

Lesson 6

Sustainable Development

Prof. Claudio Cameselle



Table of Contents

Lesson 6: Sustainable Development.

- 6.1. Environmental Impacts.
- 6.2. Sustainable development
- 6.3. Ecological Indicators
- 6.4. Ecological footprint
- 6.5. Life-Cycle Assessment
- 6.6. Carbon footprint

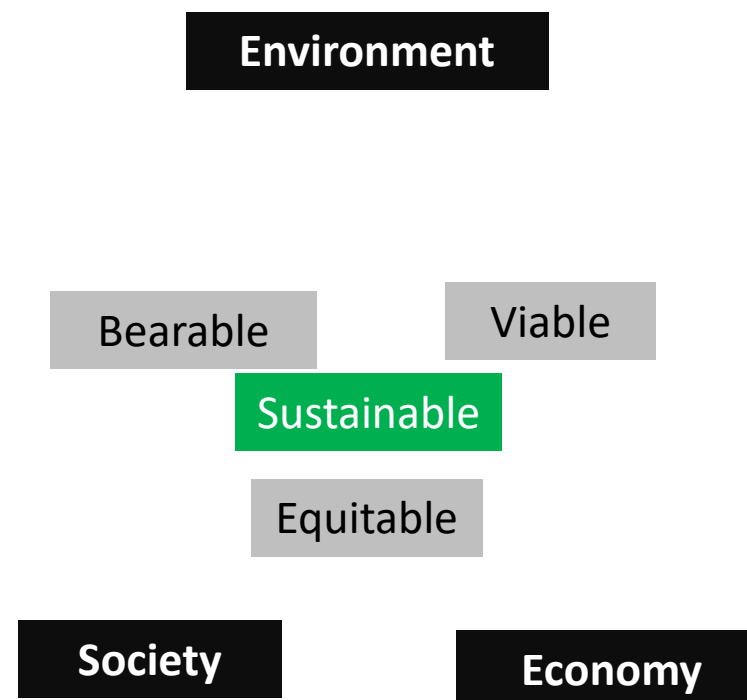
Environmental Impacts

1. Global warming and climate change
2. Desertification
3. Deforestation
4. Loss of habitat and biodiversity
5. Ozone layer depletion
6. Air pollution
7. Smog
8. Acid rain
9. Water usage and pollution
10. Eutrophication
11. Salinity
12. Wastes and disposal
13. Land contamination
14. Visibility
15. Odors
16. Aesthetic degradation
17. Land use patterns
18. Thermal pollution
19. Noise pollution

Sustainable Development

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Report of the World Commission on Environment and Development (WCED), 1987).

The three pillars of sustainable development



Ecological Indicators

Ecological indicators are used to communicate information about ecosystems and the impact human activity has on ecosystems.

Indicator	Date	Authors	Origen	Brief explanation
Ghost Area	1965	G. Brogstrom	USA	unlimited external area required to keep the population within the limits of its territory
Environmental Space	1980's	J.B. Opschoor	Holand	There are limits to the environmental pressure without irreversible ecosystem damage.
Emergy	1988	H.T. Odum	USA	Emergy accounts for all the necessary solar energy to obtain a product or service.
Ecological Footprint	1990's	W. Rees & M. Wackernagel	Canada	
Ecological Rucksack	1993	F. Schmidt-Bleek	Germany	the total quantity (in kg) of materials removed from nature to create a product or service, minus the actual weight of the product.
Water Footprint	2002	A. Hoekstra	Holand	

Indicators

The **water footprint** of an individual, community or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business.

The **carbon footprint** is the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO₂).

The ecological footprint is a measure of human demand on the Earth's ecosystems. The **ecological footprint (EF)** is defined as the amount of biologically productive land and sea area necessary to supply the resources a human population consumes, and to assimilate associated waste.

Ecological Footprint

The ecological footprint can be determined for each country or region, evaluating the area (land or aquatic ecosystem) needed to obtain the resources and assimilate the wastes.

The different ecosystems have different productivity, and therefore the value of the area will not be a direct sum of the available ecosystem area. The real productivity of each ecosystem must be considered, so the productivity of each ecosystem will be expressed in global hectares (gha). EF is expressed in gha per capita.

The capacity of an area to provide resources and absorb wastes is called **biocapacity (BC)**.

Comparing the biocapacity and the ecological footprint of a country, region or territory, it was observed that some countries would need more area than they have available.

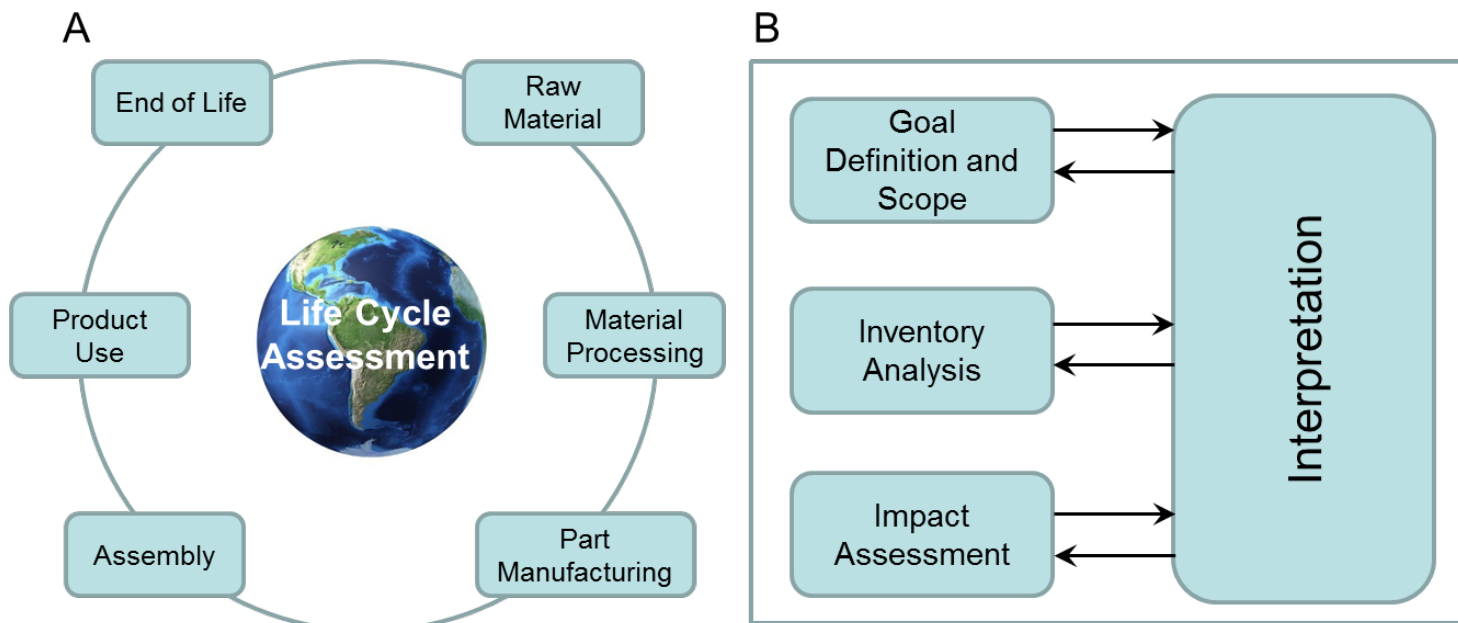
Ecological deficit (ED) is defined as the difference between the biocapacity and Ecological Footprint of a region or country.

$$ED = EF - 0.88 \cdot BC$$

Life Cycle Assessment

Life cycle assessment (LCA) is an environmental management indicator that analyzes the environmental impacts of a product throughout its life cycle (from cradle to grave), or more precisely, the environmental impacts of the system required for a product to meet a particular function.

Life Cycle Assessment



Carbon Footprint

Carbon footprint is the total greenhouse gases (GHG) emitted directly or indirectly by an individual, organization, event or product. The carbon footprint is measured in units of mass of CO₂ equivalent (CO₂e). It is determined by an inventory of GHG emissions according to recognized international standards such as ISO 14064, PAS 2050 or GHG Protocol.

GHG Protocol: <http://www.ghgprotocol.org/>

PAS 2050: <http://www.bsigroup.es/> and <http://www.bsigroup.com/>

ISO 14064-1, 2 and 3: <http://www.iso.org/>

The term "CO₂e" includes the greenhouse gases defined by the Kyoto Protocol

GHG	GWP (100 years)
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	25
Nitrous oxide (N ₂ O)	298
Hydrofluorocarbons (HFCs)	150 – 14800 C ₂ H ₄ F ₂ - CHF ₃
Perfluorocarbons (PFCs)	6500 – 9200 CF ₄ – C ₂ F ₆
Sulfur hexafluoride (SF ₆)	23900

GHG Inventory

Direct emissions: emissions from sources owned or controlled by the subject of the activity

Indirect emissions: emissions resulting from the activities of the subject that occur at sources owned or controlled by another subject.

1. Direct emissions: e.g. Emissions from heating systems or vehicles
2. Indirect emissions from power generation: emissions from energy consumption that do not belong to the individual.
3. Other indirect emissions: emissions resulting from the activity of the individual but the emission sources are outside the activity center of the individual. E.g. transportation of raw materials, fuel or products, commuting ...

Personal Carbon Footprint

Electricity	2181 kwh	0.242 kg CO ₂ -e/kwh	527.80 kg CO ₂ -e
Natural gas	20 m ³	2.15 kg CO ₂ -e/m ³	43.00 kg CO ₂ -e
Butane	12 bottle	37.06 kg CO ₂ -e/bottle	444.72 kg CO ₂ -e
Diesel	550 L	2.61 kg CO ₂ -e/L	1435.50 kg CO ₂ -e
Bus	3000 km	0.065 kg CO ₂ -e/km	195.00 kg CO ₂ -e
Water	63 m ³	0.09 kg CO ₂ -e/m ³	5.67 kg CO ₂ -e
Wastes	332.15 kg	0.61 kg CO ₂ -e/kg	202.61 kg CO ₂ -e
ToTal			2854.30 kg CO₂-e

Diesel
10000 km/year
5.5 L/100 km

Wastes
0.91 kg/capita·day

Bus
20 km/day
5 days/week
30 weeks

