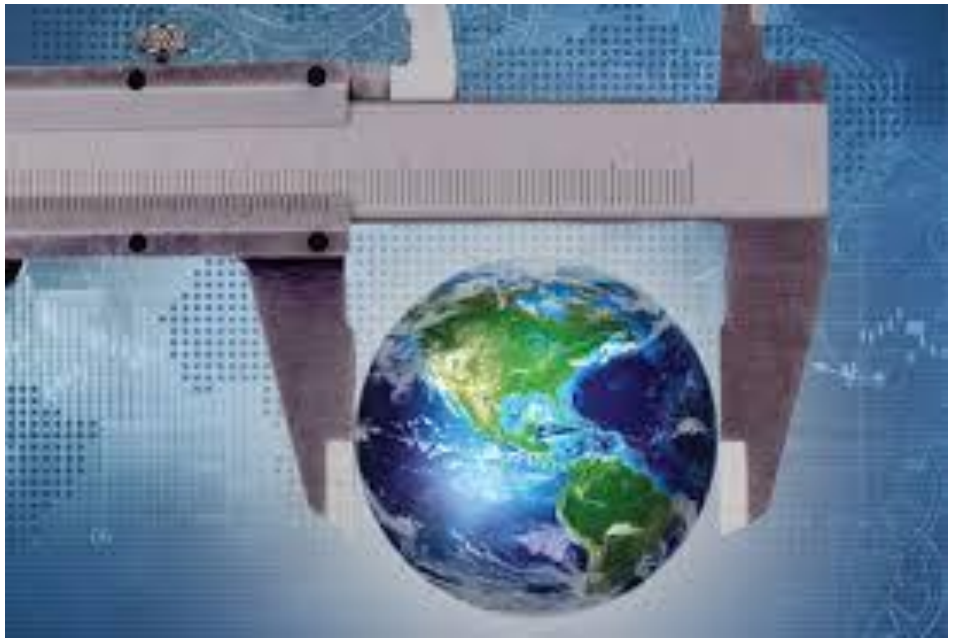
‘Βιώσιμη Ανάπτυξη’

Δρ. Χάρης Δημητριάδης

Ποσοτικοποίηση και Μέτρηση της Βιωσιμότητας

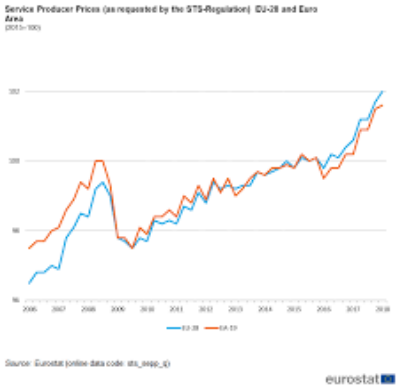


Sustainability measurement is the quantitative basis for the informed management of sustainability

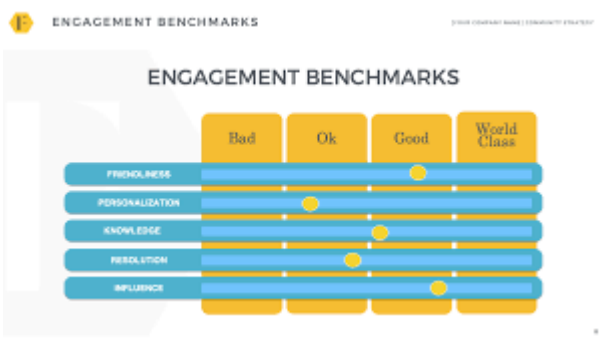
The metrics used for the measurement of sustainability (involving the sustainability of environmental, social and economic domains, both individually and in various combinations) are still evolving:

indicators

indexes



benchmarks



They are applied over a wide range of spatial and temporal scales

‘Βιώσιμη Ανάπτυξη’

Sustainability development has become yardstick of improvement for industries and are being integrated into effective business strategies. The needs for sustainability measurement are, improvement in the operations, bench-marking performances, tracking progress, evaluating process, etc. For the purpose of building a proper sustainability indicator, framework is developed and the steps are as follows:

Defining the system- A proper and definite system is defined. A proper system boundary is drawn for further analysis.

Elements of the system- The whole input, output of materials, emissions, energy and other auxiliary elements are properly analysed. The working conditions, process parameters and characteristics are defined in this step.

Indicators selection- The indicators is selected of which measurement has to be done. This forms the metric for this system whose analysis is done in the further steps.

Assessment and Measurement- Proper assessing tools are used and tests or experiments are performed for the pre-defined indicators to give a value for the indicators measurement.

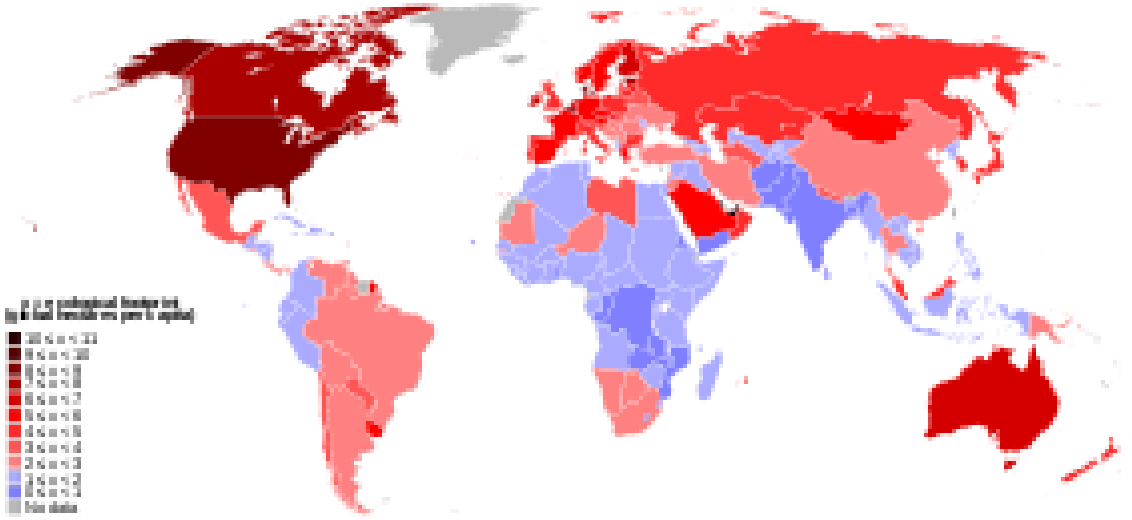
Analysis and reviewing the results- Once the results have been obtained, proper analysis and interpretation is done and tools are used to improve and revise the processes present in the system.

The principal objective of sustainability indicators is to inform public policy-making as part of the process of sustainability governance. Sustainability indicators can provide information on any aspect of the interplay between the environment and socio-economic activities. Building strategic indicator sets generally deals with just a few simple questions: what is happening? (descriptive indicators), does it matter and are we reaching targets? (performance indicators), are we improving? (efficiency indicators), are measures working? (policy effectiveness indicators), and are we generally better off? (total welfare indicators).

One popular general framework used by The European Environment Agency uses a slight modification of the Organisation for Economic Co-operation and Development DPSIR system. This breaks up environmental impact into five stages. Social and economic developments (consumption and production) (D)rive or initiate environmental (P)ressures which, in turn, produces a change in the (S)tate of the environment which leads to (I)mpacts of various kinds. Societal (R)esponses (policy guided by sustainability indicators) can be introduced at any stage of this sequence of events.

Ecological footprint

The ecological footprint measures human demand on nature, i.e., the quantity of nature it takes to support people or an economy. It tracks this demand through an ecological accounting system. The accounts contrast the biologically productive area people use for their consumption to the biologically productive area available within a region or the world (biocapacity, the productive area that can regenerate what people demand from nature). In short, it is a measure of human impact on Earth's ecosystem and reveals the dependence of the human economy on natural capital.



Ecological footprint

Footprint and biocapacity can be compared at the individual, regional, national or global scale. Both footprint and biocapacity change every year with number of people, per person consumption, efficiency of production, and productivity of ecosystems. At a global scale, footprint assessments show how big humanity's demand is compared to what planet Earth can renew. Since 2003, Global Footprint Network has calculated the ecological footprint from UN data sources for the world as a whole and for over 200 nations (known as the National Footprint Accounts). Every year the calculations are updated with the newest data. The time series are recalculated with every update since UN statistics also change historical data sets. As shown in Lin et al. (2018) the time trends for countries and the world have stayed consistent despite data updates. Also, a recent study by the Swiss Ministry of Environment independently recalculated the Swiss trends and reproduced them within 1–4% for the time period that they studied (1996–2015). Global Footprint Network estimates that, as of 2014, humanity has been using natural capital 1.7 times as fast as Earth can renew it

This means humanity's ecological footprint corresponds to 1.7 planet Earths.

Ecological footprint

Ecological footprint analysis is widely used around the Earth in support of sustainability assessments.It enables people to measure and manage the use of resources throughout the economy and explore the sustainability of individual lifestyles, goods and services, organizations, industry sectors, neighborhoods, cities, regions and nations. Since 2006, a first set of ecological footprint standards exist that detail both communication and calculation procedures

Ecological footprint

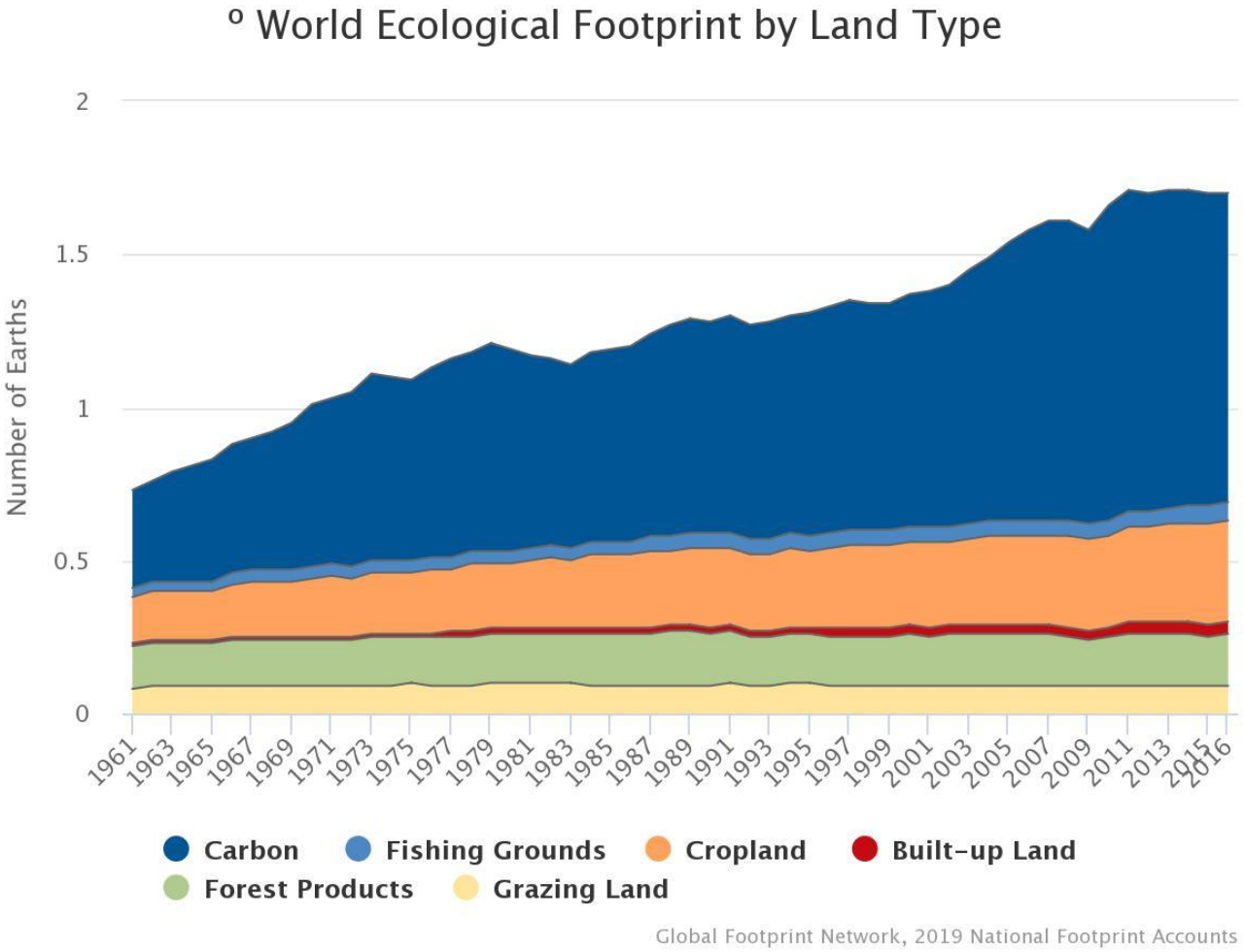
For 2014, Global Footprint Network estimated humanity's ecological footprint as 1.7 planet Earths. This means that, according to their calculations, humanity's demands were 1.7 times faster than what the planet's ecosystems renewed.

Ecological footprints can be calculated at any scale: for an activity, a person, a community, a city, a town, a region, a nation, or humanity as a whole. Cities, due to their population concentration, have large ecological footprints and have become ground zero for footprint reduction.

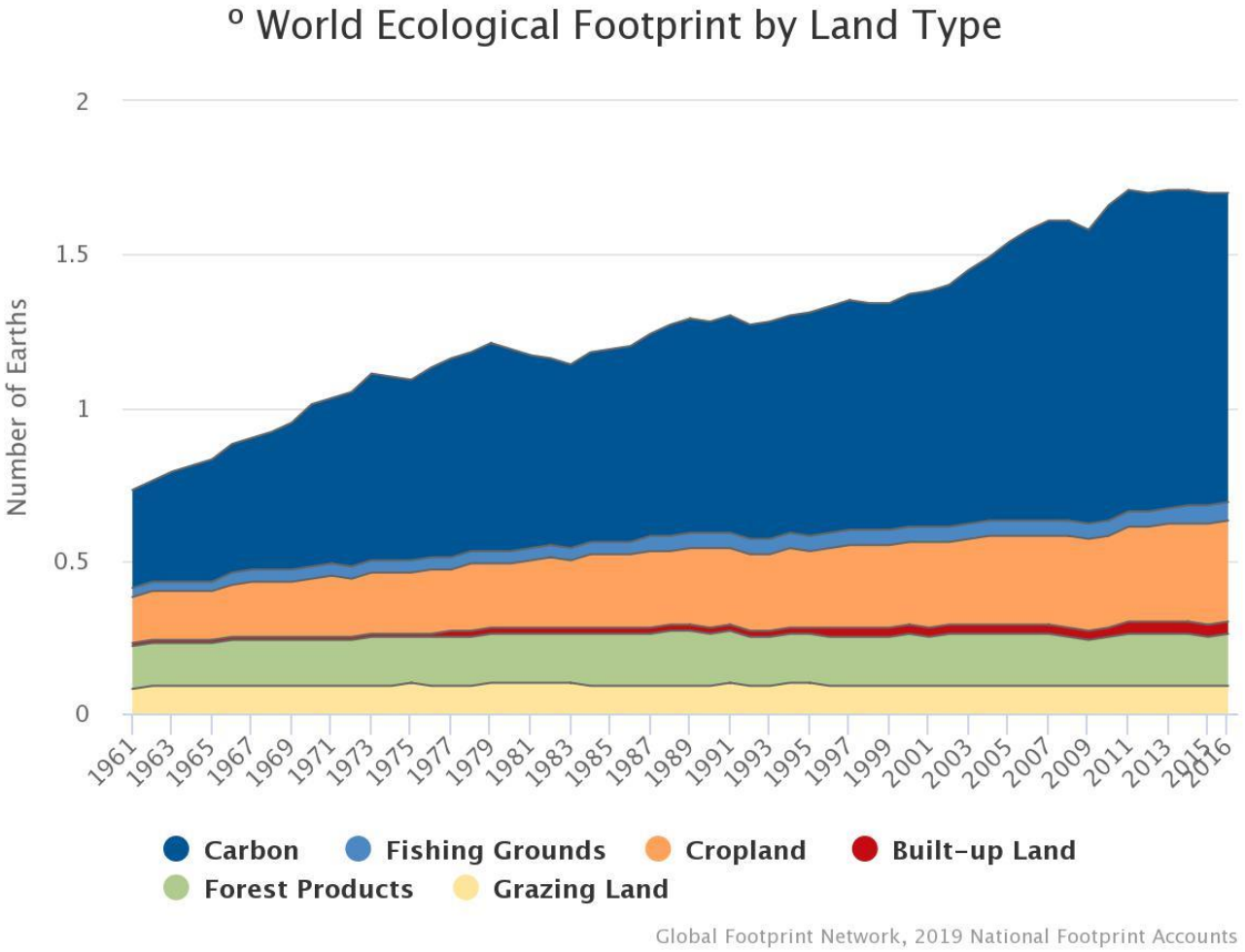
The ecological footprint accounting method at the national level is described on the web page of Global Footprint Network or in greater detail in academic papers, including Borucke et al

The National Accounts Review Committee has also published a research agenda on how to improve the accounts

Ecological footprint



Ecological footprint



Ecological footprint

Ecological Footprint of Consumption

The Ecological Footprint of consumption indicates the consumption of biocapacity by a country's inhabitants.

In order to assess the total domestic demand for resources and ecological services of a population, we use the Ecological Footprint of consumption (EF_C). EF_C accounts for both the export of national resources and ecological services for use in other countries, and the import of resources and ecological services for domestic consumption.

EFc is most amenable to change by individuals through changes in their consumption behavior.

Ecological Footprint of Production

The Ecological Footprint of production indicates the consumption of biocapacity resulting from production processes within a given geographic area, such as a country or region.

It is the sum of all the bioproductive areas within a country necessary for supporting the actual harvest of primary products (cropland, grazing land, forestland and fishing grounds), the country's built-up area (roads, factories, cities), and the area needed to absorb all fossil fuel carbon emissions generated within the country.

This measure mirrors the gross domestic product (GDP), which represents the sum of the values of all goods and services produced within a country's borders.

Net Ecological Footprint of Trade

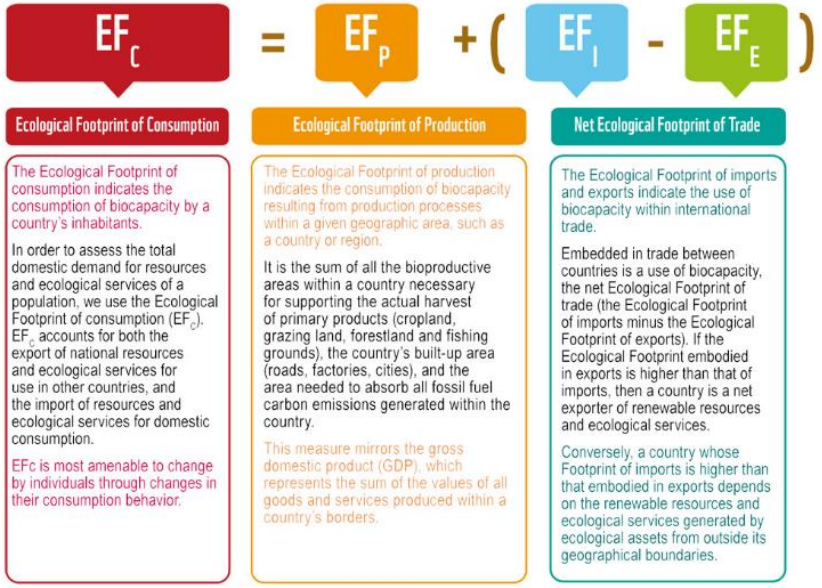
The Ecological Footprint of imports and exports indicate the use of biocapacity within international trade.

Embedded in trade between countries is a use of biocapacity, the net Ecological Footprint of trade (the Ecological Footprint of imports minus the Ecological Footprint of exports). If the Ecological Footprint embodied in exports is higher than that of imports, then a country is a net exporter of renewable resources and ecological services.

Conversely, a country whose Footprint of imports is higher than that embodied in exports depends on the renewable resources and ecological services generated by ecological assets from outside its geographical boundaries.

Ecological footprint

Results from this analysis shed light on a country’s ecological impact. A country has an **ecological reserve** if its Footprint is smaller than its biocapacity; otherwise it is operating with an **ecological deficit**. The former are often referred to as **ecological creditors**, and the latter **ecological debtors**.



Ecological footprint

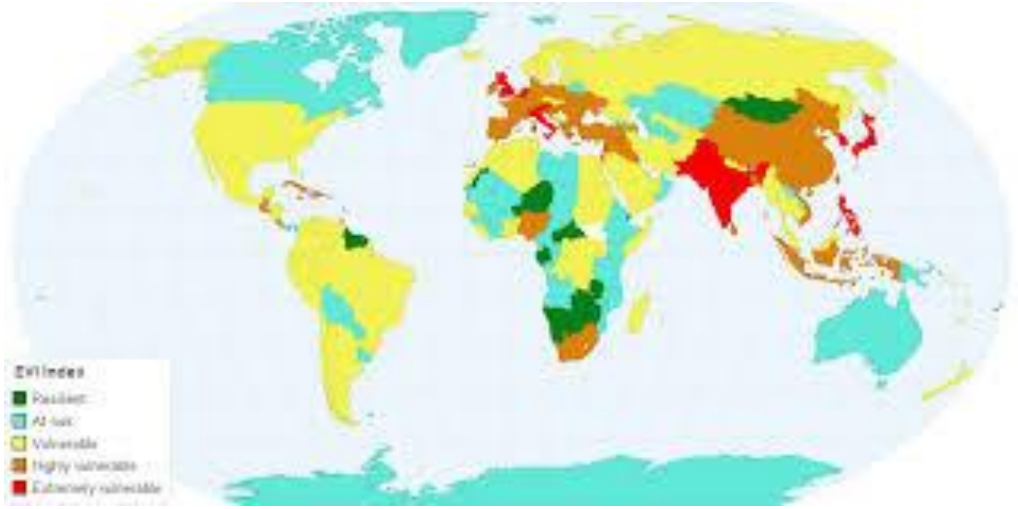
According to the 2018 edition of the National Footprint Accounts, humanity's total ecological footprint has exhibited an increasing trend since 1961, growing an average of 2.1% per year (SD= 1.9).[3] Humanity's ecological footprint was 7.0 billion gha in 1961 and increased to 20.6 billion gha in 2014. The world-average ecological footprint in 2014 was 2.8 global hectares per person. The carbon footprint is the fastest growing part of the ecological footprint and accounts currently for about 60% of humanity's total ecological footprint.

The Earth's biocapacity has not increased at the same rate as the ecological footprint. The increase of biocapacity averaged at only 0.5% per year (SD = 0.7).[3] Because of agricultural intensification, biocapacity was at 9.6 billion gha in 1961 and grew to 12.2 billion gha in 2016.

Therefore, the Earth has been in ecological overshoot (where humanity is using more resources and generating waste at a pace that the ecosystem can't renew) since the 1970s. In 2018, Earth Overshoot Day, the date where humanity has used more from nature than the planet can renew in the entire year, was estimated to be August 1.Now more than 85% of humanity lives in countries that run an ecological deficit. This means their ecological footprint for consumption exceeds the biocapacity of that country.

Environmental Vulnerability Index

The Environmental Vulnerability Index (EVI) is a measurement devised by the South Pacific Applied Geoscience Commission (SOPAC), the United Nations Environment Program and others to characterize the relative severity of various types of environmental issues suffered by 243 enumerated individual nations and other geographies (such as Antarctica). The results of the EVI are used to focus on planned solutions to negative pressures on the environment, whilst promoting sustainability.



Environmental Vulnerability Index

To be able to calculate an Environmental Vulnerability Index it requires the compilation of relevant environmental vulnerability data for the 50 indicators. Once compiled then this data must be used to calculate each indicator. As the indicators are heterogeneous, include variables for which responses are numerical, qualitative and on different scales (linear, non-linear, or with different ranges) they are mapped onto a 1–7 vulnerability scale. Where data is not available, no value is given for the indicator and the denominator of the average adjusted down by one value. Where an indicator is considered 'non-applicable' in a country (such as volcanic eruptions in Tuvalu which has no volcanoes), the lowest vulnerability score of 1 is attributed to that indicator. The vulnerability scores for each indicator are then accumulated either into categories or sub-indices and the average calculated. An overall average of all indicators is calculated to generate the country EVI. The EVI is accumulated into three sub-indices: Hazards, Resistance, Damage

The 50 EVI indicators are also divided up in the issue categories for use as required: Climate change, Biodiversity, Water, Agriculture and fisheries, Human health aspects, Desertification, and Exposure to Natural Disasters.

Environmental Vulnerability Index

EVI DEFINITIONS

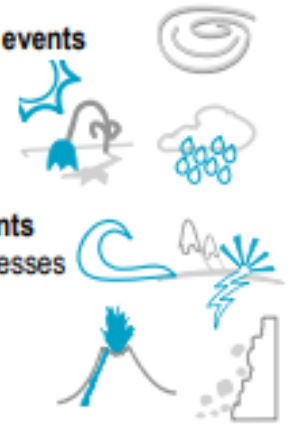
The definitions given here are pragmatic and only to be used for the purposes of the EVI.

The EVI is a numerical indicator that reflects the status of a country's environmental vulnerability, where:

- **“Environment”** includes those biophysical systems that can be sustained without human support
- **“Vulnerability”** is the extent to which the environment is prone to damage and degradation;
- **“Damage”** is the loss of diversity, extent, quality and function of environments.

WHAT ARE THE HAZARDS?

- **Meteorological events**
  - Cyclones
  - Droughts
  - Floods
  - ENSO
- **Geological events**
  - Coastal processes
  - landslides
  - earthquakes
  - tsunamis
  - volcano
- **Anthropogenic events**
  - Pollution, toxic wastes, solid wastes
  - Urbanisation
  - Mining
  - Hydrocarbons
  - Tourism
  - Exploitation
- **Climate change**
  - Ozone depletion
  - ENSO
- **Sealevel rise**

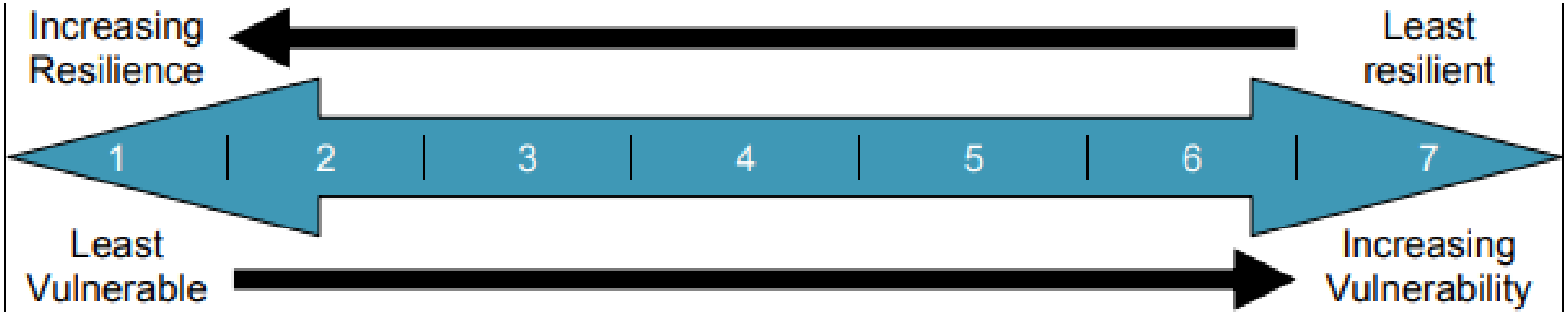


WHAT IS VULNERABLE?

Environmental variables which are affected if the risks actually happen:

- **Ecosystems**
- **Populations / communities**
- **Physical & biological resources**
- **Physical & biological processes**
- **Species**

Environmental Vulnerability Index



$$EVI = 100 \times \sum_{i=1}^{n} \frac{\text{Indicator scale value}}{n}$$

Environmental Vulnerability Index

High Winds – Average annual excess winds over the last five years (summing speeds on days during which the maximum recorded wind speed is greater than 20% higher than the 30 year average maximum wind speed for that month) averaged over all reference climate stations.
Dry Periods – Average annual rainfall deficit (mm) over the past 5 years for all months with more than 20% lower rainfall than the 30 year monthly average, averaged over all reference climate stations.
Wet Periods – Average annual excess rainfall (mm) over the past 5 years for all months with more than 20% higher rainfall than the 30 year monthly average, averaged over all reference climate stations
Hot Periods – Average annual excess heat (degrees C) over the past 5 years for all days more than 5˚C (9˚F) hotter than the 30 year mean monthly maximum, averaged over all reference climate stations.
Cold Periods – Average annual heat deficit (degrees C) over the past 5 years for all days more than 5˚C (9˚F) cooler than the 30 year mean monthly minimum, averaged overall reference climate stations.
Sea Temperatures – Average annual deviation in Sea Surface Temperatures (SST) in the last 5 years in relation to the 30 year monthly means
Volcanoes – Cumulative volcano risk as the weighted number of volcanoes with the potential for eruption greater than or equal to a Volcanic Explosively Index of 2 (VEI 2) within 100 km of the country land boundary(divided by the area of land).
Earthquakes – Cumulative earthquake energy within 100 km of country land boundaries measured as Local Magnitude (ML) ≥ 6.0 and occurring at a depth of less than or equal to fifteen kilometers(≤15 km depth) over 5 years (divided by land area).
Tsunamis – Number of tsunamis or storms surges with run-up greater than 2 meters above Mean High Water Spring tide (MHWS) per 1000 km coastline since 1900.
Slides – Number of slides recorded in the last 5 years (EMDAT definitions), divided by land area
Land Area – Total land area (km2)
Country Dispersion – Ratio of length of borders (land and maritime) to total land area.
Isolation – Distance to nearest continent (km)
Relief – Altitude range (highest point subtracted from the lowest point in country)
Lowlands – Percentage of land area less than or equal to 50m above sea level

Environmental Vulnerability Index

Borders – Number of land and sea borders (including EEZ shared with other countries.)
Ecosystem Imbalance – Weighted average change in trophic level since fisheries began (for trophic level slice ≤3.35).
Environmental Openness – Average annual USD freight imports over the past 5 years by any means per km2 land area
Migrations – Number of known species that migrate outside the territorial area at any time during their life spans (including land and all aquatic species) / area of land
Endemics – Number of known endemic species per million square kilometer land area
Introductions – Number of introduced species per 1000 square kilometer of land area
Endangered Species – Number of endangered and vulnerable species per 1000 km^2 land area (IUCN definitions)
Extinctions – Number of species known to have become extinct since 1900 per 1000 km^2 land area (IUCN definitions)
Vegetation Cover – Percentage of natural and regrowth vegetation cover remaining (include forests, wetlands, prairies, tundra, desert and alpine associations).
Loss Of Cover – Net percentage change in natural vegetation cover over the last five years
Habitat fragmentation – Total length of all roads in a country divided by land area.
Degradation – Percent of land area that is either severely or very severely degraded (FAO/AGL Terrastat definitions)
Terrestrial Reserves – Percent of terrestrial land area legally set aside as no take reserves
Marine Reserves – Percentage of continental shelf legally designated as marine protected areas (MPAs).
Intensive Farming – Annual tonnage of intensively farmed animal products (includes aquaculture, pigs, poultry) produced over the last five years per square kilometer land area.
Fertilizers – Average annual intensity of fertilizer use over the total land area over the last 5 years.
Pesticides – Average annual pesticides used as kg/km^2/year over total land area over last 5 years.
Biotechnology – Cumulative number of deliberate field trials of genetically modified organisms conducted in the country since 1986.

Environmental Vulnerability Index

Productivity Over-fishing – Average ratio of productivity : fisheries catch over the last 5 years
Fishing Effort – Average annual number of fishers per kilometer of coastline over the last 5 years
Renewable Water – Average annual water usage as percentage of renewable water resources over the last 5 years
SO_2 **Emissions** – Average annual SO_2 emissions over the last 5 years.
Generated and imported toxic, hazardous and municipal wastes per square kilometer land area over the last 5 years
Waste Treatment – Mean annual percent of hazardous, toxic and municipal waste effectively managed and treated over the past 5 years.
Industry – Average annual use of electricity for industry over the last 5 years per square kilometer of land
Spills – Total number of spills of oil and hazardous substances greater than 1000 liters on land, in rivers or within territorial waters per million km maritime coast during the last five years
Mining – Average annual mining production (include all surface and subsurface mining and quarrying) per km2 of land area over the past 5 years.
Sanitation – Density of population without access to safe sanitation (WHO definitions)
Vehicles – Number of vehicles per square kilometer of land area (most recent data)
Population – Total human population density (number per km^2 land area)
Population Growth – Annual human population growth rate over the last 5 years
Tourists Average annual number of international tourists per km2 land over the past 5 years.
Coastal Settlements – Density of people living in coastal settlements, i.e. with a city center within 100 km of any maritime or lake* coast.
Environmental Agreements – Number of environmental treaties in force in a country.
Conflicts – Average number of conflict years per decade within the country over the past 50 years.

Environmental Vulnerability Index

Rank	Country	Index	Bracket
1	French Guiana	174	Resilient
2	Western Sahara	175	Resilient
3	Botswana	181	Resilient
4	Central African Republic	193	Resilient
5	Namibia	200	Resilient
6	Zimbabwe	200	Resilient
7	Guyana	207	Resilient
8	Mongolia	208	Resilient
9	Niger	208	Resilent
10	Djibouti	210	Resilient
11	Zambia	210	Resilient
12	Gabon	211	Resilient
13	Suriname	211	Resilient
14	Kazakhstan	215	At risk
15	Mali	215	At risk
16	Svalbard	215	At risk
17	Chad	217	At risk
18	Congo	219	At risk
19	Falkland Islands	223	At risk
20	Mozambique	225	At risk
126	Antigua & Barbuda	307	Vulnerable
127	Thailand	308	Vulnerable
128	Hong Kong	309	Vulnerable
129	Niue	309	Vulnerable
130	Jordan	310	Vulnerable
131	Sweden	311	Vulnerable
132	Anguilla	312	Vulnerable
133	Malaysia	312	Vulnerable
134	Brunei	313	Vulnerable
135	Iran	313	Vulnerable
136	Cyprus	314	Vulnerable
137	Lithuania	314	Vulnerable
138	Czech Republic	315	Vulnerable
139	Grenada	315	Vulnerable
140	Malta	316	Highly vulnerable
141	Indonesia	316	Highly vulnerable
142	Macedonia	316	Highly vulnerable
143	Ukraine	317	Highly vulnerable
144	Ireland	318	Highly vulnerable
145	Moldova	322	Highly vulnerable
146	Bulgaria	323	Highly vulnerable