoxide Model level: 60 Year: Select all Month: Select all Product type: Monthly mean Time: Select all Area: Full model area
References	Wolf, M.J., Esty, D.C., Kim, H., Bell, M.L., Brigham, S., Nortonsmith, Q., Zaharieva, S., Wendling, Z.A., de Sherbinin, A. and Emerson, J.W., (2022). New Insights for Tracking Global and Local Trends in Exposure to Air Pollutants. *Environmental science & technology*, *56*(7), 3984-3996, https://doi.org/10.1021/acs.est.1c08080..
Note	Ground-level concentration data are weighted by population density to derive country-average exposure values. See Wolf et al. 2022 for details.

COM	Municipal waste composted (tonnes)
Source	What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
URL	https://datacatalog.worldbank.org/search/dataset/0039597
Date received	2023-06-16
Instructions	Download “Country level dataset” (94.5 KB)
Citation	Kaza, S., Yao, L., Bhada-Tata, P., & Von Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Urban Development Series). World Bank.

COM	Municipal waste composted (tonnes)
Source	OECD
URL	https://stats.oecd.org/index.aspx?DataSetCode=MUNW
Date received	2023-10-20
Instructions	1. Under 'Data by theme', select Environment 2. Under Environment, select Waste 3. Under Waste, select Municipal waste - Generation and Treatment 4. For Countries, select all 5. For Variable, select Composting

COW	Global distribution of coral reefs
Source	UNEP - World Conservation Monitoring Center
URL	https://doi.org/10.34892/t2wk-5t34
Date received	2024-03-27
Citation	UNEP-WCMC, WorldFish Centre, WRI, TNC (2021). Global distribution of warm-water coral reefs, compiled from multiple sources including the Millennium Coral Reef Mapping Project. Version 4.1. Includes contributions from IMaRS-USF and IRD (2005), IMaRS-USF (2005) and Spalding et al. (2001). Cambridge (UK)

CRO	Global distribution of croplands
Source	Global Lands Analysis & Discovery | University of Maryland
URL	https://glad.umd.edu/dataset/croplands
Date received	2024-03-04
Instructions	Go to URL, scroll down, and click the download links under the "Global Overview Data Dowload" section.
Citation	P. Potapov, S. Turubanova, M.C. Hansen, A. Tyukavina, V. Zalles, A. Khan, X.-P. Song, A. Pickens, Q. Shen, J. Cortez. (2021) Global maps of cropland extent and change show accelerated cropland expansion in the twenty-first century. Nature Food. https://doi.org/10.1038/s43016-021-00429-z

CRY	Average yield and harvested area by crop
Source	FAOSTAT
URL	https://www.fao.org/faostat/en/#data/QCL
Date received	2024-02-04
Instructions	In the "Bulk Downloads" section, click "All Data."

EEL	Union of world country boundaries and EEZs, version 3
Source	Flanders Marine Institute
URL	https://doi.org/10.14284/403
Date received	2024-03-26
Instructions	Click "Download Data" button
Reference	Flanders Marine Institute (2020). Union of the ESRI Country shapefile and the Exclusive Economic Zones (version 3). Available online at https://www.marineregions.org/.

EEZ	Boundaries of countries' Exclusive Economic Zones
Source	Flanders Marine Institute
URL	https://doi.org/10.14284/382
Date received	2024-03-26
Instructions	Click "Download Data" button
Reference	Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at https://www.marineregions.org/.

FCD	Fish catch discarded
Source	Sea Around Use
URL	https://www.seaaroundus.org/
Date received	2023-05-31
Instructions	1. Navigate to Tools & Data 2. Select "Global" 3. On the chart's menu "Dimension", select "Gear" 4. Click "Download Data" button on the top-right

FHP	Fraction of population-weighted exposure to ambient PM2.5 from human sources (and wildfires).
Source	Global Burden of Disease / Major Sources of Pollution
URL	https://costofairpollution.shinyapps.io/gbd_map_global_source_shinyapp/
Date received	2024-02-10
Instructions	1. Go to "Explore the Data" tab, and stay in default tabs "Air Pollution", and "By source" 2. Select type of source: "Sector" 3. Select "Aggregated sources" 4. Select "Country" level data 5. Select sector "Windblown dust" 6. Select year "2017" (only year with fractional contribution estimates) 7. Select to see results as a table 8. Click "Download" button above the table to download the data 9. Repeat same steps, but in step 5 select "Remaining sources"
Reference	McDuffie EE, Martin RV, Spadaro J, Burnett RT, Smith SJ, O' Rourke P, Hammer M, van Donkelaar A, Bindle L, Adeniran J, Lin J, Brauer M. (2021). Fine Particulate Matter and Global Health: Fuel and Sector Contributions to Ambient PM2.5 and its Disease Burden Across Multiple Scales. *Nature Communications*. http://dx.doi.org/10.1038/s41467-021-23853-y.
Note	We subtracted the fraction of pollution originating from windblown dust and other natural sources (e.g., sea spray, volcanos, and lightning).

FLD	Forest loss by dominant deforestation driver, annual (30% canopy cover)
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/
Date received	2023-07-20
References	Curtis, P.G., C.M. Slay, N.L. Harris, A. Tyukavina, M.C. Hansen. (2018). Classifying drivers of global forest loss. *Science* 361: 1108–1111. https://www.science.org/doi/10.1126/science.aau3445
Note	Prepared by Michelle Sims from Global Forest Watch, received via personal communication. Viewable online from: https://gfw.global/3abMQOe

FLI	Forest Landscape Integrity Index
Source	Forest Landscape Integrity Index Project
URL	https://www.forestintegrity.com/home
Date received	2024-02-24
Instructions	1. Go to the Download data tab 2. Enter the information required to get access to a Google Drive folder 3. Download the global file "flii_earth.tif"
Reference	Grantham et al. 2020. Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. *Nature Communications* 11: 5978 https://doi.org/10.1038/s41467-020-19493-3

FOG	F-gasses emissions [Gg CO_2-eq.]
Source	PRIMAP-hist national historical emissions time series
URL	https://zenodo.org/records/10705513
Date received	2024-02-28
Instructions	Under Files, click to download Guetschow_et_al_2024-PRIMAP-hist_v2.5.1_final_27-Feb-2024.csv (73.1 MB)
Citation	Gütschow, J.; Pflüger, M.; Busch, D. (2023): The PRIMAP-hist national historical emissions time series v2.5.1 (1750-2022). Zenodo. doi:10.5281/zenodo.10705513
Reference	Gütschow, J.; Jeffery, L.; Gieseke, R.; Gebel, R.; Stevens, D.; Krapp, M.; Rocha, M. (2016): The PRIMAP-hist national historical emissions time series, Earth Syst. Sci. Data, 8, 571-603, doi:10.5194/essd-8-571-2016

FSS	Fish stock status
Source	Sea Around Use
URL	https://www.seaaroundus.org/
Date received	2024-02-28
Instructions	1. Navigate to Tools & Data 2. Under "Search Type", select "EEZ" 3. Select on EEZ on the map or from the dropdown menu 4. Scroll down, and under the "Indicators" section, click "Stock status plot" 5. Wait for plot to load. 6. Click "Download Data" button on the top-right 7. Repeat for each EEZ.

GDP	GDP [PPP, constant 2017 international $]
Source	World Bank
URL	https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD
Date received	2023-10-21
Instructions	Under Download on right side of web page, click "csv"
Documentation	ID: NY.GDP.MKTP.PP.KD
Note	License URL: https://datacatalog.worldbank.org/public-licenses#cc-by

GDP	GDP [constant 2015 US$]
Source	World Bank
URL	https://data.worldbank.org/indicator/NY.GDP.MKTP.KD
Date received	2023-02-16
Instructions	Under Download on right side of web page, click "csv"
Note	We used this dataset for Cuba's GDP. To make it comparable, we first convert 2015 US$ to 2017 US$ using inflation rates estimates (https://www.inflationtool.com/us-dollar/2015-to-present-value) and then adjust for purchasing power parity based on estimates from the CIA World Factbook (https://www.cia.gov/the-world-factbook/field/real-gdp-purchasing-power-parity/).

GDP	GDP per capita [PPP, constant international $]]
Source	IMF
URL	https://www.imf.org/en/Publications/WEO/weo-database/2023/October
Date received	2023-10-20
Instructions	1. Click on ″By Countries (country-level data) 2. Click on ″All Countries″ 3. In ″Select Subjects″ step, select ″Gross domestic product per capita, constant prices - Purchasing Power Parity; 2017 international dollars″ 4. In ″Advanced Settings″: Start year = 1980, End year = 2022; append both Subject Notes and Series-Specific Notes; choose to show ISO Alpha-3 Code and Subject Descriptor. Sort Order by Country Group, then Subject. Decimal Symbol = ″.″, and ″Show all rows″. Select: Start year = 1994, End year = 2018
Note	We multiplied these data by countries' population to obtain total GDP and used it to fill in gaps in the World Bank's dataset for Andorra, Eritrea, South Sudan, Syria, Taiwan, Venezuela, and Yemen.

GFE	Fishing effort (based on Automatic Identification System)
Source	Global Fishing Watch
URL	globalfishingwatch.org/data-download/datasets/public-fishing-effort
Date received	2024-03-27
Instructions	1. Create free account with Global Fishing Watch 2. Go to Source URL and select files "fleet-daily-csvs-100-v2" for years 2012 to 2020 3. Click "Download" button.
Citation	Kroodsma *et al*. (2018) Tracking the global footprint of fisheries. Science 359: 904-908. DOI:10.1126/science.aao5646.

GOE	Government Effectiveness
Source	Worldwide Governance Indicators
URL	https://databank.worldbank.org/source/worldwide-governance-indicators
Date received	2024-05-17
Instructions	Country: *Select all* Series: Government Effectiveness Estimate Time: *Select all*
Citation	Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi (2010). The Worldwide Governance Indicators: Methodology and Analytical Issues". World Bank Policy Research Working Paper No. 5430 (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130)
Documentation	https://info.worldbank.org/governance/wgi/Home/Documents

HDI	Human Development Index
Source	Human Development Reports
URL	https://hdr.undp.org/data-center/documentation-and-downloads
Date received	2024-04-01
Instructions	Click on "Table 2: Trends in the Human Development Index, 1990-2022" to download file.
Reference	https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

HFD	Household Solid Fuel Air Pollution [DALY rate]
Source	Institute for Health Metrics and Evaluation
URL	http://ghdx.healthdata.org/gbd-results-tool
Date received	2024-05-13
Instructions	Select the following parameters: GDB Estimate: Risk factor Measure: DALYs Metric: Rate Risk: Household air pollution from solid fuels Cause: All causes Location: *Select all countries and territories* Age: Age-standardized Sex: both Year: Select all
Citation	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4

HFX	Household Solid Fuel Air Pollution [Exposure]
Source	Institute for Health Metrics and Evaluation
URL	https://ghdx.healthdata.org/record/ihme-data/gbd-2021-air-pollution-exposure-estimates-1990-2021
Date received	2024-05-13
Instructions	1. Go to "Files" tab. 2. Click on "Air Pollution Exposure Estimates" to download.
Citation	Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2021 (GBD 2021) Air Pollution Exposure Estimates 1990-2021. Seattle, United States of America: Institute for Health Metrics and Evaluation (IHME), 2024.
Reference	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4

IFA	Intact forest landscape area in 2000 (30% canopy cover)
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/
Date received	2023-07-20
References	Potapov, P., M. C. Hansen, L. Laestadius, S. Turubanova, A. Yaroshenko, C. Thies, W. Smith, I. Zhuravleva, A. Komarova, S. Minnemeyer, and E. Esipova. 2017. "The last frontiers of wilderness: Tracking loss of intact forest landscapes from 2000 to 2013." Science Advances 3: e1600821. Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53.
Note	Prepared by Michelle Sims from Global Forest Watch, received via personal communication. Viewable online from: https://gfw.global/3fDigzO

IFC	Intact forest landscape area, annual (30% canopy cover)
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/
Date received	2023-07-20
References	Potapov, P., M. C. Hansen, L. Laestadius, S. Turubanova, A. Yaroshenko, C. Thies, W. Smith, I. Zhuravleva, A. Komarova, S. Minnemeyer, and E. Esipova. 2017. "The last frontiers of wilderness: Tracking loss of intact forest landscapes from 2000 to 2013." Science Advances 3: e1600821. Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53.
Note	Prepared by Michelle Sims from Global Forest Watch, received via personal communication. Viewable online from: https://gfw.global/3fDigzO

INC	Municipal waste incinerated without energy recovery (tonnes)
Source	What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
URL	https://datacatalog.worldbank.org/search/dataset/0039597
Date received	2023-06-16
Instructions	Download "Country level dataset" (94.5 KB)
Citation	Kaza, S., Yao, L., Bhada-Tata, P., & Von Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Urban Development Series). World Bank.

INC	Municipal waste incinerated without energy recovery (tonnes)
Source	OECD
URL	https://stats.oecd.org/index.aspx?DataSetCode=MUNW
Date received	2023-10-20
Instructions	1. Under 'Data by theme', select Environment 2. Under Environment, select Waste 3. Under Waste, select Municipal waste - Generation and Treatment 4. For Countries, select all 5. For Variable, select Incineration without energy recovery

INE	Municipal waste incinerated with energy recovery (tonnes)
Source	What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
URL	https://datacatalog.worldbank.org/search/dataset/0039597
Date received	2023-06-16
Instructions	Download "Country level dataset" (94.5 KB)
Citation	Kaza, S., Yao, L., Bhada-Tata, P., & Von Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Urban Development Series). World Bank.

INE	Municipal waste incinerated with energy recovery (tonnes)
Source	OECD
URL	https://stats.oecd.org/index.aspx?DataSetCode=MUNW
Date received	2023-10-20
Instructions	1. Under 'Data by theme', select Environment 2. Under Environment, select Waste 3. Under Waste, select Municipal waste - Generation and Treatment 4. For Countries, select all 5. For Variable, select Incineration with energy recovery

KBA	Key Biodiversity Areas
Source	World Database of Key Biodiversity Areas (September 2023 version) | BirdLife International
URL	http://keybiodiversityareas.org/kba-data/request
Date received	2024-03-04
Instructions	Fill out form to request spatial KBA dataset.
Citation	BirdLife International (2023) World Database of Key Biodiversity Areas. Developed by the KBA Partnership: BirdLife International, International Union for the Conservation of Nature, American Bird Conservancy, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Re:Wild (formerly Global Wildlife Conservation), NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, Wildlife Conservation Society and World Wildlife Fund. September 2023 version.

KNS	Global distribution of seamounts and knolls
Source	UNEP - World Conservation Monitoring Center
URL	http://data.unep-wcmc.org/datasets/41
Date received	2024-03-27
Citation	Yesson C, Clark MR, Taylor M, Rogers AD (2011). The global distribution of seamounts based on 30-second bathymetry data. Deep Sea Research Part I: Oceanographic Research Papers 58: 442-453. doi: 10.1016/j.dsr.2011.02.004.

LED	Lead Exposure [DALY rate]
Source	Institute for Health Metrics and Evaluation
URL	http://ghdx.healthdata.org/gbd-results-tool
Date received	2024-05-13
Instructions	Select the following parameters: GDB Estimate: Risk factor Measure: DALYs Metric: Rate Risk: Lead exposure Cause: All causes Location: *Select all countries and territories* Age: Age-standardized Sex: both Year: Select all
Citation	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4
Note	Users must register for a free account to download data.

LFU	Municipal waste treated in landfills (tonnes)
Source	What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
URL	https://datacatalog.worldbank.org/search/dataset/0039597
Date received	2023-06-16
Instructions	Download "Country level dataset" (94.5 KB)
Citation	Kaza, S., Yao, L., Bhada-Tata, P., & Von Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Urban Development Series). World Bank.

LFU	Municipal waste treated in landfills (tonnes)
Source	OECD
URL	https://stats.oecd.org/index.aspx?DataSetCode=MUNW
Date received	2023-10-20
Instructions	1. Under 'Data by theme', select Environment 2. Under Environment, select Waste 3. Under Waste, select Municipal waste - Generation and Treatment 4. For Countries, select all 5. For Variable, select Landfill

LUE	CO_2 *net* fluxes (emissions *and* sinks) from land use and land cover change
Source	Global Carbon Budget
URL	https://globalcarbonbudgetdata.org/latest-data.html
Date received	2024-02-02
Instructions	Download National Land Use Change carbon emissions v2023.
Citation	Friedlingstein et al. 2023 Earth System Science Data https://doi.org/10.5194/essd-15-5301-2023
Note	Average of the three bookkeeping approaches.

MAN	Global distribution of mangroves
Source	Global Mangrove Watch
URL	https://data.unep-wcmc.org/datasets/45
Date received	2024-03-27
Citation	Bunting P., Rosenqvist A., Lucas R., Rebelo L-M., Hilarides L., Thomas N., Hardy A., Itoh T., Shimada M. and Finlayson C.M. (2018). The Global Mangrove Watch – a New 2010 Global Baseline of Mangrove Extent. Remote Sensing 10(10): 1669. doi: 10.3390/rs1010669.

MPA	Marine protected areas
Source	World Database on Protected Areas
URL	https://www.protectedplanet.net/
Date received	2024-03-01
Citation	IUCN and UNEP-WCMC (2024), The World Database on Protected Areas (WDPA), March 2024 Release, Cambridge, UK: UNEP-WCMC.

MWG	Municipal waste generated per year (tonnes)
Source	What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
URL	https://datacatalog.worldbank.org/search/dataset/0039597
Date received	2023-06-16
Instructions	Download “Country level dataset” (94.5 KB)
Citation	Kaza, S., Yao, L., Bhada-Tata, P., & Von Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Urban Development Series). World Bank.

MWG	Municipal waste generated per year (tonnes)
Source	OECD
URL	https://stats.oecd.org/index.aspx?DataSetCode=MUNW
Date received	2023-10-20
Instructions	1. Under 'Data by theme', select Environment 2. Under Environment, select Waste 3. Under Waste, select Municipal waste - Generation and Treatment 4. For Countries, select all 5. For Variable, select Municipal waste generated

NCR	Nitrogen Crop Removal (kg/ha)
Source	FAOSTAT's Cropland Nutrient Balance Database
URL	https://www.fao.org/faostat/en/#data/ESB
Date received	2024-02-04
Instructions	1. For Countries, select all 2. For Elements, select Cropland nitrogen per unit area 3. For Items, select Crop Removal 4. For Years, select all 5. Rename downloaded dataset to FAOSTAT_data_Nitrogen_Crop_Removal.csv

NOD	Nitrogen dioxide pollution [DALY rate]
Source	Institute for Health Metrics and Evaluation
URL	http://ghdx.healthdata.org/gbd-results-tool
Date received	2024-05-13
Instructions	Select the following parameters: GDB Estimate: Risk factor Measure: DALYs Metric: Rate Risk: Nitrogen dioxide pollution Cause: All causes Location: *Select all countries and territories* Age: Age-standardized Sex: both Year: Select all
Citation	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4

NOE	NO_X exposure
Source	Copernicus Atmosphere Monitoring Service
URL	https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly
Date received	2021-09-14
Instructions	Variable: Multi Level; Nitrogen monoxide and Nitrogen dioxide Model level: 60 Year: Select all Month: Select all Product type: Monthly mean Time: Select all Area: Full model area
References	Wolf, M.J., Esty, D.C., Kim, H., Bell, M.L., Brigham, S., Nortonsmith, Q., Zaharieva, S., Wendling, Z.A., de Sherbinin, A. and Emerson, J.W., (2022). New Insights for Tracking Global and Local Trends in Exposure to Air Pollutants. *Environmental science & technology*, *56*(7), 3984-3996, https://doi.org/10.1021/acs.est.1c08080..
Note	Ground-level concentration data are weighted by population density to derive country-average exposure values. See Wolf et al. 2022 for details.

NOT	N_2O emissions [Gg]
Source	PRIMAP-hist national historical emissions time series
URL	https://zenodo.org/records/10705513
Date received	2024-02-28
Instructions	Under Files, click to download Guetschow_et_al_2024-PRIMAP-hist_v2.5.1_final_27-Feb-2024.csv (73.1 MB)
Citation	Gütschow, J.; Pflüger, M.; Busch, D. (2023): The PRIMAP-hist national historical emissions time series v2.5.1 (1750-2022). Zenodo. doi:10.5281/zenodo.10705513
Reference	Gütschow, J.; Jeffery, L.; Gieseke, R.; Gebel, R.; Stevens, D.; Krapp, M.; Rocha, M. (2016): The PRIMAP-hist national historical emissions time series, Earth Syst. Sci. Data, 8, 571-603, doi:10.5194/essd-8-571-2016

NOx	NOx emissions [Gg]
Source	Community Emissions Data Systems
URL	https://zenodo.org/records/10904361
Date received	2024-05-01
Instructions	Download CEDS_v_2024_04_01_aggregate.zip
Citation	Hoesly, R., & Smith, S. (2024). CEDS v_2024_04_01 Release Emission Data (v_2024_04_01) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.10904361
Reference	Hoesly et al. 2018. Historical (1750–2014) anthropogenic emissions of reactive gases and aerosols from the Community Emissions Data System (CEDS). Geosci. Model Dev. 11, 369-408. https://doi.org/10.5194/gmd-11-369-2018

NTI	Nitrogen Total Inputs (kg/ha)
Source	FAOSTAT's Cropland Nutrient Balance Database
URL	https://www.fao.org/faostat/en/#data/ESB
Date received	2024-02-04
Instructions	1. For Countries, select all 2. For Elements, select Cropland nitrogen per unit area 3. For Items, select Input + (Total) 4. For Years, select all 5. Rename downloaded dataset to FAOSTAT_data_Nitrogen_Total_Inputs.csv

OCE	Ocean polygon split into contiguous pieces (version 4.1.0)
Source	Natural Earth Data
URL	https://www.naturalearthdata.com/downloads/110m-physical-vectors/110m-ocean/
Date received	2024-03-27

OZD	Ozone [DALY rate]
Source	Institute for Health Metrics and Evaluation
URL	http://ghdx.healthdata.org/gbd-results-tool
Date received	2024-05-13
Instructions	Select the following parameters: GDB Estimate: Risk factor Measure: DALYs Metric: Rate Risk: Ambient ozone pollution Cause: All causes Location: *Select all countries and territories* Age: Age-standardized Sex: both Year: Select all
Citation	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4
Note	Users must register for a free account to download data.

OZE	Ozone exposure [ppm]
Source	Copernicus Atmosphere Monitoring Service
URL	https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly
Date received	2023-07-10
Instructions	Variable: Multi Level; Ozone Model level: 60 Year: Select all Month: Select all Product type: Monthly mean Time: Select all Area: Full model area
References	Wolf, M.J., Esty, D.C., Kim, H., Bell, M.L., Brigham, S., Nortonsmith, Q., Zaharieva, S., Wendling, Z.A., de Sherbinin, A. and Emerson, J.W., (2022). New Insights for Tracking Global and Local Trends in Exposure to Air Pollutants. *Environmental science & technology*, *56*(7), 3984-3996, https://doi.org/10.1021/acs.est.1c08080..
Note	Ground-level concentration data are weighted by population density to derive country-average exposure values. See Wolf et al. 2022 for details.

PAR	Protected Areas Representativeness Index
Source	Commonwealth Scientific and Industrial Research Organization
URL	https://doi.org/10.25919/e3jp-jh25
Date received	2024-04-02
Citations	Ferrier, S., Manion, G., Elith, J. and Richardson, K. (2007) Using generalised dissimilarity modelling to analyse and predict patterns of betadiversity in regional biodiversity assessment. Diversity and Distributions 13: 252-264. Ferrier, S., Powell, G.V.N., Richardson, K.S., Manion, G., Overton, J.M., Allnutt, T.F., Cameron, S.E., Mantle, K., Burgess, N.D., Faith, D.P., Lamoreux, J.F., Kier, G., Hijmans, R.J., Funk, V.A., Cassis, G.A., Fisher, B.L., Flemons, P., Lees, D., Lovett, J.C., and van Rompaey, R.S.A.R (2004) Mapping more of terrestrial biodiversity for global conservation assessment. BioScience 54: 1101-1109. GEO BON (2015) Global Biodiversity Change Indicators. Version 1.2. Group on Earth Observations Biodiversity Observation Network Secretariat. Leipzig. http://www.geobon.org/Downloads/brochures/2015/GBCI_Version1.2_low.pdf Williams, K.J., Harwood, T.D., Ferrier, S. (2016) Assessing the ecological representativeness of Australia's terrestrial National Reserve System: A community-level modelling approach. Publication Number EP163634. CSIRO Land and Water, Canberra, Australia. https://publications.csiro.au/rpr/pub?pid=csiro:EP163634
Note	Prepared by CSIRO, received via personal communication

PCR	Phosphorus Crop Removal (kg/ha)
Source	FAOSTAT's Cropland Nutrient Balance Database
URL	https://www.fao.org/faostat/en/#data/ESB
Date received	2024-02-04
Instructions	1. For Countries, select all 2. For Elements, select Cropland phosphorus per unit area 3. For Items, select Crop Removal 4. For Years, select all 5. Rename downloaded dataset to FAOSTAT_data_Phosphorus_Crop_Removal.csv

PDN	Population Density
Source	World Bank
URL	https://data.worldbank.org/indicator/EN.POP.DNST
Date received	2023-12-20
Notes	Downloaded as CSV file and renamed ""WB_PDN_Data.csv".

PFA	Humid Tropical Primary Forest area in 2001 (30% canopy cover)
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/
Date received	2023-07-20
References	Turubanova, S., P.V. Potapov, A. Tyukavina, M.C. Hansen. 2018. "Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia." Environmental Research Letters, 13(7), p.074028 Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53.
Note	Prepared by Michelle Sims from Global Forest Watch, received via personal communication. Viewable online from: https://gfw.global/3Hqsq0C

PFC	Humid Tropical Primary Forest loss, annual (30% canopy cover)
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/
Date received	2023-07-20
References	Turubanova, S., P.V. Potapov, A. Tyukavina, M.C. Hansen. 2018. "Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia." Environmental Research Letters, 13(7), p.074028 Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53.
Note	Prepared by Michelle Sims from Global Forest Watch, received via personal communication. Viewable online from: https://gfw.global/3Hqsq0C

PMD	Ambient PM2.5 [DALY rate]
Source	Institute for Health Metrics and Evaluation
URL	http://ghdx.healthdata.org/gbd-results-tool
Date received	2024-05-13
Instructions	Select the following parameters: GDB Estimate: Risk factor Measure: DALYs Metric: Rate Risk: Ambient particular matter pollution Cause: All causes Location: *Select all countries and territories* Age: Age-standardized Sex: both Year: Select all
Citation	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4
Note	Users must register for a free account to download data.

PME	Ambient fine particulate matter exposure ($PM_{2.5}$)
Source	Atmospheric Composition Analysis Group (Washington University in St. Louis)
URL	https://sites.wustl.edu/acag/datasets/surface-pm2-5/#V5.GL.04
Date received	2023-10-11
Instructions	1. Click on the link under "Annual and monthly mean PM2.5 [ug/m3] at 0.01° × 0.01°". 2. Open folder "Global" 3. Download folder "Annual"
References	Aaron van Donkelaar, Melanie S. Hammer, Liam Bindle, Michael Brauer, Jeffery R. Brook, Michael J. Garay, N. Christina Hsu, Olga V. Kalashnikova, Ralph A. Kahn, Colin Lee, Robert C. Levy, Alexei Lyapustin, Andrew M. Sayer and Randall V. Martin (2021). Monthly Global Estimates of Fine Particulate Matter and Their Uncertainty Environmental Science & Technology, 2021, doi:10.1021/acs.est.1c05309.https://pubs.acs.org/doi/full/10.1021/acs.est.1c05309 Wolf, M.J., Esty, D.C., Kim, H., Bell, M.L., Brigham, S., Nortonsmith, Q., Zaharieva, S., Wendling, Z.A., de Sherbinin, A. and Emerson, J.W., (2022). New Insights for Tracking Global and Local Trends in Exposure to Air Pollutants. *Environmental science & technology*, *56*(7), 3984-3996, https://doi.org/10.1021/acs.est.1c08080..
Note	Ground-level PM2.5 concentration data are weighted by population density to derive country-average exposure values. See Wolf et al. 2022 for details.

POP	Population
Source	World Bank
URL	https://databank.worldbank.org/source/population-estimates-and-projections
Date received	2023-10-21
Instructions	4. Under tab "Country", select all 5. Under tab "Series", select "Population, total" 6. Under tab "Time", select all 7. Apply selections and download as a CSV file
Documentation	SP.POP.TOTL
Note	Eritrea and Taiwan: IMF replaces incomplete World Bank data for entire time series

POP	Population
Source	IMF
URL	https://www.imf.org/en/Publications/WEO/weo-database/2021/April
Date received	2022-01-18
Instructions	-Click on "By Countries (country-level data) -Click on "All Countries" -Click on "Clear all", and check boxes next to Eritrea and Taiwan -Click "Continue" at bottom of page -Select "Population" -Click "Continue" at bottom of page -Select: Start year = 1994, End year = 2018 -Unclick all Notes -Click next to "ISO Alpha-3 Code" -Unclick "Subject descriptor" -Click "Prepare Report"
Note	This produces a report to help fill data gaps in the World Bank data.

PRS	Pesticide risk score
Source	Tang et al.
URL	https://doi.org/10.1038/S41561-021-00712-5
Date received	2023-02-23
Reference	Tang, F.H., Lenzen, M., McBratney, A. and Maggi, F., (2021). Risk of pesticide pollution at the global scale. Nature Geoscience, 14(4), 206-210.
Notes	Updated values based on PESTCHEM-GRIDS v2: figshare.com/articles/dataset/PESTCHEMGRIDS_v2_01_beta_version_/25854769 National average values are calculated from global raster files processed with scripts in "EPI2024/Source/Pesticides/"

PTI	Phosphorus Total Inputs (kg/ha)
Source	FAOSTAT's Cropland Nutrient Balance Database
URL	https://www.fao.org/faostat/en/#data/ESB
Date received	2024-02-04
Instructions	1. For Countries, select all 2. For Elements, select Cropland phosphorus per unit area 3. For Items, select Input + (Total) 4. For Years, select all 5. Rename downloaded dataset to FAOSTAT_data_Phosphorus_Total_Inputs.csv

RLI	Red List Index
Source	International Union for the Conservation of Nature (IUCN)
URL	https://unstats.un.org/sdgs/dataportal/database
Date received	2024-04-17
Metadata	https://unstats.un.org/sdgs/metadata/files/Metadata-15-05-01.pdf
Instructions	1. Select Data Series = 15.5.1 2. Select Geographic Areas = All groupings (264 of 264) 3. Select Period = all years 4. Click "Show Results" and click on the generated series 5. Click "Download XLS" under the data table preview
Reference	Rodrigues A.S.L., Brooks T.M., Butchart S.H.M., Chanson J., Cox N., Hoffmann M., Stuart S.N. 2014. Spatially Explicit Trends in the Global Conservation Status of Vertebrates. PLOS ONE 9(11): e113934: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0113934

RMS	Trend in Regional Marine Trophic Index over the last decade
Source	Sea Around Use
URL	https://www.seaaroundus.org/
Date received	2024-02-28
Instructions	1. Navigate to Tools & Data 2. Under "Search Type", select "EEZ" 3. Select on EEZ on the map or from the dropdown menu 4. Under the "Indicators" section, click "Marine trophic index" 5. Enter "3.2" into the "Min TL" field and click "redraw graph" . 6. Click "Download Data" button on the top-right 7. Repeat for each EEZ.

ROL	Rule of Law
Source	Worldwide Governance Indicators
URL	https://databank.worldbank.org/source/worldwide-governance-indicators
Date received	2024-05-17
Instructions	Country: *Select all* Series: Rule of Law Estimate Time: *Select all*
Citation	Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi (2010). The Worldwide Governance Indicators: Methodology and Analytical Issues". World Bank Policy Research Working Paper No. 5430 (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130)
Documentation	https://info.worldbank.org/governance/wgi/Home/Documents

RQU	Regulatory Quality
Source	Worldwide Governance Indicators
URL	https://databank.worldbank.org/source/worldwide-governance-indicators
Date received	2024-05-17
Instructions	Country: *Select all* Series: Regulatory Quality Estimate Time: *Select all*
Citation	Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi (2010). The Worldwide Governance Indicators: Methodology and Analytical Issues". World Bank Policy Research Working Paper No. 5430 (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130)
Documentation	https://info.worldbank.org/governance/wgi/Home/Documents

SGR	Global distribution of sea grasses
Source	UNEP – World Conservation Monitoring Center
URL	https://data.unep-wcmc.org/datasets/7
Date received	2024-03-27
Citation	UNEP-WCMC, Short FT (2021). Global distribution of seagrasses (version 7.1). Seventh update to the data layer used in Green and Short (2003). Cambridge (UK): UN Environment World Conservation Monitoring Centre. Data DOI: https://doi.org/10.34892/x6r3-d211

SHI	Species Habitat Index
Source	Map of Life
URL	https://mol.org/indicators/habitat/background
Date received	2024-04-02
Citations	Jetz, W., D. S. Wilcove, and A. P. Dobson. 2007. Projected Impacts of Climate and Land-Use Change on the Global Diversity of Birds. PLoS Biology 5:1211-1219. Rondinini, C., et al. 2011. Global habitat suitability models of terrestrial mammals. Philosophical Transactions of the Royal Society B: Biological Sciences 366:2633-2641. Jetz, W., J. M. McPherson, and R. P. Guralnick. 2012. Integrating biodiversity distribution knowledge: toward a global map of life. Trends in Ecology and Evolution 27:151-159. GEO BON (2015) Global Biodiversity Change Indicators. Version 1.2. Group on Earth Observations Biodiversity Observation Network Secretariat. Leipzig. http://www.geobon.org/Downloads/brochures/2015/GBCI_Version1.2_low.pdf
Note	Prepared by Map of Life, received via personal communication. Due to time constraints, this version of the Species Habitat Index only includes the area component, not the connectivity component.

SLT	Global distribution of saltmarshes
Source	UNEP – World Conservation Monitoring Center
URL	https://data.unep-wcmc.org/datasets/43
Date received	2024-03-27
Citation	Mcowen C, Weatherdon LV, Bochove J, Sullivan E, Blyth S, Zockler C, Stanwell-Smith D, Kingston N, Martin CS, Spalding M, Fletcher S (2017). A global map of saltmarshes (v6.1). Biodiversity Data Journal 5: e11764. Paper DOI: https://doi.org/10.3897/BDJ.5.e11764; Data DOI: https://doi.org/10.34892/07vk-ws51

SO2	SO2 emissions [Gg]
Source	Community Emissions Data Systems
URL	https://zenodo.org/records/10904361
Date received	2024-05-01
Instructions	Download CEDS_v_2024_04_01_aggregate.zip
Citation	Hoesly, R., & Smith, S. (2024). CEDS v_2024_04_01 Release Emission Data (v_2024_04_01) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.10904361
Reference	Hoesly et al. 2018. Historical (1750–2014) anthropogenic emissions of reactive gases and aerosols from the Community Emissions Data System (CEDS). Geosci. Model Dev. 11, 369-408. https://doi.org/10.5194/gmd-11-369-2018

SOE	SO_2 exposure
Source	Copernicus Atmosphere Monitoring Service
URL	https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly
Date received	2023-07-10
Instructions	Variable: Multi Level; Sulfur dioxide Model level: 60 Year: Select all Month: Select all Product type: Monthly mean Time: Select all Area: Full model area
References	Wolf, M.J., Esty, D.C., Kim, H., Bell, M.L., Brigham, S., Nortonsmith, Q., Zaharieva, S., Wendling, Z.A., de Sherbinin, A. and Emerson, J.W., (2022). New Insights for Tracking Global and Local Trends in Exposure to Air Pollutants. *Environmental science & technology*, *56*(7), 3984-3996, https://doi.org/10.1021/acs.est.1c08080..
Note	Ground-level concentration data are weighted by population density to derive country-average exposure values. See Wolf et al. 2022 for details.

SPI	Species Protection Index
Source	Map of Life
URL	https://mol.org/indicators/
Date received	2024-02-12
Citation	Jetz, W., J. M. McPherson, and R. P. Guralnick. 2012. Integrating biodiversity distribution knowledge: toward a global map of life. Trends in Ecology and Evolution 27:151-159. GEO BON (2015) Global Biodiversity Change Indicators. Version 1.2. Group on Earth Observations Biodiversity Observation Network Secretariat. Leipzig. http://www.geobon.org/Downloads/brochures/2015/GBCI_Version1.2_low.pdf
Note	Prepared by Map of Life, received via personal communication

TCA	Forest area in 2000 (30% canopy cover)
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/
Date received	2023-07-20
References	Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53.
Note	Prepared by Michelle Sims from Global Forest Watch, received via personal communication. Viewable online from: https://gfw.global/3abMQOe

TCC	Forest loss, annual (30% canopy cover)
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/
Date received	2023-07-20
References	Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53.
Note	Prepared by Michelle Sims from Global Forest Watch, received via personal communication. Viewable online from: https://gfw.global/3abMQOe

TCH	Components of net change in tree cover globally
Source	Global Forest Watch
URL	https://www.globalforestwatch.org/dashboards/global/
Date received	2024-02-20
Instructions	1. Go to the Global Dashboard on the Global Forest Watch website. 2. Scroll down to widget "Components of net change in tree cover globally". 3. Click "Download data" button on the top right corner of the widget.
References	Potapov, P., Hansen, M.C., Pickens, A., Hernandez-Serna, A., Tyukavina, A., Turubanova, S., Zalles, V., Li, X., Khan, A., Stolle, F., Harris, N., Song, X-P., Baggett, A., Kommareddy, I., and Kommareddy, A. 2022. The Global 2000-2020 Land Cover and Land Use Change Dataset Derived From the Landsat Archive: First Results. Frontiers in Remote Sensing, 13, April 2022. https://doi.org/10.3389/frsen.2022.856903. Harris, N., E. Goldman and S. Gibbes. 2019. "Spatial Database of Planted Trees (SDPT) Version 1.0." Washington, DC: World Resources Institute.

TEW	Areas of biomes
Source	World Wildlife Fund
URL	https://www.worldwildlife.org/publications/terrestrial-ecoregionsofthe-world
Date received	2022-02-01
Citation	Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V. N., Underwood, E. C., D'amico, J. A., Itoua, I., Strand, H. E., Morrison, J. C., Loucks, C. J., Allnutt, T. F., Ricketts, T. H., Kura, Y., Lamoreux, J. F., Wettengel, W. W., Hedao, P., & Kassem, K. R. (2001). Terrestrial Ecoregions of the World: A New Map of Life on Earth. BioScience, 51(11), 933–938. https://doi.org/10.1641/0006-3568(2001)051[0933:TEOTWA]2.0.CO;2

TPA	Terrestrial protected areas
Source	World Database on Protected Areas
URL	https://www.protectedplanet.net/
Date received	2024-03-01
Citation	IUCN and UNEP-WCMC (2024), The World Database on Protected Areas (WDPA), March 2024 Release, Cambridge, UK: UNEP-WCMC.

URB	Urbanization (urban population percentage)
Source	World Bank
URL	https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS
Date received	2023-12-20

USD	Unsafe Sanitation [DALY rate]
Source	Institute for Health Metrics and Evaluation
URL	http://ghdx.healthdata.org/gbd-results-tool
Date received	2024-05-13
Instructions	Select the following parameters: GDB Estimate: Risk factor Measure: DALYs Metric: Rate Risk: Unsafe sanitation Cause: All causes Location: *Select all countries and territories* Age: Age-standardized Sex: both Year: Select all
Citation	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4
Note	Users must register for a free account to download data.

UWD	Unsafe Water [DALY rate]
Source	Institute for Health Metrics and Evaluation
URL	http://ghdx.healthdata.org/gbd-results-tool
Date received	2024-05-13
Instructions	Select the following parameters: GDB Estimate: Risk factor Measure: DALYs Metric: Rate Risk: Unsafe water source Cause: All causes Location: *Select all countries and territories* Age: Age-standardized Sex: both Year: Select all
Citation	Brauer *et al.* (2024). Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, 403 (10440), P2162-2203. https://doi.org/10.1016/S0140-6736(24)00933-4
Note	Users must register for a free account to download data.

VOA	Voice and Accountability
Source	Worldwide Governance Indicators
URL	https://databank.worldbank.org/source/worldwide-governance-indicators
Date received	2024-05-17
Instructions	Country: *Select all* Series: Voice and Accountability Estimate Time: *Select all*
Citation	Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi (2010). The Worldwide Governance Indicators: Methodology and Analytical Issues". World Bank Policy Research Working Paper No. 5430 (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130)
Documentation	https://info.worldbank.org/governance/wgi/Home/Documents

VOE	Volatile organic compound exposure
Source	Copernicus Atmosphere Monitoring Service
URL	https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly
Date received	2023-07-10
Instructions	Variable: Multi Level; Ethane, Propane, Formaldehyde, and Isoprene Model level: 60 Year: Select all Month: Select all Product type: Monthly mean Time: Select all Area: Full model area
References	Wolf, M.J., Esty, D.C., Kim, H., Bell, M.L., Brigham, S., Nortonsmith, Q., Zaharieva, S., Wendling, Z.A., de Sherbinin, A. and Emerson, J.W., (2022). New Insights for Tracking Global and Local Trends in Exposure to Air Pollutants. *Environmental science & technology*, *56*(7), 3984-3996, https://doi.org/10.1021/acs.est.1c08080..
Note	Ground-level concentration data are weighted by population density to derive country-average exposure values. See Wolf et al. 2022 for details.

WHR	Overall life satisfaction
Source	World Happiness Report
URL	https://worldhappiness.report/ed/2023/#appendices-and-data
Date received	2023-05-19
Instructions	Find Appendices & Data Click on download 'Data for Figure 2.1'
Reference	Helliwell, J. F., Layard, R., Sachs, J. D., Aknin, L. B., De Neve, J.-E., & Wang, S. (Eds.). (2023). World Happiness Report 2023 (11th ed.). Sustainable Development Solutions Network.

WRE	Municipal waste recycled (tonnes)
Source	What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
URL	https://datacatalog.worldbank.org/search/dataset/0039597
Date received	2023-06-16
Instructions	Download "Country level dataset" (94.5 KB)
Citation	Kaza, S., Yao, L., Bhada-Tata, P., & Von Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 (Urban Development Series). World Bank.

WRE	Municipal waste recycled (tonnes)
Source	OECD
URL	https://stats.oecd.org/index.aspx?DataSetCode=MUNW
Date received	2023-10-20
Instructions	1. Under 'Data by theme', select Environment 2. Under Environment, select Waste 3. Under Waste, select Municipal waste - Generation and Treatment 4. For Countries, select all 5. For Variable, select Recycling

WWC	Proportion of wastewater collected
Source	Jones et al. 2020
URL	https://doi.pangaea.de/10.1594/PANGAEA.918731
Date received	2024-03-27
Citation	Jones, Edward R; van Vliet, Michelle T H; Qadir, Manzoor; Bierkens, Marc F P (2021): Country-level and gridded estimates of wastewater production, collection, treatment and reuse. Earth System Science Data, 13(2), 237-254, https://doi.org/10.5194/essd-13-237-2021

WWC	Proportion of wastewater collected
Source	Eurostat
URL	https://ec.europa.eu/eurostat/databrowser/view/MED_EN47__custom_6618129/
Date received	2023-06-21
Instructions	Under the "Download" tab, select "SDMX-CSV 1.0 (1 observation = 1 row)
Note	Data for Non-EU countries: Algeria, Egypt, Morocco, Tunisia, Israel, Jordan, Palestine.

WWC	Proportion of wastewater collected
Source	Eurostat
URL	ec.europa.eu/eurostat/databrowser/view/ENV_WW_CON__custom_7076554/
Date received	2023-06-21
Instructions	Under the "Download" tab, select "SDMX-CSV 1.0 (1 observation = 1 row)

WWC	Proportion of wastewater collected
Source	UN Statistics Division
URL	https://unstats.un.org/unsd/envstats/qindicators.cshtml
Date received	2024-03-07
Instructions	1. Select "Inland Water Resources" 2. Click "Population connected to wastewater treatment" to download

WWC	Proportion of wastewater collected
Source	OECD
URL	https://stats.oecd.org/Index.aspx?DataSetCode=WATER_TREAT
Date received	2023-06-20
Instructions	1. Hover over "Export" 2. Select Text file (CSV) to download
Note	These data measure the total percentage of the population connected to some type of wastewater treatment (septic tanks, public treatment plants, or other).

WWG	Wastewater generated (m^3 per year)
Source	Jones et al. 2020
URL	https://doi.pangaea.de/10.1594/PANGAEA.918731
Date received	2024-03-27
Citation	Jones, Edward R; van Vliet, Michelle T H; Qadir, Manzoor; Bierkens, Marc F P (2021): Country-level and gridded estimates of wastewater production, collection, treatment and reuse. Earth System Science Data, 13(2), 237-254, https://doi.org/10.5194/essd-13-237-2021

WWG	Wastewater generated (m^3 per year)
Source	UN Statistics Division
URL	https://unstats.un.org/unsd/envstats/qindicators.cshtml
Date received	2024-03-07
Instructions	1. Select "Inland Water Resources" 2. Click "Wastewater generated" to download

WWT	Proportion of wastewater collected that is treated
Source	Jones et al. 2020
URL	https://doi.pangaea.de/10.1594/PANGAEA.918731
Date received	2024-03-27
Citation	Jones, Edward R; van Vliet, Michelle T H; Qadir, Manzoor; Bierkens, Marc F P (2021): Country-level and gridded estimates of wastewater production, collection, treatment and reuse. Earth System Science Data, 13(2), 237-254, https://doi.org/10.5194/essd-13-237-2021

WWT	Proportion of wastewater collected that is treated
Source	UN Statistics Division
URL	https://unstats.un.org/unsd/envstats/qindicators.cshtml
Date received	2024-03-07
Instructions	1. Select "Inland Water Resources" 2. Click in the following three links to download: • "Wastewater treated in urban treatment plants" • "Wastewater treated in other treatment plants" • "Wastewater treated in independent treatment facilities"

WWT	Proportion of wastewater collected that is treated
Source	OECD
URL	https://stats.oecd.org/Index.aspx?DataSetCode=WATER_TREAT
Date received	2023-08-03
Instructions	1. Under "Time period", select all years 2. Under "Reference Area", select all countries. 3. Under "Measure", select "Public total treatment" 4. Download as unfiltered CSV files
Note	These data measure the total percentage of the population connected to public wastewater treatment plants.

WWR	Proportion of wastewater treated that is reused
Source	Jones et al. 2020
URL	https://doi.pangaea.de/10.1594/PANGAEA.918731
Date received	2024-03-27
Citation	Jones, Edward R; van Vliet, Michelle T H; Qadir, Manzoor; Bierkens, Marc F P (2021): Country-level and gridded estimates of wastewater production, collection, treatment and reuse. Earth System Science Data, 13(2), 237-254, https://doi.org/10.5194/essd-13-237-2021

3. Indicator Construction

Chapter 14 of the 2024 EPI report describes the general approach to construct indicators. Data from sources undergo several steps before they can be used as indicators, including additional calculations, standardizations, transformations, and scoring. This section describes how the data are used to construct the 58 indicators of the 2024 EPI. On the following pages, you will see each metric described according to the following template.

TLA : Indicator / Issue Category / Policy Objective

Short description of the indicator.

Units	Units of the raw data
Years	Years for which raw data are available
Source	Organization
Transformation	Whether the normalized data had to be transformed
Targets	Basis for selection of targets

Performance	Nominal	Raw	Transformed
Best	Value or percentile	Value	Transformed value
Worst	Value or percentile	Value	Transformed value

Calculations
If any calculations were required, they are described here.

Imputations
If any imputation was required, it is described here.

Note
Any additional information that would be helpful for understanding indicator construction.

Due to the variety of data sources, not every field is applicable to every indicator. Each entry below provides the fullest account possible.

3.1 Air Quality

HPE: Anthropogenic particulate matter pollution / Air Quality / Environmental Health

We measure exposure to human sources of *$PM_{2.5}$ exposure* using the population-weighted annual average concentration of the $PM_{2.5}$ pollution at ground level and multiplying that by the fraction of $PM_{2.5}$ pollution from human sources (and wildfires) in the country.

Units	Micrograms per cubic meter of air (μg/m^3)
Years	1998–2022
Source	Washington University in St. Louis
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	2.5	2.5	0.9162907
Worst	95th percentile	28.57979	3.3527

Calculations

Abbreviation	Component	Units	Source
PME	Population-weighted average of country-wide concentration of ambient $PM_{2.5}$	μg/m^3	Washington University in St. Louis
FHP	Fraction of population-weighted exposure to ambient particulate matter from human sources.	Proportion	Global Burden of Disease – Major Air Pollution Sources

This new indicator measures the exposure to fine particulate matter pollution from anthropogenic sources, such as the burning of fossil fuels, which are easier to influence through policy than natural sources. To this end, in each country we discount the fraction of PM2.5 exposure originating from natural sources such as windblown dust, sea spray, lighting, and volcanoes.

$$HPE = PME \times FHP$$

HFD: Household air pollution from solid fuels / Air Quality / Environmental Health

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

Units	Age-standardized DALYs/100k people
Years	1990–2021
Source	Institute for Health Metrics and Evaluation
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	0.05	0.05	-2.995732
Worst	10000	10000	9.21034

OZD: Ozone / Air Quality / Environmental Health

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

Units	Age-standardized DALYs/100k people
Years	1990–2021
Source	Institute for Health Metrics and Evaluation
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	1	1	0
Worst	250	250	5.521461

NOD: NO2 Exposure / Air Quality / Environmental Health

We measure *nitrogen dioxide exposure* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to ground-level NO_2 pollution.

Units	Age-standardized DALYs/100k people
Years	1990–2021
Source	Institute for Health Metrics and Evaluation
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	5th percentile	0.02522841	-3.679785
Worst	99th percentile	17.08124	2.837981

SOE: SO2 Exposure / Air Quality / Environmental Health

We measure *sulfur dioxide exposure* using the population-weighted annual average concentration of the air pollutant at ground level.

Units	Concentration (ppm)
Years	2003–2022
Source	Copernicus; Wolf et al. 2021
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	5th percentile	0.0002816023	- 8.175015
Worst	95th percentile	0.06093163	- 2.798003

COE: CO Exposure / Air Quality / Environmental Health

We measure *carbon monoxide exposure* using the population-weighted annual average concentration of the air pollutant at ground level.

Units	Concentration (ppm)
Years	2003–2022
Source	Copernicus; Wolf et al. 2021
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	1st percentile	0.05054882	-2.984816
Worst	99th percentile	0.7531222	-0.2835278

VOE: VOCs Exposure / Air Quality / Environmental Health

We measure *volatile organic compound exposure* using the population-weighted annual average concentration of the air pollutant at ground level.

Units	Concentration (ppm)
Years	2003–2022
Source	Copernicus; Wolf et al. 2021
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	5th percentile	0.0007321244	-7.21956
Worst	95th percentile	0.09718114	-2.331179

3.2 Sanitation & Drinking Water

USD: Unsafe sanitation / Sanitation & Drinking Water / Environmental Health

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.

Units	Age-standardized DALYs/100k people
Years	1990–2021
Source	Institute for Health Metrics and Evaluation
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	1st percentile	0.7565639	-0.2789682
Worst	99th percentile	7064.659	8.86286

UWD: Unsafe Drinking Water / Sanitation & Drinking Water / Environmental Health

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.

Units	Age-standardized DALYs/100k people
Years	1990–2021
Source	Institute for Health Metrics and Evaluation
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	1st percentile	1.931692	0.6583964
Worst	99th percentile	8350.549	9.030083

3.3 Heavy Metals

LED: Lead Exposure / Heavy Metals / Environmental Health
We measure *lead exposure* using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to lead contamination in the environment.

Units	Age-standardized DALYs/100k people
Years	1990–2021
Source	Institute for Health Metrics and Evaluation
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	1st percentile	62.31889	4.132265
Worst	99th percentile	2058.333	7.629652

3.4 Waste Management

Data sources and compilation
The World Bank's What a Waste 2.0 report is the most comprehensive assessment of municipal solid waste generation and treatment in countries around the world, but uses data from 2016 or earlier. We updated the What a Waste 2.0 data set with data from the OECD, Eurostat, and UNEP/UNSD Environmental Questionnaires, whenever they were available. Eurostat data (used for Cyprus, Kosovo, Malta, Montenegro, and Serbia) only includes waste from households, while the other two sources generally include waste from both households and certain commercial activities.

The data compilation process was challenging since countries report different types of data and use different definitions of solid municipal waste and waste treatments. When the UNSD was deemed incomparable, we used data from the What a Waste 2.0 report.

None of the sources above (World Bank's What a Waste 2.0 Report, UNSD, OECD, Eurostat) include data for Taiwan. We therefore obtained municipal solid waste generation and treatment data directly from the website of Taiwan's Ministry of Environment Solid Waste Statistics (https://www.moenv.gov.tw/en/513B0B39D090DE4C). Specifically, we used data from Table 4-1 "Generation and Treatment of Municipal Waste", published on 2024-02-15.

Eritrea was the only country without any waste management data in any of our sources. In the *Controlled Solid Waste* indicator, we assigned a value of zero to Eritrea for two reasons. First, both Ethiopia and Djibouti, two of Eritrea's neighboring countries, do not report managing any of their waste in a way that mitigates environmental impacts. Second, an article from Eritrea's Ministry of Information (https://shabait.com/2020/03/07/efforts-on-waste-managment/, accessed on February 18th, 2024), mentions that waste is typically dumped in sites without any management (that is, in open dumps).

For municipal solid waste generation data, we compared the most recent values compiled from various sources to the values in the What a Waste 2.0 report to help identify cases where countries reported data using different units, methods, and/or definitions of waste. Given that global waste generation trends have almost universally increased in recent years, we carefully examined any recent values that were less than half of the values reported in the What a Waste 2.0 report. We also examined values that were more than three times higher than those in the What a Waste 2.0 report. If we could not find an explanation for the discrepancy, we reverted to the What a Waste 2.0 data. These cases are described in the table below.

For more details and code for cleaning and merging data, see R scripts in: "~/Source/Solid Waste/".

Countries with values of Municipal Solid Waste generated (MWG) in the UNEP/UNSD Waste Questionnaires that differed markedly from values in the What a Waste 2.0 report (WaW) and were subject to further examination.

Country	Explanation
Countries with MWG values more than three times larger than in the What a Waste 2.0 report	
Antigua and Barbuda	Based on the footnotes in the UNSD Questionnaire, it seems that the MWG data includes sewage waste, which is normally not considered municipal solid waste. Therefore, we reverted to data from *WaW*.
Curaçao	Looking at Curaçao's Environmental Statistics Compendium 2020, we discovered that the UNSD questionnaire data includes demolition waste, which is typically excluded from the definition of MSW. We thus reverted to using data from *WaW*.
Kuwait	Kuwait included demolition waste in its reporting of total municipal waste collected. Thus, we replaced the values with the sum of waste generated from households and other economic activities reported in sheet R1 of the Questionnaire.
Qatar	The value from *WaW* is similar to that reported in the Questionnaire for waste collected from households, suggesting that the other waste might include demolition waste. We were not able to corroborate this due to incomplete data in the questionnaire. Moreover, the waste collected from households drops by nearly 50% from 2017 to 2018, and then increases nearly 20-fold in 2019. Therefore, we used the values of waste collected from households only up to 2017.
Singapore	Data reported in the UNSD/UNEP Questionnaire includes construction and industrial waste. We calculated the ratio of total waste generated in 2016 between the *WaW* report (which presumably does not include construction and industrial waste) and used that to adjust all values in the time series.
Suriname	Data in the UNSD/UNEP Questionnaire was relatively recent and complete, and consistent with other sources. In contrast, *WaW* data is an estimate from 2010 and came from the CIA's World Factbook. Thus, we decided to keep the most recent data.
Countries with MWG values less than half of values in the What a Waste 2.0 report	
Burkina Faso	Data in UNSD/UNEP Questionnaire is incomplete, inconsistent through time, and less than 20% of values in *WaW*. We thus reverted to *WaW* data.
Burundi	Data in the UNSD/UNEP Questionnaire has several issues. First, the tonnage is estimated from data in cubic meters. Second, data is only from the city of Bujumbura, Burundi, and represents only waste collected, not generated. For these reasons, we decided to revert to *WaW* data.
Saudi Arabia	The UNSD/UNEP Questionnaire includes only one value of MWG that is less than 20% of the value in *WaW*, and inconsistent with other sources. We therefore reverted to using *WaW* data.
Uganda	UNSD/UNEP Questionnaire included only data about waste collected in 30 out of 44 municipalities. We thus reverted to using data from WaW.
Zimbabwe	UNSD/UNEP Questionnaire included data about waste collected in some municipalities, which changed through time. We thus reverted to using data from WaW.

SMW: Controlled Solid Waste / Waste Management / Environmental Health

Controlled solid waste refers to the proportion of household and commercial waste generated in a country that is collected and treated in a manner that controls environmental risks. Examples of controlled disposal methods include sanitary landfills, incineration, recycling, composting, and anaerobic digestion.

Units	proportion
Years	2016–2022
Sources	Kaza et al. 2018, UNEP/UNSD; OECD; Eurostat
Transformation	none

Performance	Nominal	Raw
Best	0.0	0.0
Worst	1.0	1.0

Calculations

Abbreviation	Component	Units	Source
MWG	Total municipal solid waste generated per year	tonnes	*Various*
COM	Total municipal solid waste composted per year	tonnes	*Various*
INC	Total municipal solid waste incinerated (without energy recovery) per year	tonnes	*Various*
INE	Total municipal solid waste incinerated (with energy recovery) per year	tonnes	*Various*
LFU	Total municipal solid waste landfilled per year	tonnes	*Various*
WRE	Total municipal solid waste recycled per year	tonnes	*Various*

$$SMW = (LFU + INC + COM + INE + WRE) / MWG$$

WRR: Waste Recovery Rate / Waste Management / Environmental Health

Waste recovery rate refers to the proportion of household and commercial waste generated in a country that is collected and treated in a manner that recovers energy and/or materials and thereby contributes to a circular economy. Recycling and composting help recover valuable materials from waste, while anaerobic digestion and incineration yield energy.

Units	proportion
Years	2016–2022
Sources	Kaza et al. 2018, UNEP/UNSD; OECD; Eurostat
Transformation	none

Performance	Nominal	Raw
Best	0.0	0.0
Worst	1.0	1.0

Calculations

Abbreviation	Component	Units	Source
MWG	Total municipal solid waste generated per year	tonnes	*Various*
COM	Total municipal solid waste composted per year	tonnes	*Various*
INE	Total municipal solid waste incinerated (with energy recovery) per year	tonnes	*Various*
WRE	Total municipal solid waste recycled per year	tonnes	*Various*

$$WRR = (COM + INE + WRE) / MWG$$

Imputation of missing values

Data for to calculate WRR were not available for 56 countries, for which we used a model to impute the missing values. Specifically, for countries for which data were available data, we fitted a linear model to predict the natural logarithm of WRR values based on countries' EPI region (R), and their GDP per capita (GPC.

$$\ln(WRR)= \alpha + \beta GPC + \gamma R + \varepsilon$$

Next, we used this model, which explained 42% of the variance in available WRR scores, to predict values for countries where WRR was missing but GPC and R were not. Since all countries are supposed to report their waste management data through the UNEP environmental questionnaires, or the reporting channels of the OECD and EUROSTAT, we applied a penalty of 25% of the predicted score to encourage countries to report their data going forward:

$$\widehat{WRR} = \exp(\hat{\alpha} + \hat{\beta}GPC + \hat{\gamma}R) \times 0.75$$

The 56 countries for which we imputed RCY values using this model are:

Afghanistan
Albania
Angola
Armenia
Bahamas
Belize
Burundi
Cabo Verde
Cambodia
Central African Republic
Chad
Comoros
Djibouti
El Salvador
Equatorial Guinea
Eritrea
Eswatini
Ethiopia
Gabon
Gambia
Georgia
Guatemala
Guinea-Bissau
Haiti
Honduras
Iraq
Jamaica
Kiribati
Kyrgyzstan
Lesotho
Liberia
Malawi
Mali
Micronesia
Mongolia
Myanmar
New Zealand
Nicaragua
Nigeria
Panama
Paraguay
Rwanda
Sao Tome and Principe
Senegal
Seychelles
Sierra Leone
Solomon Islands
Sudan
Tajikistan
Tanzania
Timor-Leste
Tonga
Turkmenistan
Uzbekistan
Venezuela
Zambia

WPC: Waste Generated *per capita* / Waste Management / Environmental Health

Waste generated per capita measures the how much municipal solid waste an average person produces in one year.

Units	Tonnes per person
Years	2016–2022
Sources	Kaza et al. 2018, UNEP/UNSD; OECD; Eurostat
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	1st percentile	0.04303115	-3.145831
Worst	99th percentile	1.257877	0.2294254

Calculations

Abbreviation	Component	Units	Source
MWG	Total municipal solid waste generated per year	tonnes	*Various*
POP	Country population	persons	World Bank, IMF

WPC = MWG / POP

3.5 Climate Change

CDA: CO_2 intensity trend / Climate Change Mitigation / Climate Change

The *CO_2 growth rate* is calculated as the average annual rate of increase or decrease in raw carbon dioxide emissions over the years 2013–2022, and then adjusting for economic trends to isolate the effect of policy from that of economic fluctuations.

Units	proportion
Years	1999-2022
Source	Global Carbon Budget
Transformation	none

Performance	Nominal	Raw
Best	-0.13	-0.13
Worst	0.13	0.13

The best performance target is based on the global CO_2 emissions growth rate required for the world to reach the year near-zero emissions by 2050 without exceeding the remaining carbon budget for a 50% chance of limiting warming to 1.5 ºC (275 billion tonnes of CO_2 from the beginning of 2024).

The worst performance target is the absolute of the best performance target. As a result, scores above 50 falling emissions, and vice versa.

Calculations

Component		Units	Source
CDO	Emissions of CO_2	Gg	Global Carbon Budget
GDP	Gross Domestic Product	2017 $	World Bank & IMF
CDR	Correlation coefficient	—	
CDB	Emission growth rate	proportion	

First, we calculate Spearman's correlation coefficient between CO_2 emissions and GDP over a ten-year period,

$$\text{CDR} = \text{corr}(\text{CDO}, \text{GDP})$$

Second, we regress logged CO_2 emissions over ten years to find a slope,

$$\ln(\text{CDO}) = \alpha + \beta$$

Third, we calculate an unadjusted average annual growth rate in CO_2 emissions,

$$\text{CDB} = \exp(\beta) - 1$$

Fourth, we adjust the negative growth rates by a factor of 1 – the correlation coefficient,

$$\text{CDA} = \begin{cases} \text{CDB if CDB} \geq 0 \\ \text{CDB} \times (1 - \text{CDR}) \text{ if CDB} < 0 \end{cases}$$

CDF: CO_2 intensity trend with country-specific targets/ Climate Change Mitigation

The *CO_2 growth rate* is calculated exactly the same as in CDA: as the average annual rate of increase or decrease in raw carbon dioxide emissions over the years 2013–2022, and then adjusting for economic trends to isolate the effect of policy from that of economic fluctuations. However, instead of using a single "Best" and "Worst" performance target for every country, each country has specific targets. For each country, the "Best" target is the emissions growth rate at which the country could reach the year 2050 without exceeding its allocated share of the remaining carbon budget, while the "Worst" target is the growth rate at which the country would reach 2050 exceeding its allocated share of the budget by more than 10 times.

Units	unitless
Years	1999-2022
Source	Global Carbon Budget
Transformation	none

Performance	Nominal	Raw
Best	100	100
Worst	0	0

Calculations

We used an estimate of the CO_2 budget remaining after 2023 for a 50 percent chance of limiting warming to 1.5 ºC, a total of 275 Gt CO_2 (Friedlingstein et al. 2023). To allocate this global budget to different countries, we used the blended approach proposed by Raupach et al. (2014). This method combines two common methods of allocating the global carbon budget: (1) in proportion to countries' current emission levels (the "inertia" approach), and (2) in proportion to countries' current population size (the "equal-per-capita" approach). We give equal weight to each approach, so that the fraction of the budget allocated to country *i* (s_i) is:

$$s_i = 0.5 \times \frac{e_i}{E} + 0.5 \times \frac{p_i}{P}$$

where e_i are the annual CO_2 emissions of country *i*, *E* are the world's annual CO_2 emissions, p_i is the population of country *i*, and *P* is the global population.

CHA: Methane intensity trend / Climate Change Mitigation / Climate Change

The *CH_4 growth rate* is calculated as the average annual rate of increase or decrease in raw methane emissions over the years 2013–2022. It is then adjusted for economic trends to isolate change due to policy rather than economic fluctuation.

Units	proportion
Years	1999-2022
Source	PRIMAP-hist dataset
Transformation	none

Performance	Nominal	Raw
Best	-0.05	-0.05
Worst	0.05	0.05

The best performance target is based on the global methane emissions reduction rate needed to meet the Global Methane Pledge (reducing emissions 30% by 2030 relative to 2020 levels).

Calculations

Component		Units	Source
CH4	Emissions of CH_4	Gg	PRIMAP-hist dataset
GDP	Gross Domestic Product	2017$	World Bank & IMF
CHR	Correlation coefficient	—	
CHB	Emission growth rate	proportion	

First, we calculate Spearman's correlation coefficient between CH_4 emissions and GDP over a ten-year period,

$$\text{CHR} = \text{corr}(\text{CH4}, \text{GDP})$$

Second, we regress logged CH_4 emissions over ten years to find a slope,

$$\ln(\text{CH4}) = \alpha + \beta$$

Third, we calculate an unadjusted average annual growth rate in CH_4 emissions,

$$\text{CHB} = \exp(\beta) - 1$$

Fourth, we adjust the negative growth rates by a factor of 1 – the correlation coefficient,

$$\text{CHA} = \begin{cases} \text{CHB if CHB} \geq 0 \\ \text{CHB} \times (1 - \text{CHR}) \text{ if CHB} < 0 \end{cases}$$

FGA: F-gasses intensity trend / Climate Change Mitigation / Climate Change

The *F-gas growth rate* is calculated as the average annual rate of increase or decrease in raw fluorinated gas emissions over the years 2013–2022.

Units	proportion
Years	1999–2022
Source	PRIMAP-hist dataset
Transformation	none

Performance	Nominal	Raw
Best	-0.12	-0.12
Worst	0.12	0.12

Calculations

Component		Units	Source
FOG	Emissions of F-gases	Gg CO_2-eq.	PRIMAP-hist dataset
FGB	Emission growth rate	proportion	

First, we regress logged F-gas emissions over ten years to find a slope,

$$\ln(FOG) = \alpha + \beta$$

Second, we calculate an unadjusted average annual growth rate in F-gas emissions,

$$FGB = \exp(\beta) - 1$$

Third, because F-gas emissions are largely uncorrelated with GDP, we simply use the unadjusted average annual emission growth rate,

$$FGA = FGB$$

NDA: N2O intensity trend / Climate Change Mitigation / Climate Change

The *N_2O growth rate* is calculated as the average annual rate of increase or decrease in raw nitrous oxide emissions over the years 2013–2022, adjusted for economic trends to isolate change due to policy from changes due to economic fluctuation.

Units	proportion
Years	1999–2022
Source	PRIMAP-hist
Transformation	none

Performance	Nominal	Raw
Best	-0.05	-0.05
Worst	0.05	0.05

Calculations

Component		Units	Source
NOT	Emissions of N_2O	Gg	PRIMAP-hist
GDP	Gross Domestic Product	2017$	World Bank & IMF
NDR	Correlation coefficient	—	
NDB	Emission growth rate	proportion	

First, we calculate Spearman's correlation coefficient between N_2O emissions and GDP over a ten-year period,

$$\text{NDR} = \text{corr}(\text{NOT}, \text{GDP})$$

Second, we regress logged N_2O emissions over ten years to find a slope,

$$\ln(\text{NOT}) = \alpha + \beta$$

Third, we calculate an unadjusted average annual growth rate in N_2O emissions,

$$\text{NDB} = \exp(\beta) - 1$$

Fourth, we adjust the negative growth rates by a factor of 1 – the correlation coefficient,

$$\text{NDA} = \begin{cases} \text{NDB if NDB} \geq 0 \\ \text{NDB} \times (1 - \text{NDR}) \text{ if NDB} < 0 \end{cases}$$

BCA: Black Carbon intensity trend / Climate Change Mitigation / Climate Change

The *black carbon growth rate* is calculated as the average annual rate of increase or decrease in black carbon over the years 2013–2022. It is then adjusted for economic trends to isolate change due to policy rather than economic fluctuation.

Units	proportion
Years	1999-2022
Source	Community Emissions Data Systems
Transformation	none

Performance	Nominal	Raw
Best	-0.05	-0.05
Worst	0.05	0.05

Calculations

Component		Units	Source
BLC	Emissions black carbon	Gg	CEDS
GDP	Gross Domestic Product	2017$	World Bank & IMF
BCR	Correlation coefficient	—	
BCB	Emission growth rate	proportion	

First, we calculate Spearman's correlation coefficient between black carbon emissions and GDP over a ten-year period,

$$\text{BCR} = \text{corr}(\text{BLC}, \text{GDP})$$

Second, we regress logged black carbon emissions over ten years to find a slope,

$$\ln(\text{BLC}) = \alpha + \beta t$$

Third, we calculate an unadjusted average annual growth rate in black carbon emissions,

$$\text{BCB} = \exp(\beta) - 1$$

Fourth, we adjust the negative growth rates by a factor of 1 – the correlation coefficient,

$$\text{BCA} = \begin{cases} \text{BCB if BCB} \geq 0 \\ \text{BCB} \times (1 - \text{BCR}) \text{ if BCB} < 0 \end{cases}$$

GHN: Projected 2050 GHG Emissions / Climate Change Mitigation / Climate Change

The *projected GHG emissions in 2050* metric is calculated by extrapolating each country's emissions trajectory over the most recent 10 years of data to 2050. Countries projected to reach low emissions by or before 2050 receive top scores.

Units	Gg CO_2-eq.
Years	1999–2022
Source	Global Carbon Budget, PRIMAP-hist
Transformation	$\ln(x + \alpha)$ $\alpha = 1$

Performance	Nominal	Raw	Transformed
Best	0	0	0
Worst	95th percentile	1072273	13.88529

Calculations

Component		Units	Source
CDO	Emissions of CO_2	Gg	Global Carbon Budget
CH4	Emissions of CH_4	Gg	PRIMAP-hist
FOG	Emissions of F-gases	Gg CO_2-eq.	PRIMAP-hist
NOT	Emissions of N_2O	Gg	PRIMAP-hist
GHR	Correlation coefficient	—	
GHG	Emissions of GHG	Gg CO_2-eq.	
E50	Projected 2050 GHG Emissions	Gg CO_2-eq.	
t	Latest year of data		

First, we calculate total greenhouse gas emissions, applying Global Warming Potentials (GWP, AR6) to convert all units to Gg of CO_2-equivalents. N.B. that F-gas emissions are already provided as CO_2-eq. in the PRIMAP-hist dataset (based on AR4 GWP estimates).

$$GHG = CDO + FOG + 273 \times NOT + 27.2 \times CH4$$

Then, we calculate Spearman's correlation coefficient between total greenhouse gas emissions and GDP over a ten-year period,

$$GHR = \mathrm{corr}(GHG, GDP)$$

Next, we regress GHG emissions from over 10 years to find a slope,

$$GHG = \alpha + \beta$$

To avoid projecting emissions that have been declining due to economic recessions, we adjust the slopes as follows:

$$\beta' = \begin{cases} \beta \text{ if } \beta \leq 0 \text{ OR } GHR < 0 \\ \beta \times (1 - GHR) \text{ if } \beta < 0 \text{ OR } GHR \geq 0 \end{cases}$$

Using this adjusted slope, we then extrapolate emissions from the latest year's data out to 2050:

$$E50 = GHG_t + \beta'(2050 - t)$$

Country scores are based on logged projected emissions in 2050.

$$GHN = E50$$

CBP: Projected cumulative GHG emissions to 2050 relative to carbon budget

This indicator uses countries' emissions trajectory over the most recent 10 years of data to linearly extrapolate emissions to 2050, and compares the cumulative sum of projected emissions between 2023 and 2050 to countries' allocated share of the remaining carbon budget.

Units	unitless
Years	2022
Source	Global Carbon Budget, PRIMAP-hist
Transformation	None

Performance	Nominal	Raw
Best	1	1
Worst	10	10

Calculations

Component		Units	Source
CDO	Emissions of CO_2	Gg	Global Carbon Budget
CH4	Emissions of CH_4	Gg	PRIMAP-hist
FOG	Emissions of F-gases	Gg CO_2-eq.	PRIMAP-hist
NOT	Emissions of N_2O	Gg	PRIMAP-hist
GHR	Correlation coefficient	—	
GHG	Emissions of GHG	Gg CO_2-eq.	
E_t	Projected GHG Emissions in year t	Gg CO_2-eq.	
E_c	Cumulative projected emissions (2023 to 2050)	Gg CO_2-eq.	
t	Index for years		

First, we calculate total greenhouse gas emissions, applying Global Warming Potentials (GWP, AR6) to convert all units to Gg of CO_2-equivalents. N.B. that F-gas emissions are already provided as CO_2-eq. in the PRIMAP-hist dataset (based on AR4 GWP estimates).

$$\text{GHG} = \text{CDO} + \text{FOG} + 273 \times \text{NOT} + 27.2 \times \text{CH4}$$

Then, we calculate Spearman's correlation coefficient between total greenhouse gas emissions and GDP over a ten-year period,

$$\text{GHR} = \text{corr}(\text{GHG}, \text{GDP})$$

Next, we regress GHG emissions from over 10 years to find a slope,

$$\text{GHG} = \alpha + \beta$$

To avoid projecting emissions that have been declining due to economic recessions, we adjust the slopes as follows:

$$\beta' = \begin{cases} \beta \text{ if } \beta \leq 0 \text{ OR GHR} < 0 \\ \beta \times (1 - \text{GHR}) \text{ if } \beta < 0 \text{ OR GHR} \geq 0 \end{cases}$$

Using this adjusted slope, we then extrapolate emissions from the latest year's (2022) to each year t between 2023 and 2050:

$$E_t = \text{GHG}_{2022} + \beta'(t - 2022)$$

Next, we calculate the cumulative sum of projected emissions between 2023 and 2050:

$$E_c = \sum_{t=2023}^{2050} E_t$$

Finally, we divide each country's cumulative projected emissions (E_c) by its allocated share of the remaining carbon budget. We used an estimate for the remaining carbon budget for a 50% likelihood of limiting warming to 1.5 ºC of 275 Gt CO_2 from the beginning of 2024 based on Friedlingstein et al. (2023). Since our emissions data only span up to 2022, we assumed that emissions in 2023 were the same as in 2022 (50.42 Gt CO_2-eq.) and added this to the 275 Gt of CO_2 budget to get the remaining budget *from the beginning of 2023* (325.42 Gt CO_2-eq.).

To allocate this global budget to each country, we follow Raupach et al.'s (2014) blended approach considering both countries' shares of the global population and of global emissions. For simplicity, we only consider countries' shares of population and GHG emissions in 2022, the latest year of data available. The fair share of the remaining carbon budget of country i (F_i) was determined by the equation.

$$F_i = 0.5 \times \left(\frac{p_i}{P}\right) + 0.5 \times \left(\frac{e_i}{E}\right)$$

where p_i is the population of country i, P is the global population, e_i are the GHG emissions of country i, and E are global GHG emissions; all in year 2022.

Countries' scores in the CBP indicator are based on the ratio of countries' cumulative emissions to their fair share of the remaining carbon budget:

$$\text{CBP}_i = \frac{E_{c,i}}{F_i \times 325.42}$$

References

Friedlingstein et al. 2023. Global Carbon Budget 2023. Earth System Science Data **15**, 5301 – 5369. https://doi.org/10.5194/essd-15-5301-2023

Raupach et al. 2014. Sharing a quota on cumulative carbon emissions. *Nature Climate Change* **4, 873 – 879**. https://doi.org/10.1038/nclimate2384

GHP: GHG trend adjusted by per capita emissions / Climate Change Mitigation

We calculate annual *greenhouse gas (GHG) emissions per capita* for each country.

Units	Gg CO_2-eq. / person
Years	1999–2022
Source	Global Carbon Budget; PRIMAP-hist
Transformation	$\ln(x + \alpha)$ $\alpha = 0.0009$

Performance	Nominal	Raw	Transformed
Best	0	0	-7.013116
Worst	99th percentile	0.07059108	-2.638183

Calculations

Component		Units	Source
CDO	Emissions of CO_2	Gg	Global Carbon Budget
CH4	Emissions of CH_4	Gg	PRIMAP-hist
FOG	Emissions of F-gases	Gg CO_2-eq.	PRIMAP-hist
NOT	Emissions of N_2O	Gg	PRIMAP-hist
POP	Population	persons	World Bank & IMF
GHG	Emissions of GHG	Gg CO_2-eq.	

First, we calculate total greenhouse gas emissions, applying Global Warming Potentials (GWP, AR6) to convert all units to Gg of CO_2-equivalents. N.B. that F-gas emissions are already provided as CO_2-eq. in the PRIMAP-hist dataset (based on AR4 GWP estimates).

$$GHG = CDO + FOG + 273 \times NOT + 27.2 \times CH4$$

Second, we calculate GHG emissions per capita (GHP) as the GHG emissions divided by population (POP).

$$GHP = GHG \div POP$$

GHI: GHG emission intensity / Climate Change Mitigation / Climate Change

The *greenhouse gas (GHG) intensity growth rate* indicator is the ratio of a country's annual GHG emissions to its GDP. As such, this metric can help track the decoupling of emissions from economic growth.

Units	Gg CO_2-eq. / $
Years	1999–2022
Source	Global Carbon Budget; PRIMAP-hist
Transformation	$\ln(x + \alpha)$ $\alpha = 0.0000001$

Performance	Nominal	Raw	Transformed
Best	0	0	-7.013116
Worst	99th percentile	0.07059108	-2.638183

Calculations

Component		Units	Source
CDO	Emissions of CO_2	Gg	Global Carbon Budget
CH4	Emissions of CH_4	Gg	PRIMAP-hist
FOG	Emissions of F-gases	Gg CO_2-eq.	PRIMAP-hist
NOT	Emissions of N_2O	Gg	PRIMAP-hist
GDP	GDP	2017$, PPP	World Bank & IMF
GHI	GHG Intensity	Gg CO_2-eq./$	

First, we calculate total greenhouse gas emissions, applying Global Warming Potentials (GWP, AR6) to convert all units to Gg of CO_2-equivalents. N.B. that F-gas emissions are already provided as CO_2-eq. in the PRIMAP-hist dataset (based on AR4 GWP estimates).

$$\text{GHG} = \text{CDO} + \text{FOG} + 273 \times \text{NOT} + 27.2 \times \text{CH4}$$

Second, we calculate the GHI, which is the quotient of GHG and GDP,

$$\text{GHI} = \frac{\text{GHG}}{\text{GDP}}$$

GHA: GHG emission intensity / Climate Change Mitigation / Climate Change

The *greenhouse gas (GHG) intensity growth rate* indicator is the ratio of a country's annual GHG emissions to its GDP. As such, this metric can help track the decoupling of emissions from economic growth.

Units	proportion
Years	1999–2022
Source	Global Carbon Budget; PRIMAP-hist
Transformation	none

Performance	Nominal	Raw
Best	-0.1	-0.1
Worst	0.1	0.1

Calculations

Component		Units	Source
CDO	Emissions of CO_2	Gg	Global Carbon Budget
CH4	Emissions of CH_4	Gg	PRIMAP-hist
FOG	Emissions of F-gases	Gg CO_2-eq.	PRIMAP-hist
NOT	Emissions of N_2O	Gg	PRIMAP-hist
GDP	GDP	2017$, PPP	World Bank & IMF
GHG	GHG emissions	Gg CO_2-eq./$	
GHR	Correlation coefficient	—	
GHB	Emission growth rate	proportion	

First, we calculate total greenhouse gas emissions, applying Global Warming Potentials (GWP, AR6) to convert all units to Gg of CO_2-equivalents. N.B. that F-gas emissions are already provided as CO_2-eq. in the PRIMAP-hist dataset (based on AR4 GWP estimates).

$$GHG = CDO + FOG + 273 \times NOT + 27.2 \times CH4$$

Then, we calculate Spearman's correlation coefficient between total greenhouse gas emissions and GDP over a ten-year period,

$$GHR = corr(GHG, GDP)$$

Next, we regress GHG emissions from over 10 years to find a slope,

$$GHB = \alpha + \beta$$

Finally, we adjust the negative growth rates by a factor of 1 – the correlation coefficient,

$$GHA = \begin{cases} GHB \text{ if } GHB \geq 0 \\ GHB \times (1 - GHR) \text{ if } GHB < 0 \end{cases}$$

GTP: GHG trend adjusted by emissions per capita / Climate Change Mitigation

The indicator of *greenhouse gas (GHG) emissions trend adjusted by per capita emissions* recognizes that countries with high emissions per capita most urgently need to rapidly decarbonize, while the rate of decarbonization is likely to slow down as countries approach net-zero.

Units	unitless
Years	1999–2022
Source	Global Carbon Budget; PRIMAP-hist
Transformation	none

Performance	Nominal	Raw
Best	100	100
Worst	0	0

Calculations

Component		Units	Source
GHP	GHG emissions per capita	unitless	
GHA	GHG emissions adjusted trend	unitless	

Having calculated the *adjusted trend of GHG emissions* indicator (GHA), as described in the previous section, we used countries' scores on the *per capita GHG emissions* indicator (GHP) to adjust GHA scores according to the following logic:

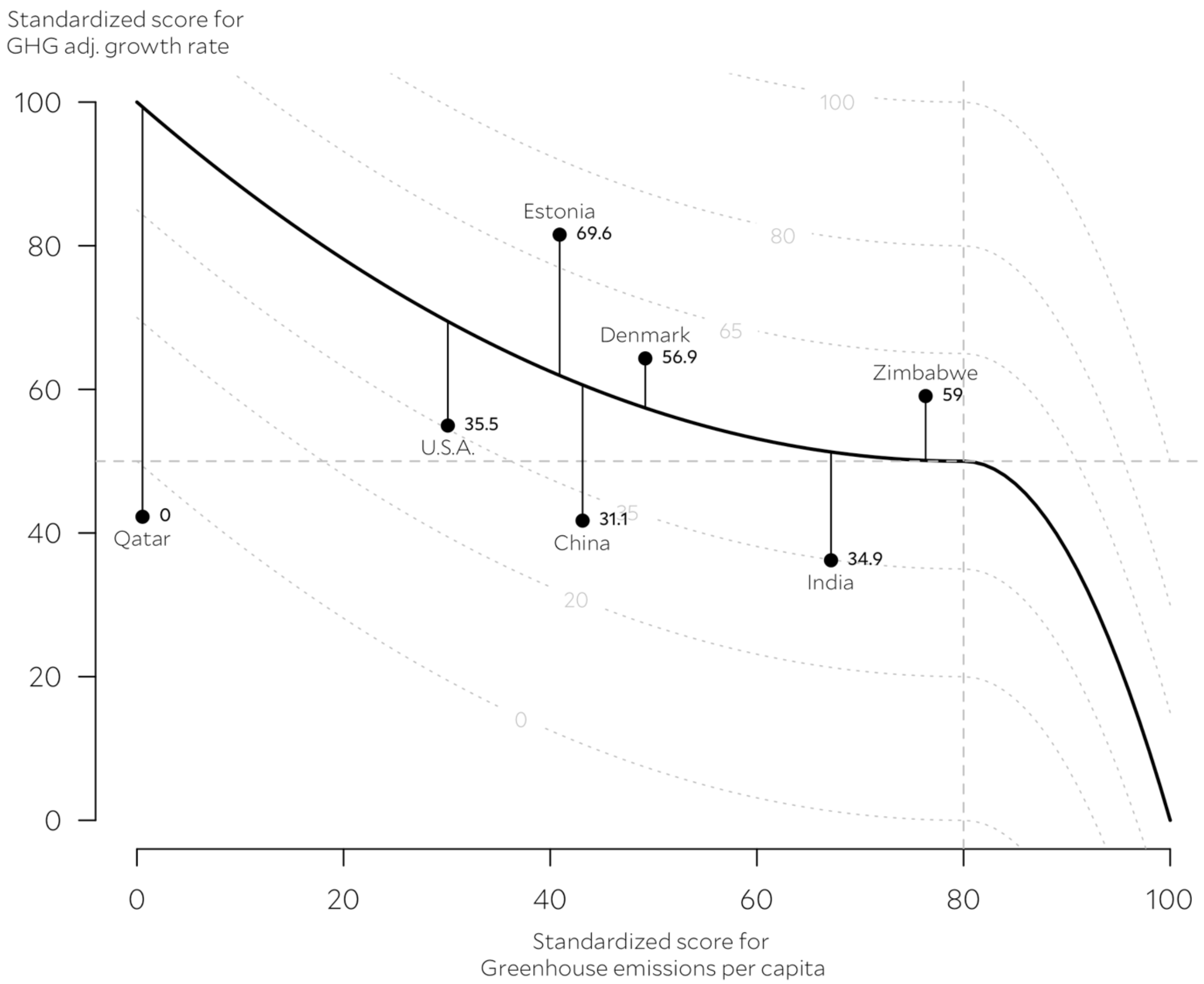
1. If GHP_c score = 100 (per capita GHG emissions in country *c* are equal to zero or *net*-zero), country *c* should get a perfect GTP score even if its GHG emission trend is neutral (GHA score = 50).

2. If GHP_c score = 0 (per capita GHG emissions in country *c* are among the highest in the world), country *c* should *not* get a perfect score no matter its recent GHG trend (i.e., even if GHA score = 100). In fact, we (arbitrarily) determined that countries with the highest *per capita* emission levels (GHP score = 0), even when their emissions were falling the fastest (GHA = 100), could get a maximum GTP score of 50, which would be equivalent to a country with a flat emission trajectory (GHA = 50), but low absolute levels of *per capita* emissions (GHP = 80), and to a country with emissions rapidly rising (GHA = 0) from a very low level *per capita* emissions (GHP = 100).

3. Based on (1) and (2), we defined GHP as:

$$GTP = \begin{cases} 50 + \left(GHA + \left(\frac{(GHP - 80)}{100}\right)^2 \div 0.04\right) & \text{if } GHP \geq 80 \\ 50 + \left(GHA - \left(\frac{(80 - GHP)}{80}\right)^2 \div 0.04\right) & \text{if } GHP < 80 \end{cases}$$

GTP can also be defined as the vertical distance from the curve below. Countries falling anywhere along the solid black line get a GTP score of 50. The dotted gray lines show the combination of GHA and GHP scores that result in a given value of GTP (0, 20, 45, 65, 80, and 100). For example, both the U.S.A. and India get a GTP score of nearly 35. The United States of America has slowly falling emissions (GHA > 50) but high emissions per capita (GHP < 40). In contrast, India has rising GHG emissions (GHA < 50) but emissions per capita mucho lower than in the U.S.A. (GHP > 60).



GTI: GHG trend adjusted by emissions intensity / Climate Change Mitigation

The indicator of *greenhouse gas (GHG) emissions trend adjusted by emissions intensity* recognizes that countries with high emissions intensity of GDP most urgently need to rapidly decarbonize, while the rate of decarbonization is likely to slow down as countries approach net-zero.

Units	unitless
Years	1999–2022
Source	Global Carbon Budget; PRIMAP-hist
Transformation	none

Performance	Nominal	Raw
Best	100	100
Worst	0	0

Calculations

Component		Units	Source
GHI	GHG emissions intensity	unitless	
GHA	GHG emissions adjusted trend	unitless	

Having calculated the *adjusted trend of GHG emissions* indicator (GHA), we used countries' scores on *GHG emissions intensity* (GHI) to adjust GHA scores according to the following logic:

1. If GHI_c score = 100 (GHG emissions in country *c* are equal to zero or *net*-zero), country *c* should get a perfect GTI score even if its GHG emission trend is neutral (GHA score = 50).

2. If GHI_c score = 0 (GHG emissions intensity in country *c* is among the highest in the world), country *c* should *not* get a perfect score no matter its recent GHG trend (i.e., even if GHA score = 100). In fact, we (arbitrarily) determined that countries with the highest emission intensity levels (GHI score = 0), even when their emissions were falling the fastest (GHA = 100), could get a maximum GTI score of 50, which would be equivalent to a country with a flat emission trajectory (GHA = 50), but low emissions intensity (GHI = 80), and to a country with emissions rapidly rising (GHA = 0) from a very low level (GHI = 100).

3. Based on (1) and (2), we defined GHP as:

$$GTI = \begin{cases} 50 + \left(GHA + \left(\frac{(GHI - 80)}{100}\right)^2 \div 0.04\right) & \text{if } GHI \geq 80 \\ 50 + \left(GHA - \left(\frac{(80 - GHI)}{80}\right)^2 \div 0.04\right) & \text{if } GHI < 80 \end{cases}$$

LFU: Net carbon fluxes from land cover change / Climate Change Mitigation

This indicator quantifies the *net* carbon fluxes (the sum of both carbon emissions and sinks) from land use, land cover change, and forestry (LULCF) over the last decade, normalized by countries' forested area in 2000.

Units	Gg CO_2 per hectare of forested land
Years	1999–2022
Source	Global Carbon Budget; Global Forest Watch
Transformation	none

Performance	Nominal	Raw
Best	-0.5	-0.5
Worst	0.5	0.5

Calculations

Abbreviation	Description	Units	Source
LUE	Net carbon fluxes from LULCF	Gg CO_2	Global Carbon Budget
TCA	Forest (30 % canopy cover) area in 2000	ha	Global Forest Watch
L10	Cumulative carbon fluxes over the last decade	Gg CO_2	
t	An index for years		

First, we calculate L10 as the sum of the last 10 years of net carbon fluxes from LULCF in a country,

$$L10 = \sum_{i=0}^{9} LUE_{t-i}$$

Next, we divide L10 by the area of forest in the country in 2000:

$$LFU = \frac{L10}{TCA}$$

3.6 Biodiversity & Habitat

TBN: Terrestrial Biome Protection / Biodiversity / Ecosystem Vitality
We measure the percentage of the area of each of a country's biome types that are covered by protected areas. The indicator is based on the weighted sum of the protection percentages for all biomes within a country. Protection percentages are weighted according to the prevalence of each biome type within the country. This indicator evaluates a country's efforts to achieve 30% protection for all biomes within its borders, as per target 3 of the Kunming-Montreal Global Biodiversity Framework ("30x30" target).

Units	%
Years	1990–2024
Source	World Database on Protected Areas
Transformation	none

Performance	Nominal	Raw
Best	30.0	30.0
Worst	0.0	0.0

Calculations

Component		Units	Source
TEW	Area of biomes	sq. km	World Wide Fund for Nature
TPA	Area of TPAs	sq. km	World Database of Protected Areas
PCT	Raw % of biome within TPA		
ICT	Credited % of biome within TPA		
w	Weight of ICT in indicator construction		
i	An index of all TPAs in a country		
b	An index of biomes		
c	An index of countries		

First, the percent of each biome present in a country that lies within a protected area is given by,

$$PCT_{bc} = \sum_i TPA_{ibc} / TEW_{bc}$$

Second, the credit given to a country for protecting any given biome is capped at 30%,

$$ICT_{bc} = \begin{cases} PCT_{bc} \text{ if} PCT_{bc} \leq 0.30 \\ 0.17 \text{ if } PCT_{bc} > 0.30 \end{cases}$$

Third, the national weight placed on each biome is calculated by the proportion of that biome for the entire country,

$$w_{bc} = {TEW_{bc}} / {\sum_b TEW_{bc}}$$

Fourth, the metric is calculated as the weighted sum of percent protection for all biomes in a country.

$$TBN_c = \sum_b [w_{bc} \times ICT_{bc}] \times 100$$

TKP: Terrestrial KBA Protection / Biodiversity / Ecosystem Vitality

Experts around the world have identified locations of disproportionate importance for biodiversity conservation, called Key Biodiversity Areas (KBAs). This indicator measures the percentage of the total area of terrestrial KBAs in a country that is covered by protected areas.

Units	%
Years	2010–2024
Source	WDPA, WDKBA
Transformation	none

Performance	Nominal	Raw
Best	100.0	100.0
Worst	0.0	0.0

Calculations

Component		Units	Source
KBA	Area of terrestrial KBAs	sq. km	World Database of Key Biodiversity Areas
TPA	Area of terrestrial protected areas	sq. km	World Database of Protected Areas
KPA	Total area that is protected and within a KBA		
i	An index of all TPAs in a country		
b	An index of KBAs in a country		
c	An index of countries		

First, we merged and rasterized all protected area and KBA polygons to avoid double counting areas that are recorded under different types of protected areas in the WDPA. Next, we looked at the intersection (or overlap) between the rasterized KBA and protected area (TPA) polygons:

$$KPA_c = KBA_c \cap TPA_c$$

That is, KPA represents the pixels that are under protection and within a KBA. The indicator TKP measures the ratio between the total area of KPA and the area of KBA.

$$TKP_c = \frac{KPA_c}{KBA_c} \times 100$$

PAR: Protected Areas Representativeness Index / Biodiversity & Habitat / Ecosystem Vitality

The *Protected Areas Representativeness Index* measures how well protected areas represent the full range of environmental conditions and biological diversity within a country or territory. The metric relies on remote sensing, biodiversity informatics, and global modeling of fine-scaled variation in biodiversity composition for plant, vertebrate, and invertebrate species.

Units	unitless
Years	2024
Source	Commonwealth Scientific and Industrial Research Organization
Transformation	none

Performance	Nominal	Raw
Best	95th percentile	0.27
Worst	5th percentile	0.05

SPI: Species Protection Index / Biodiversity & Habitat / Ecosystem Vitality

Species Protection Index (SPI) evaluates the species-level ecological representativeness of each country's protected area network. The *SPI* metric uses remote sensing data, global biodiversity informatics, and integrative models to map suitable habitat for over 30,000 terrestrial vertebrate, invertebrate, and plant species at high resolutions. Data for this indicator come from the Map of Life.

Units	%
Years	1980–2024
Source	Map of Life
Transformation	none

Performance	Nominal	Raw
Best	100.0	100.0
Worst	0.0	0.0

PHL: Land consumption in protected areas / Biodiversity & Habitat / Ecosystem Vitality

This pilot indicator measures the percentage of the total area under protection in a country that was cropland and buildings in 2022.

Units	%
Years	2022
Source	WDPA, DynamicWorld v1
Transformation	none

Performance	Nominal	Raw
Best	100.0	100.0
Worst	5^{th} percentile	82.4

We used Google Earth Engine for the land use / land cover change (LULC) analysis. This online platform for spatial analysis allows easy access to the two key datasets used in the analysis: country's protected area spatial polygons from the World Database of Protected Areas and a high-resolution land cover and land use classification from DynamicWorld. Based on AI-driven classification of Sentinel-2 satellite imagery, Dynamic World provides a 10-m resolution LULC classification in near real time for the entire world. For each 10-m pixel, Dynamic World calculates the probability of nine LULC classes:

LULC Class	Description
Water	Permanent and seasonal water bodies
Trees	Primary and secondary forests, as well as large-scale plantations
Grass	Natural grasslands, livestock pastures, and parks
Flooded vegetation	Mangroves and other inundated ecosystems
Crops	Include row crops and paddy crops
Shrub & Scrub	Sparse to dense open vegetation consisting of shrubs
Built Area	Low- and high-density buildings, roads, and urban open space
Bare ground	Deserts and exposed rock
Snow & Ice	Permanent and seasonal snow cover

In Google Earth Engine, for each large (>100 km^2) protected area, we accessed Dynamic World imagery from 2017 and 2022. We created annual mode-composite images by using the most frequent class for each pixel across the year's images. Next, we calculate the percentage of the pixels in the protected area classified as crops and as built area.

As a proxy for the quality and conservation value of a country's protected areas, the pilot indicator measures the percentage of all area under protection in the country classified as crops and built area in 2022. This indicator helps identify countries where an important fraction of the area counted toward targets of the Global Biodiversity Framework may be of relatively low conservation value.

PAE: Protected area effectiveness / Biodiversity & Habitat / Ecosystem Vitality

This pilot indicator measures the percentage of protected areas in a country considered "effective". A protected area is *not* effective if the more than 0.25% of its territory was converted to cropland and built environment from 2017 to 2022.

Units	%
Years	2022
Source	WDPA, DynamicWorld v1
Transformation	none

Performance	Nominal	Raw
Best	100.0	100.0
Worst	5th percentile	30.3

We used Google Earth Engine for the land use / land cover change (LULC) analysis. This online platform for spatial analysis allows easy access to the two key datasets used in the analysis: country's protected area spatial polygons from the World Database of Protected Areas and a high-resolution land cover and land use classification from DynamicWorld. Based on AI-driven classification of Sentinel-2 satellite imagery, Dynamic World provides a 10-m resolution LULC classification in near real time for the entire world. For each 10-m pixel, Dynamic World calculates the probability of nine LULC classes:

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Built Area	Low- and high-density buildings, roads, and urban open space
Bare ground	Deserts and exposed rock
Snow & Ice	Permanent and seasonal snow cover

In Google Earth Engine, for each large (>100 km^2) protected area, we accessed Dynamic World imagery from 2017 and 2022. We created annual mode-composite images by using the most frequent class for each pixel across the year's images. Next, we calculate the percentage of the pixels in the protected area classified as crops and as built area.

As a proxy for the effectiveness of protected areas in a country, the pilot indicator measures the percentage of protected areas in the country where less than 0.25% of the protected area's pixels shifted to crops and built area from 2017 to 2022.

SHI: Species Habitat Index / Biodiversity & Habitat / Ecosystem Vitality

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 *SHI* indicator measures the proportion of suitable habitat within a country that remains intact for each species in that country relative to a baseline set in the year 2001.

Units	%
Years	2001–2022
Source	Map of Life
Transformation	none

Performance	Nominal	Raw
Best	100.0	100.0
Worst	5th percentile	96.6

RLI: Red List Index / Biodiversity & Habitat / Ecosystem Vitality

The *Red List Index* (RLI) tracks the overall extinction risk for species in a country, weighting species by the fraction of their range occurring within the country or region. A score of 100 indicates that none of the evaluated species in the country is threatened, while a score of 0 indicates a very high average extinction risk (⩽5th-percentile of RLI values)

Units	%
Years	2000–2024
Source	IUCN
Transformation	none

Performance	Nominal	Raw
Best	1.00	1.00
Worst	5th percentile	0.69

BER: Bioclimatic Ecosystem Resilience Index / Biodiversity & Habitat

The *Bioclimatic Ecosystem Resilience Index* (BERI) measures the capacity of natural ecosystems to retain species diversity in the face of climate change, as a function of ecosystem area, connectivity and integrity. This metric is calculated by CSIRO based on land use maps and species occurrence data.

Units	unitless
Years	2000, 2005, 2010, 2015, 2020
Source	Commonwealth Scientific and Industrial Research Organization
Transformation	none

Performance	Nominal	Raw
Best	95^{th} percentile	0.5436
Worst	5^{th} percentile	0.1054

MKP: Marine KBA Protection / Biodiversity / Ecosystem Vitality

Experts around the world have identified locations of disproportionate importance for biodiversity conservation, called Key Biodiversity Areas (KBAs). This indicator measures the percentage of the total area of KBAs in a country's Exclusive Economic Zone(s) that is covered by marine protected areas.

Units	%
Years	2010–2024
Source	WDPA, WDKBA
Transformation	none

Performance	Nominal	Raw
Best	100.0	100.0
Worst	0.0	0.0

Calculations

Component		Units	Source
KBA	Area of marine KBAs	sq. km	World Database of Key Biodiversity Areas
MPA	Area of marine protected areas	sq. km	World Database of Protected Areas
KPA	Total area that is protected *and* within a marine KBA		
i	An index of all MPAs in a country		
b	An index of marine KBAs in a country		
c	An index of countries		

First, we merged and rasterized all marine protected area and marine KBA polygons to avoid double counting areas that are recorded under different types of protected areas in the WDPA. Next, we looked at the intersection (or overlap) between the rasterized KBA and marine protected area (TPA) polygons:

$$KPA_c = KBA_c \cap TPA_c$$

That is, KPA represents the pixels that are under protection and within a KBA. The indicator MKP measures the ratio between the total area of KPA and the area of KBA.

$$MKP_c = \frac{KPA_c}{KBA_c} \times 100$$

MHP: Marine Habitat Protection / Biodiversity / Ecosystem Vitality

This indicator measures the percentage of the area of important marine and coastal habitats under official protection within a country's Exclusive Economic Zone(s). Important habitats, with a disproportionate contribution to sustaining marine biodiversity and providing ecosystem services, include mangroves, sea grass meadows, salt marshes, coral reefs, cold-water corals, seamounts, and knolls.

Units	%
Years	2010–2024
Source	WDPA, UNEP-WCMC
Transformation	none

Performance	Nominal	Raw
Best	100.0	100.0
Worst	0.0	0.0

Calculations

Component		Units	Source
MPA	Area of marine protected areas	sq. km	World Database of Protected Areas
SGR	Global distribution of sea grasses	-	UNEP-WCMC
SLT	Global distribution of salt marshes	-	UNEP-WCMC
MAN	Global distribution of mangroves	-	Global Mangrove Watch
KNS	Global distribution of knolls and seamounts	-	UNEP-WCMC
COW	Global distribution of coral reefs	-	UNEP-WCMC
CCO	Global distribution of cold-water corals	-	UNEP-WCMC

As with the marine KBA protection indicator, we started by merging and rasterizing all marine protected areas. Some protected areas in the WDPA are available only as points. For such MPAs, we created circular polygons with an area equal to the area reported in the WDPA, centered at the point's coordinates. Similarly, we merged and rasterized the polygons of each of the six types of important marine and coastal habitats.

Next, for each habitat type, we intersected the habitat raster with the MPA raster to obtain a raster representing the area of a particular habitat *within* MPAs in each area of interest (i.e., the union of a country's land and its EEZ to ensure that coastlines did not clip the extent of coastal habitats like mangroves and saltmarshes).

For each habitat, we then calculated the percentage of habitat pixels falling within MPAs in each country. Our MHP indicator is a simple average of the percentage of protection of the six habitats types, and is exactly the same as the *Local Proportion of Habitats Protected Index* developed by Kumagai et al. (2022). We refer the interested reader to Kumagai et al.'s (2022) paper for further methodological details.

MPE: Marine Protection Effectiveness / Biodiversity / Ecosystem Vitality

This indicator serves as a proxy for the effectiveness or stringency of countries' marine protection by measuring annual industrial fishing effort intensity (fishing hours per km^2) within marine protected areas relative to country's entire Exclusive Economic Zone(s).

Units	unitless
Years	2012–2020
Source	WDPA, Global Fishing Watch
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	0.01	0.01	-4.60517
Worst	100	100	4.60517

Calculations

Component		Units	Source
MPA	Area of marine protected areas	sq. km	World Database of Protected Areas
EEZ	Area of Exclusive Economic Zone(s)		
GFE	Global fishing effort	hours per day	Global Fishing Watch
AFE	Annual fishing effort	hours per year	
AFI	Annual fishing intensity	hours per km^2 per year	
d	An index of days in each year		

We started by processing CSV files of daily fishing effort downloaded from Global Fishing Watch. For each year from 2012 to 2020, we added daily fishing effort values at each location (0.01º grid cells). In calculating these sums, we excluded fishing effort with gear types "pole_and_line" and "pots_and_traps", as the ecological impact of one hour of fishing with these smaller scale gears is not comparable to one hour fishing with other industrial-scale gears.

$$AFE = \sum_{d=1}^{365\ (\text{or } 366)} GFE_d$$

Next, for each country and year, we computed the total fishing effort intensity (fishing hours per km^2) within marine protected areas (MPAs) as well as across the country's entire EEZ(s).

$$AFI_{MPA,\,c} = \frac{AFE_{MPA,\,c}}{MPA_c}$$

$$AFI_{EEZ,\,c} = \frac{AFE_{EEZ,\,c}}{EEZ_c}$$

The ratio of fishing intensity within MPAs to fishing intensity across the entire EEZ (including both protected and unprotected regions) yields the raw values of the Marine Protection Effectiveness indicator. When calculating this ratio, we added a constant value of 0.00001 to both the numerator and denominator to deal with cases where fishing intensity across the EEZ(s) was zero.

$$MPE = \frac{AFI_{MPA} + 0.00001}{AFI_{EEZ} + 0.00001}$$

3.7 Forests

PFL: Primary Forest Loss / Forests / Ecosystem Vitality

Humid tropical primary forests are the most biodiverse terrestrial ecosystems on the planet and provide irreplaceable ecosystem services. We quantify losses of primary forest by constructing a five-year moving average of the proportion of primary forest lost relative to their extent in 2001. We define a forest as areas with over 30% canopy cover.

Units	proportion
Years	2006–2022
Source	Global Forest Watch
Transformation	$\ln(x + \alpha)$ $\alpha = 0.001$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-6.907755
Worst	99th percentile	0.04838875	-3.008033

Calculations

Component		Units	Source
PFA	Area of primary forest in 2001 (30% canopy cover)	ha	Global Forest Watch
PFC	Annual cover loss of primary forest from 2002 to 2022	ha	Global Forest Watch
PF5	Sum of last 5 years of loss	ha	Global Forest Watch
t	An index of years		

First, we calculated PF5 by adding the last 5 years of primary forest loss for each country,

$$PF5 = \sum_{i=0}^{4} PFC_{t-i}$$

Next, we calculate PFL by dividing PF5 by five times the area of primary forest in the reference year of 2001 (PFA),

$$PFL = \frac{PF5}{5 \times PFA}$$

IFL: Primary Forest Loss / Forests / Ecosystem Vitality

Intact forest landscapes are large expanses of forest and treeless ecosystems that play a disproportionate role providing habitat for biodiversity and storing carbon. We quantify losses of these highly valuable landscapes by constructing a five-year moving average of the proportion of intact forest landscape lost relative to their extent in the year 2000. We define a forest as areas with over 30% canopy cover.

Units	proportion
Years	2005–2022
Source	Global Forest Watch
Transformation	$\ln(x + \alpha)$ $\alpha = 0.0001$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-9.21034
Worst	99th percentile	0.01909019	-3.953356

Calculations

Component		Units	Source
IFA	Area of intact forest landscape in 2000 (30% canopy cover)	ha	Global Forest Watch
IFC	Annual cover loss of intact forest landscape from 2001 to 2022	ha	Global Forest Watch
IF5	Sum of last 5 years of loss	ha	Global Forest Watch
t	An index of years		

First, we calculated IF5 by adding the last 5 years of intact forest landscape loss for each country,

$$IF5 = \sum_{i=0}^{4} IFC_{t-i}$$

Next, we calculated IFL by dividing IF5 by five times the area of intact forest landscape in the reference year of 2000 (IFA),

$$IFL = \frac{IF5}{5 \times IFA}$$

FCL: Tree Cover Loss weighted by permanency / Forests / Ecosystem Vitality

Different drivers of deforestation have different ecological consequences. This indicator measures forest losses weighted by the likely permanency of loss given the dominant driver of deforestation in different regions. As with other forest loss indicators in this issue category, we first measure by constructing a five-year moving average of the proportion forest lost relative to the total forest extent in the year 2000. We define a forest as areas with over 30% canopy cover.

Units	proportion
Years	2005–2022
Source	Global Forest Watch
Transformation	$\ln(x + \alpha)$ $\alpha = 0.001$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-6.907755
Worst	99th percentile	0.01689057	-4.023481

Calculations

Component		Units	Source
TCA	Forest area in year 2000 (30% canopy cover)	ha	Global Forest Watch
TCC	Annual forest loss	ha	Global Forest Watch
TC5	Sum of last 5 years of forest loss	ha	
TCL	Average forest loss over last 5 years	proportion	
FLD	Forest loss by dominant driver	ha	Global Forest Watch
t	An index of years		

First, we calculated TC5 by adding the last 5 years of forest loss for each country,

$$TC5 = \sum_{i=0}^{4} IFC_{t-i}$$

Next, we calculated TCL by dividing TC5 by five times the area of forest in the reference year of 2000 (TCA),

$$TCL = \frac{TC5}{5 \times TCA}$$

Then, based on the fraction of forest loss each year in areas with different dominant drivers of deforestation (FLD), we calculated an average weight – or adjusting factor – to multiply average values of forest loss (TCL). Specifically, we used the values in the table below to adjust forest loss in areas with different dominant deforestation drivers:

Driver	**Weight**
Commodity-driven deforestation	1.00
Urbanization	1.00
Shifting agriculture	0.75
Forestry	0.50
Wildfire	0.25
Unknown	1.00

While these weights were selected arbitrarily, they are meant to correspond to the likely permanency of forest loss due to different drivers, as well as the degree of policy control over different drivers.

$$\bar{w} = \left(1 \times \frac{FLD_{Commodity}}{TCC}\right) + \left(1 \times \frac{FLD_{Urbanization}}{TCC}\right) + \left(0.75 \times \frac{FLD_{Shift.\ Ag.}}{TCC}\right) + \left(0.5 \times \frac{FLD_{Forestry}}{TCC}\right) + \left(0.25 \times \frac{FLD_{Fire}}{TCC}\right) + \left(1 \times \frac{FLD_{Unknown}}{TCC}\right)$$

Finally, we multiplied average forest loss values over the last 5 years by the average adjustment weight to obtain the FCL indicator:

$$FCL = TCL \times \bar{w}$$

TCG: Net forest cover gain / Forests / Ecosystem Vitality

This indicator measures the net change in forest cover from 2000 to 2020. In contrast to the forest loss indicators in this issue category, the underlying forest cover data is defined based on tree height data instead of tree canopy data.

Units	percentage
Years	2020
Source	Global Forest Watch
Transformation	none

Performance	Nominal	Raw
Best	10	10
Worst	-10	-10

Calculations

Component		Units	Source
TCH	Components of tree cover change from height (stable forest, loss, gain, disturbed, and net change)	ha	Global Forest Watch

We calculated the net change in forest cover between 2000 and 2020 (TCG) by dividing the net change in cover by the original forest cover in 2000, given by the sum of the area of stable forest, disturbed forest, and forest losses:

$$TCG = \frac{TCH_{net\ change}}{TCH_{stable} + TCH_{disturbed} + TCH_{loss}} \times 100$$

FLI: Forest Landscape Integrity / Forests / Ecosystem Vitality

Going beyond measuring changes in tree cover, this indicator estimates the integrity of forest landscapes based on observed and inferred human disturbances and losses of forest connectivity. Country scores represent the average forest integrity index value across the country's territory multiplied by 100.

Units	percentage
Years	2020
Source	Grantham et al. 2020. Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. *Nature Communications* 11: 5978 https://doi.org/10.1038/s41467-020-19493-3
Transformation	none

Performance	**Nominal**	**Raw**
Best	100	100
Worst	0	0

3.8 Fisheries

FSS: Fish Stock Status / Fisheries / Ecosystem Vitality

Fish stock status evaluates the percentage of the total catch that comes from collapsed stocks, considering all fish stocks within a country's EEZs. Because continued and increased stock exploitation leads to smaller catches, this indicator sheds light on the impact of a country's fishing practices.

Units	percentage
Years	1950–2019
Source	Sea Around Us
Transformation	$\ln(x + \alpha)$ $\alpha = 0.1$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-2.302585
Worst	99th percentile	17.39273	2.861785

Calculations

Component		Units	Source
FSC	Fish stock class	%	Sea Around Us
CTH	Catch	tonnes	Sea Around Us
e	An index of EEZs in a country		
k	An index of classes: {1 = collapsed, 2 = over-exploited, 3 = exploited, 4= developing, 5= rebuilding}		

The metric is calculated as an average percentage weighted by catch and summed across classes of concern.

$$\text{FSS} = \frac{\sum_e \left[\text{FSC}_{k=1,e} \times \text{CTH}_e\right]}{\sum_e \text{CTH}_e}$$

FCD: Fish Catch Discarded / Fisheries / Ecosystem Vitality

The proportion of a country's total catch that is discarded at sea instead of landed and utilized. This metric serves as a proxy for rates of bycatch and of wasteful and indiscriminate fishing practices.

Units	proportion
Years	1950–2019
Source	Sea Around Us
Transformation	$\ln(x + \alpha)$ $\alpha = 0.01$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-4.60517
Worst	99th percentile	0.6737853	- 0.3801113

Calculations

We calculate the metric by dividing the catch discarded by the total catch (both reported in tonnes):

$$\text{FCD} = \frac{\text{Fish catch discarded}}{\text{Total catch}}$$

RMS: Regional Marine Trophic Index / Fisheries / Ecosystem Vitality

The *Marine Trophic Index* (MTI), computed by Sea Around Us, describes the degree to which a country is depleting species at higher trophic levels and "fishing down the food web." The metric describes the average trophic level of a country's catch, while accounting for the geographic expansion of fishing operations. Our indicator is based on the slope of a line fitted to MTI values over one decade.

Units	unitless
Years	1989–2019
Source	Sea Around Us
Transformation	none

Performance	Nominal	Raw
Best	0.015	0.015
Worst	-0.015	-0.015

Calculations

Component		Units	Source
MTI	Time series of Regional Marine Trophic Index values, calculated excluding species with a trophic level below 3.2.	trophic level	Sea Around Us
CTH	Catch	tonnes	Sea Around Us
e	An index of EEZs in a country		

First, for each EEZ, we regress logged MTI values over ten years to find a slope,

$$\ln(\text{MTI}) = \alpha + \beta$$

Second, we calculate the average annual growth rate in MTI values,

$$\text{MTB} = \exp(\beta) - 1$$

Finally, we calculated the average MTB value across all the EEZs of a country, weighting values by the proportion of a country's total catch coming from each EEZ:

$$\text{RMS} = \frac{\sum_e [\text{MTB}_e \times \text{CTH}_e]}{\sum_e \text{CTH}_e}$$

BTZ: Domestic Bottom Trawling and Dredging / Fisheries / Ecosystem Vitality

Fish caught by trawling measures the fraction of the entire catch in a country's EEZ(s) captured with bottom trawling, where a fishing net is pulled along the seafloor behind a boat, or dredging, where the seafloor is scraped in search bottom-dwelling species. These practices are indiscriminate and wasteful and can severely damage marine ecosystems.

Units	proportion
Years	1950–2019
Source	Sea Around Us
Transformation	$\ln(x + \alpha)$ $\alpha = 0.1$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-2.302585
Worst	99th percentile	0.8216591	- 0.08157983

Calculations

Component		Units	Source
FTD	Catch by gear type and EEZ	tonnes	Sea Around Us
CTH	Catch by EEZ	tonnes	Sea Around Us
e	An index of EEZs in a country		
g	An index of gear types: {1 = bottom trawling, 2 = dredging, 3 = pelagic trawling, 4 = gillnets, 5 = longline, 6 = other}		

$$BTZ = \frac{\sum_{g=1}^{2} \sum_e FTD_{eg}}{\sum_e CTH_e}$$

BTO: Bottom Trawling in the Global Ocean / Fisheries / Ecosystem Vitality

Fish caught by trawling measures the fraction of the entire catch of a country's fleet across the global ocean captured with bottom trawling or dredging.

Units	proportion
Years	1950–2019
Source	Sea Around Us
Transformation	$\ln(x + \alpha)$ $\alpha = 0.1$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-2.302585
Worst	99th percentile	0.9212876	0.02106419

Calculations

Component		Units	Source
FTD	Catch by gear type	tonnes	Sea Around Us
g	An index of gear types: {1 = bottom trawling, 2 = dredging, 3 = pelagic trawling, 4 = gillnets, 5 = longline, 6 = other}		

$$\text{BTO} = \frac{\sum_{g=1}^{2} \text{FTD}_g}{\text{Total catch}}$$

3.9 Air Pollution

SDA: SO2 intensity trend / Air Pollution / Ecosystem Vitality

The *SO_2 growth rate* is calculated as the average annual rate of increase or decrease in SO_2 over the last ten years of data. It is then adjusted for economic trends to isolate change due to policy rather than economic fluctuation.

Units	unitless
Years	1999–2022
Source	Community Emissions Data Systems
Transformation	none

Performance	**Nominal**	**Raw**
Best	-0.03943723	-0.03943723
Worst	95th percentile	0.09564343

Calculations

Component		**Units**	**Source**
SO2	Emissions of SO_2	Gg	CEDS
GDP	Gross Domestic Product	2017$ international	World Bank & IMF
SDR	Correlation coefficient	—	
SDB	Emission growth rate	proportion	
t	Years		

First, we calculate Spearman's correlation coefficient between SO_2 emissions and GDP over a ten-year period,

$$SDR = corr(SO2, GDP)$$

Second, we regress logged SO_2 emissions over ten years to find a slope,

$$\ln(SO2) = \alpha + \beta t$$

Third, we calculate an unadjusted average annual growth rate in SO_2 emissions,

$$SDB = \exp(\beta) - 1$$

Fourth, we adjust the negative growth rates by a factor of 1 – the correlation coefficient,

$$SDA = \begin{cases} SDB \text{ if } SDB \geq 0 \\ SDB \times (1 - SDR) \text{ if } SDB < 0 \end{cases}$$

NXA: NOx intensity trend / Air Pollution / Ecosystem Vitality

The *NO_X growth rate* is calculated as the average annual rate of increase or decrease in NO_X over the last ten years of data. It is then adjusted for economic trends to isolate change due to policy rather than economic fluctuation.

Units	unitless
Years	1999–2022
Source	Community Emissions Data Systems
Transformation	none

Performance	Nominal	Raw
Best	-0.03943723	-0.03943723
Worst	95th percentile	0.07583405

Calculations

Component		Units	Source
NOX	Emissions of NO_X	Gg	CEDS
GDP	Gross Domestic Product	2017$ international	World Bank & IMF
NXR	Correlation coefficient	—	
NXB	Emission growth rate	proportion	
t	Years		

First, we calculate Spearman's correlation coefficient between NO_X emissions and GDP over a ten-year period,

$$NXR = corr(NOX, GDP)$$

Second, we regress logged NO_X emissions over ten years to find a slope,

$$\ln(NOX) = \alpha + \beta t$$

Third, we calculate an unadjusted average annual growth rate in NO_X emissions,

$$NXB = \exp(\beta) - 1$$

Fourth, we adjust the negative growth rates by a factor of 1 – the correlation coefficient,

$$NXA = \begin{cases} NXB \text{ if } NXB \geq 0 \\ NXB \times (1 - NXR) \text{ if } NXB < 0 \end{cases}$$

OEB: Ozone exposure in Key Biodiversity Areas / Air Pollution / Ecosystem Vitality

The *Ozone exposure in Key Biodiversity Areas* is calculated as the average concentration of ground-level ozone across a country's Key Biodiversity Areas.

Units	ppm
Years	2003–2022
Source	Copernicus Atmosphere Monitoring Service, WDKBA
Transformation	none

Performance	Nominal	Raw
Best	5th percentile	0.04031052
Worst	95th percentile	0.110068

OEC: Ozone exposure croplands / Air Pollution / Ecosystem Vitality

The *Ozone exposure in croplands* is calculated as the average concentration of ground-level ozone across a country's croplands.

Units	ppm
Years	2003–2022
Source	Copernicus Atmosphere Monitoring Service Global Lands Analysis & Discovery | University of Maryland
Transformation	none

Performance	Nominal	Raw
Best	5th percentile	0.05029189
Worst	95th percentile	0.1071858

3.10 Agriculture

SNM: Sustainable Nitrogen Management Index / Agriculture / Ecosystem Vitality

The *Sustainable Nitrogen Management Index (SNMI)* seeks to balance efficient application of nitrogen fertilizer with maximum crop yields as a measure of the environmental performance of agricultural production. The 2024 EPI uses the *SNMI* as a proxy for agricultural drivers of environmental damage.

Units	unitless
Years	1965–2021
Source	FAOSTAT
Transformation	none

Performance	Nominal	Raw
Best	0.0	0.0
Worst	99th percentile	1.315801

Calculations

Component		Units	Source
NCR	Nitrogen crop removal	kg / ha	FAOSTAT
NTI	Nitrogen total inputs	kg / ha	FAOSTAT
NUE	Nitrogen use efficiency	—	
NUE_{norm}	Normalized NUE	—	
NCR_{norm}	Normalized NCR	—	
t	index for years		

First, we calculate nitrogen use efficiency as the ratio of nitrogen removed by crops (i.e., nitrogen yield) to total nitrogen inputs:

$$\mathrm{NUE} = \frac{\mathrm{NCR}}{\mathrm{NTI}}$$

Second, we normalize NUE relative to an optimal reference value of 1. NUE below 1 means that some nitrogen inputs are not being recovered in crops, while NUE values above 1 indicate that nitrogen inputs are insufficient and the soil is progressively losing fertility:

$$\mathrm{NUE}_{norm} = \begin{cases} \mathrm{NUE} \;\; if\, \mathrm{NUE} \leq 1 \\ 1 - (\mathrm{NUE} - 1)\; if\, (1 < \mathrm{NUE} \leq 2) \\ 0 \; if\, \mathrm{NUE} > 2 \end{cases}$$

Third, we normalize nitrogen crop removal relative to a reference value of 90 kg/ha, which is the average global yield required to meet food demand in 2050 (Zhang et al. 2022):

$$NCR_{norm} = \begin{cases} 1 \; \mathit{if} \; NCR > 90 \\ \frac{NCR}{90} \; \mathit{if} \; NCR \leq 90 \end{cases}$$

The Sustainable Nitrogen Management Index is given by the Euclidean distance to an optimal point in which both NCR_{norm} and NUE_{norm} are equal to 1:

$$SNM = \sqrt{(1 - NCR_{norm})^2 + (1 - NUE_{norm})^2}$$

Finally, we calculate a 5-year moving average to smooth over noise in annual time series of fertilizer use data:

$$SNM = \frac{\sum_{i=0}^{4} SNM_{t-i}}{5}$$

Reference

Zhang X., Wang Y., Schulte-Uebbing L., De Vries W., Zou T., and Davidson E.A. (2022). Sustainable Nitrogen Management Index: Definition, Global Assessment, and Potential Improvements. *Front. Agr. Sci. Eng.* 9 (3): 356-365. doi: 10.15302/J-FASE-2022458

PSU: Phosphorus surplus / Agriculture / Ecosystem Vitality

Defined as the difference between phosphorus fertilizer inputs and phosphorus recovered in harvested crops, the *Phosphorus Surplus* indicator serves as a proxy for potential pollution of water bodies due to excessive phosphorus fertilizer use.

Units	kg/ha
Years	1965–2021
Source	FAOSTAT
Transformation	$\ln(x + \alpha)$ $\alpha = 0.09$

Performance	Nominal	Raw	Transformed
Best	0.0	0.0	-2.407946
Worst	99th percentile	223.0851	5.407956

Calculations

Component		Units	Source
PCR	Phosphorus crop removal	kg / ha	FAOSTAT
PTI	Phosphorus total inputs	kg / ha	FAOSTAT
t	index for years		

Since the indicator is a simple proxy for potential pollution due to excessive fertilizer use, we disregard negative values. Negative values indicate soil mining, which is only problematic in certain contexts (Zou et al. 2022):

$$PSU = \begin{cases} 0 \; \textit{if} \; PCR > PTI \\ PCR - PTI \; \textit{if} \; PCR \leq PTI \end{cases}$$

Finally, we calculate a 5-year moving average to smooth over noise in annual time series of fertilizer use data:

$$PSU = \frac{\sum_{i=0}^{4} PSU_{t-i}}{5}$$

Reference

Zou T., Zhang X., and Davidson E.A. (2022). Global trends of cropland phosphorus use and sustainability challenges. *Nature* 611: 81-87. doi: 10.1038/s41586-022-05220-z

PRS: Pesticide Pollution Risk / Agriculture / Ecosystem Vitality

The *Pesticide Pollution Risk* indicator summarize the risk to biodiversity from pesticide pollution and is calculated as the geometric mean of a country's pesticide risk scores (Tang et al. 2021).

Units	unitless
Years	2015, 2018
Source	Tang et al. 2021; Maggi and Tang 2024.
Transformation	none

Performance	Nominal	Raw
Best	0.0	0.0
Worst	4.5	4.5

Notes

The 2024 EPI's *Pesticide Pollution Risk* indicator is derived from updated pesticide risk scores computed with the methods described in Tang et al. (2021) but based on a new version of the PESTCHEMGRIDS dataset which incorporates more recent data on pesticide application rates, more pesticide active ingredients, and is available at a finer spatial resolution (Maggi and Tang, 2024).

References

Maggi F. and Tang F.H.M. (2024). PESTCHEMGRIDS v2.01 (beta version). Figshare. Dataset. doi: 10.6084/m9.figshare.25854769.v2

Tang F.H.M., Lenzen M., McBratney A., and Maggi F. (2021). Risk of pollution risk at the global scale. *Nature Geoscience* **14**: 206-210. doi: 10.1038/s41561-021-00712-5

RCY: Relative Crop Yield / Agriculture / Ecosystem Vitality

The *Relative Crop Yield* indicator measures the average yield of 17 major crops relative to country-specific maximum attainable yields. It serves as a proxy for the land use efficiency of agriculture the productivity of countries' croplands.

Units	proportion
Years	1961 – 2022
Source	FAOSTAT, Mueller et al. 2012
Transformation	none

Performance	Nominal	Raw
Best	1.0	1.0
Worst	1^{st} percentile	0.1348339

Calculations

Component		Units	Source
CRY	Crop yields	tonnes / ha	FAOSTAT
CAH	Area harvested per crop	ha	FAOSTAT
ATY	Maximum attainable yields	tonnes / ha	Mueller et al. 2012
CYG	Crop yield gap		
c	index for 17 major crops		

Mueller et al. (2012) provide country-specific estimates of the maximum attainable yield of 17 major crops (barley, cassava, cotton, groundnut, maize, millet, oil palm, potato, rapeseed, rice, rye, sorghum, soybean, sugar beet, sugarcane, sunflower, and wheat) based on historical yield data.

For each crop, we divided the average yield by the maximum attainable yield in the country:

$$\text{CYG}_c = \frac{\text{CRY}_c}{\text{ATY}_c}$$

Next, we average the relative yield of all crops in a country, weighting by the area harvested of each crop:

$$\text{RCY} = \sum_{c=1}^{17} \text{CYG}_c \times \frac{\text{CAH}_c}{\sum_{c=1}^{17} \text{CAH}_c}$$

Since Mueller et al.'s (2012) maximum attainable yields are defined as the 95^{th} percentile of observed yields in a particular climate zone, some actual yields may be higher than the maximum attainable yield. To deal with such cases, we capped the RCY values at 1.

Materiality filter

We only calculated the RCY indicator for the 130 countries in which the 17 major crops represented at least 5% of the total area harvested in the country, to ensure that the yield gaps of these crops were representative of the agricultural productivity of the country.

Imputation of missing values

For the other 50 countries and territories included in the EPI for which data about maximum attainable yields was not available, we used a model to impute missing values. Specifically, for countries with available data, we fitted a linear model to predict RCY values based on countries' EPI region (R), their GDP per capita (GPC), and their nitrogen relative yield (NRY).

$$RCY = \alpha + \beta GPC + \gamma NRY + \delta R + \varepsilon$$

Next, we used this model, which explained 51% of the variance in available RCY scores, to predict values for countries where RCY is missing but GPC, NRY, and R are not.

$$\widehat{RCY} = \hat{\alpha} + \hat{\beta} GPC + \hat{\gamma} NRY + \hat{\delta} R$$

The 50 countries for which we imputed RCY values using this model are:

Antigua and Barbuda
Bahamas
Bahrain
Barbados
Belgium
Botswana
Cabo Verde
Central African Republic
Chad
Comoros
Cyprus
Djibouti
Dominica
Dominican Republic
Equatorial Guinea
Eswatini
Fiji
Grenada
Guinea-Bissau
Haiti
Iceland
Kiribati
Kuwait
Laos
Lesotho
Liberia
Maldives
Malta
Marshall Islands
Mauritania
Mauritius
Micronesia
Montenegro
Qatar
Saint Lucia
St. Vincent and the Grenadines
Samoa
Sao Tome and Principe
Serbia
Seychelles
Sierra Leone
Singapore
Solomon Islands
Taiwan
Timor-Leste
Tonga
Turkmenistan
United Arab Emirates
Uzbekistan
Vanuatu

References

Mueller N.D., Gerber J.S., Johnston M., Ray D.K., Ramankutty N., and Foley J.A. (2012). Closing yield gaps through nutrient and water management. *Nature* 490: 254 – 257. doi: 10.1038/nature11420

3.11 Water Resources

WWG: Wastewater generated per capita / Water Resources / Ecosystem Vitality

The total volume of municipal wastewater generated divided by a country's population.

Units	m^3 per person per year
Years	2015–2021
Source	Jones et al. 2021, UNSD
Transformation	ln(x)

Performance	Nominal	Raw	Transformed
Best	5th percentile	4.465758	1.496439
Worst	95th percentile	261.7005	5.567201

WWC: Wastewater collected / Water Resources / Ecosystem Vitality

Proportion of wastewater collected for treatment. Sometimes measured as the percentage of the population connected to urban or independent wastewater treatment facilities.

Units	proportion
Years	2015–2021
Source	Jones et al. 2021, Eurostat, UNSD, OECD
Transformation	none

Performance	Nominal	Raw
Best	1.0	1.0
Worst	0.0	0.0

WWT: Wastewater treated / Water Resources / Ecosystem Vitality

Proportion of municipal wastewater that undergoes at least primary treatment.

Units	proportion
Years	2015–2021
Source	Jones et al. 2021, UNSD, OECD
Transformation	none

Performance	Nominal	Raw
Best	1.0	1.0
Worst	0.0	0.0

WWR: Wastewater reused / Water Resources / Ecosystem Vitality

Proportion of wastewater reused after treatment, either for irrigation in agriculture or, when clean enough, in industry or as drinking water.

Units	proportion
Years	2015
Source	Jones et al. 2021
Transformation	none

Performance	Nominal	Raw
Best	1.0	1.0
Worst	0.0	0.0

4. Country Coverage

The EPI seeks to cover as many countries as possible. When selecting datasets for our calculations, the EPI team gathers information on all territories that data providers have to offer. After the team has finalized the list of indicators used in the EPI, a survey of country data coverage determines which countries have sufficient information to be included in rankings. Unfortunately, some countries do not have sufficient data to support the calculation of an overall EPI score. Whether or not a country is included is not a reflection of the environmental performance of those countries; rather, data sparseness makes it impossible to say something meaningful. Another set of countries is excluded because government instability skews available information. As we discuss in Chapter 14 the 2024 EPI Report, we also identify certain territories for which data may be reported separately but should be considered as under the control or protection of a sovereign government. In these cases, we aggregate data on the territories with the sovereign country.

4.1 Countries in the 2024 EPI

Afghanistan
Albania
Algeria
Angola
Antigua & Barbuda
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahamas
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia & Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Central African Rep.
Chad
Chile
China
Colombia
Comoros
Costa Rica
Côte d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Dem. Rep. Congo
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eritrea
Estonia
Eswatini
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Kiribati
Kuwait
Kyrgyzstan
Laos

Countries in the 2024 EPI (continues from previous page)

Latvia
Lebanon
Lesotho
Liberia
Lithuania
Luxembourg
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Marshall Islands
Mauritania
Mauritius
Mexico
Micronesia
Moldova
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
North Macedonia
Norway
Oman
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Republic of Congo
Romania
Russia
Rwanda
Saint Lucia
St Vincent & Grenadines
Samoa
São Tomé and Príncipe
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
Solomon Islands
South Africa
South Korea
Spain
Sri Lanka
Sudan
Suriname
Sweden
Switzerland
Taiwan
Tajikistan
Tanzania
Thailand
Timor-Leste
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States of America
Uruguay
Uzbekistan
Vanuatu
Venezuela
Viet Nam
Zambia
Zimbabwe

4.2 Countries excluded from the 2024 EPI

Andorra
Anguilla
Aruba
Bermuda
British Virgin Isls.
Cayman Islands
Cook Islands
Curacao
Faeroe Islands
Falkland Islands
French Polynesia
Greenland
Guernsey
Holy See
Hong Kong
Isle of Man
Jersey
Kosovo
Libya
Liechtenstein
Macao
Monaco
Nauru
New Caledonia
Niue
North Korea
Palau
Saint Barthelemy
St Kitts & Nevis
San Marino
Sint Maarten
Somalia
South Sudan
State of Palestine
Syria
Turks & Caicos Isls.
Tuvalu
Wallis & Futuna Isls.
Western Sahara
Yemen

4.3 Territories within sovereign countries

Table TA-2. Territories found in gathered data sets and their sovereign countries.

Territory	Sovereign
Åland Islands	Finland
American Samoa	United States of America
Bonaire, Sint Eustatius, and Saba	Netherlands
Bouvet Island	Norway
British Indian Ocean Territory	United Kingdom
Christmas Island	Australia
Cocos Islands	Australia
French Guiana	France
French Southern Territories	France
Gibraltar	United Kingdom
Guadeloupe	France
Guam	United States of America
Heard Island and McDonald Islands	Australia
Martinique	France
Mayotte	France
Montserrat	United Kingdom
Norfolk Island	Australia
Northern Mariana Islands	United States of America
Pitcairn	United Kingdom
Puerto Rico	United States of America
Reunion	France
Saint Helena	United Kingdom
Saint Martin	France
Saint Pierre and Miquelon	France
South Georgia and the South Sandwich Islands	United Kingdom
Svalbard and Jan Mayen Islands	Norway
Tokelau	New Zealand
United States Minor Outlying Islands	United States of America
United States Virgin Islands	United States of America

5. Temporal Coverage

Table TA-3. Temporal coverage for indicators used in the 2024 EPI. Variables marked with an asterisk (*) have very different temporal coverage for different countries.

TLA	95					00					05					10					15					20				
CDA					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
CDF					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
CHA					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
FGA					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
NDA					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
BCA					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
LUF					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
GTI					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
GTP					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
GHN					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
CBP																												■		
HPE				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
HFD	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
OZD	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
NOD	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
SOE									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
COE									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
VOE									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
USD	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
UWD	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
LED	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
WPC*																					■	■	■	■	■	■	■	■		
SMW*																					■	■	■	■	■	■	■	■		
WRR*																					■	■	■	■	■	■	■	■		
MKP																■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
MHP																■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
MPE																		■	■	■	■	■	■	■	■	■				
PAR																														■
SPI	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
TBN	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
TKP																■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
PAE																												■		
PHL																												■		
RLI						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SHI							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
BER						■					■					■					■					■				
PFL												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
IFL											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
FCL											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
TCG																										■				
FLI																										■				

Table TA-3 (cont.). Temporal coverage for indicators used in the 2024 EPI. Variables marked with an asterisk (*) have very different temporal coverage for different countries.

TLA	95					00					05					10					15					20				
FSS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
FCD	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
BTZ	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
BTO	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
RMS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
OEB									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
OEC									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
NXA					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
SDA					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
SNM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
PSU	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
PRS																					■			■						
RCY	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
WWG*																					■	■	■	■	■	■	■			
WWC*																					■	■	■	■	■	■	■			
WWT*																					■	■	■	■	■	■	■			
WWR																					■									
GDP	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒		
POP	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒		

Table TA-4. Designations of years supporting the current and baseline scores for each indicator.

Policy Objective	Issue Category	Indicator	TLA	Current	Baseline
Ecosystem Vitality	Biodiversity & Habitat	Marine KBA Protection	MKP	2024	2015
		Marine Habitat Protection	MHP	2024	2015
		Marine Protection Stringency	MPE	2020	2012
		Protected Areas Representativeness Index	PAR	2024	2024
		Species Protection Index	SPI	2024	2015
		Terrestrial Biome Protection	TBN	2023	2014
		Terrestrial KBA Protection	TKP	2024	2015
		Protected Area Effectiveness	PAE	2022	2022
		Protected Human Land	PHL	2022	2022
		Red List Index	RLI	2024	2015
		Species Habitat Index	SHI	2024	2015
		Bioclimatic Ecosystem Resilience	BER	2020	2010
	Forests	Primary Forest Loss	PFL	2022	2013
		Intact Forest Landscape Loss	IFL	2022	2013
		Tree cover loss weighted by permanency	FCL	2022	2013
		Net change in tree cover	TCG	2020	2020
		Forest Landscape Integrity	FLI	2020	2020
	Fisheries	Fish Stock Status	FSS	2019	2010
		Fish Catch Discarded	FCD	2019	2010
		Bottom Trawling in EEZ	BTZ	2019	2010
		Bottom Trawling in Global Ocean	BTO	2019	2010
		Regional Marine Trophic Index	RMS	2019	2010
	Air Pollution	Ozone exposure KBAs	OEB	2022	2013
		Ozone exposure croplands	OEC	2022	2013
		Adjusted emissions growth rate for nitrous oxides	NXA	2022	2013
		Adjusted emissions growth rate for sulfur dioxide	SDA	2022	2013
	Agriculture	Sustainable Nitrogen Management Index	SNM	2021	2012
		Phosphorus Surplus	PSU	2021	2012
		Pesticide Pollution Risk	PRS	2018	2015
		Relative Crop Yield	RCY	2022	2013
	Water Resources	Wastewater generated	WWG	2015-2021	2015
		Wastewater collected	WWC	2015-2021	2015
		Wastewater treated	WWT	2015-2021	2015
		Wastewater reused	WWR	2015	2015

(Continues on the next page).

Table TA-4 (continuation). Designations of years supporting the current and baseline scores for each indicator.

Policy Objective	Issue Category	Indicator	TLA	Current	Baseline
Environmental Health	Air Quality	Anthropogenic PM2.5 exposure	HPE	2022	2013
		Household solid fuels	HFD	2021	2012
		Ozone exposure	OZD	2021	2012
		NOx exposure	NOD	2021	2012
		SO2 exposure	SOE	2022	2013
		CO exposure	COE	2022	2013
		VOC exposure	VOE	2022	2013
	Sanitation & Drinking Water	Unsafe sanitation	USD	2021	2012
		Unsafe drinking water	UWD	2021	2012
	Heavy Metals	Lead exposure	LED	2021	2012
	Waste Management	Waste generated per capita	WPC	2016-2022	2016
		Controlled solid waste	SMW	2016-2022	2016
		Waste recovery rate	WRR	2016-2022	2016
Climate Change	Climate Change Mitigation	Adjusted emissions growth rate for carbon dioxide	CDA	2022	2013
		CO_2 growth rate (country-specific targets)	CDF	2022	2013
		Adjusted emissions growth rate for methane	CHA	2022	2013
		Adjusted emissions growth rate for F-gases	FGA	2022	2013
		Adjusted emissions growth rate for nitrous oxide	NDA	2022	2013
		Adjusted emissions growth rate for black carbon	BCA	2022	2013
		Net carbon fluxes due to land cover change	LUF	2022	2013
		GHG growth rate adjusted by emissions intensity	GTI	2022	2013
		GHG growth rate adjusted by per capita emissions	GTP	2022	2013
		Projected emissions in 2050	GHN	2022	2013
		Projected cumulative emissions to 2050 relative to carbon budget	CBP	2022	2022

6. Data File Guide

The data underlying the 2024 EPI report's analyses is available for download from https://epi.yale.edu/downloads. These include both raw data and indicator data. Raw data files contain the data in their original units. Section 2 of this appendix describes the sources for these data. Indicator data contain the scores for the 58 metrics on a 0 to 100 scale. Section 3 of this appendix describes how the raw data are converted into indicator data.

Raw data files are named according to three-letter abbreviations (TLAs) unique to each variable. Within these files, columns are labeled ***TLA.raw.YYYY***, where ***YYYY*** is the year. Higher level aggregations, i.e., issue categories and policy objectives, do not have raw data files.

We provide two versions of each raw data file, with and without missing data codes. For all raw data files that are named ***TLA_raw.csv***, missing values are noted with the following codes:

-9999	the source dataset has cells with missing values
-8888	the country is not reported by the data source
-7777	the missing values are missing because they are not material

For all raw data files that are named ***TLA_raw_na.csv***, missing values are noted simply as NA.

Indicator file columns are formatted as ***TLA.ind.YYYY***. The years covered in each indicator file are not necessarily the same as the underlying raw data files for two reasons. First, the EPI team resizes every file to begin in 1995 and end in 2024. Second, the EPI data processing pipeline uses linear interpolation to fill in missing data years between observations and hold values constant to extend to beginning and ending years. For example, if a data series ends in the year 2019, we hold that value constant over the years 2020 to 2024. Table TA-3 illustrates the actual temporal coverage of raw data between 1995 and 2024.