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Towards the Assessment of an Ecological Index for Quantifying Sustainability of Day Life. A Case Study of the Environmental Consequences of Dietary and Transport in a Standard Workday

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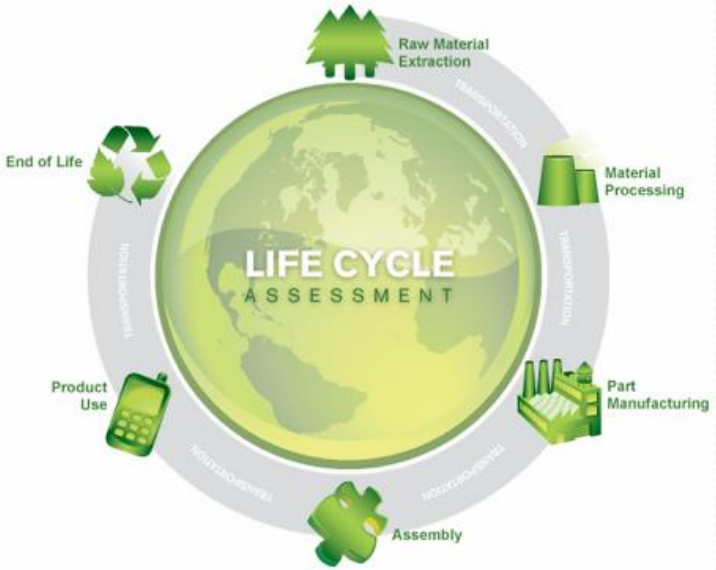
Aim of the work

Evaluation of a

SUSTAINABILITY INDEX

pertaining to a typical workday:

DIETARY vs TRANSPORT



✓Present an overview of environmental loads due to choices of an individual consumer, adopting the Life Cycle Assessment (LCA) methodology

✓Offer to individual consumers the possibility to reflect about how to fulfill our daily need, taking in consideration also the planet and the sustainability

The environmental load of food (1)

✓ Recent LCA studies showed that environmental impacts associated to the food are severely high

✓ High environmental damages come from intensive agriculture and farming (massive use of pesticides and chemical fertilizers)

✓ A report of the FAO (2006) has estimated that modern farming appears as the first contributor to GWP, producing the 18% of the total amount while transport by contrast accounts just for 13%

The environmental load of food (2)

✓To produce 1 kg of beef meat, 100000 liters of water are required

✓ A large part of the Amazon forest has been recently destroyed and used for grazing

✓Intensive farming is also indirectly linked to malnutrition, using cereals and food to feed animals instead that the local population directly (to produce 1 kg of meat appr. 15 kg of cereals are required)

Environmental effects of transport (1)

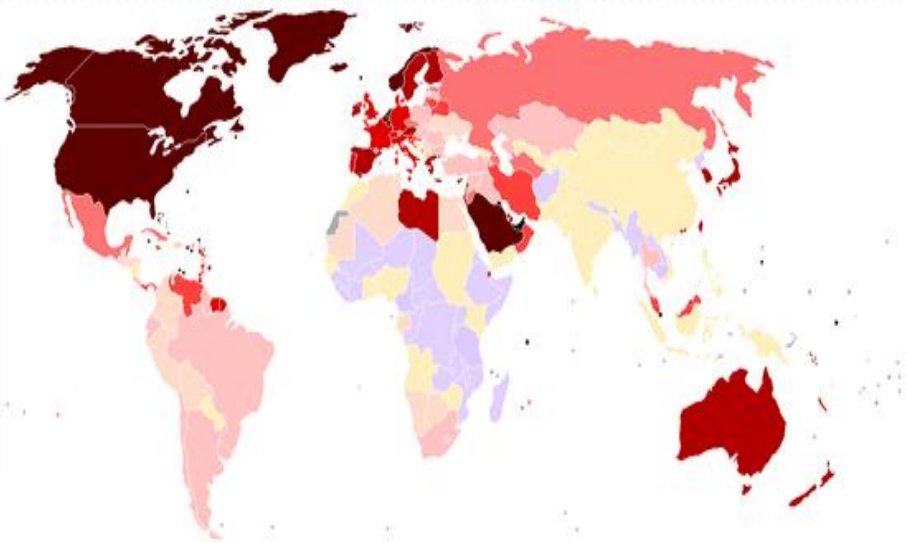
Country	Number of cars every 100 persons
Greece	35,0
Denmark	35,3
Portugal	38,2
Ireland	38,5
Norway	42,6
Finland	43,5
Netherland	44,4
Sweden	45,9
Spain	46,9
Belgium - Luxembourg	47,2
France	49,8
Austria	50,3
UE	**50,5**
Great Britain	50,5
Switzerland	51,8
Germany	54,6
Iceland	57,8
Italy	59,2

The table shows the density of cars in Europe

✓ Studies by the American Public Transportation Authority (APTA) show that public transportation produces 95% less carbon monoxide and nearly 50% less carbon dioxide and nitrogen oxide per passenger mile than a private vehicle does

✓In the year 2002, 9.4 billion people took trips on public transit. They were 23.4 billions in 1946.

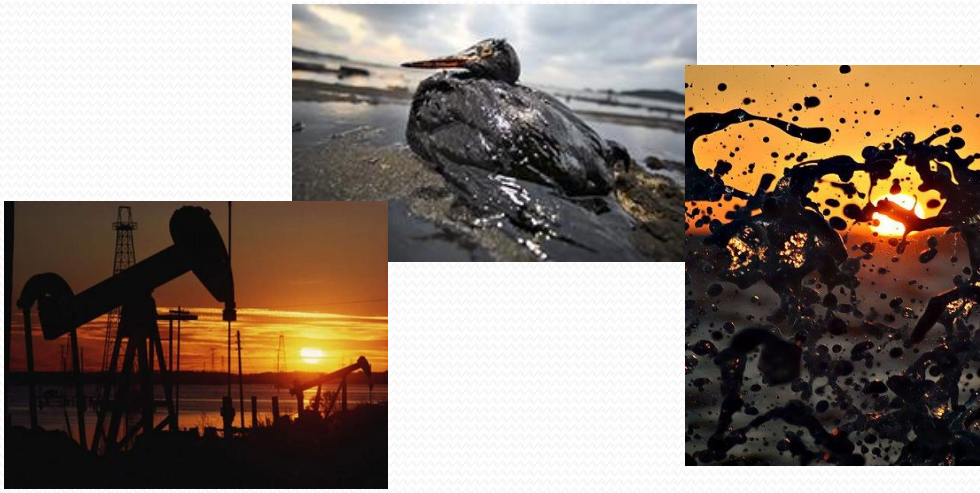
The figure shows the oil consumption per capita (darker colors represent more consumption)



Environmental effects of transport (2)

Consuming Nation 2008	kbbl/day	population in millions	bbl/year per capita
United States	19,497.95	314	22.6
China	7,831.00	1345	2.1
Japan	4,784.85	127	13.7
India	2,962.00	1198	**0.9**
Russia	2,916.00	140	7.6
Germany	2,569.28	82	11.4
Brazil	2,485.00	193	4.7
Saudi Arabia (OPEC)	2,376.00	25	**13**
Canada	2,261.36	33	24.6
South Korea	2,174.91	48	16.4
Mexico	2,128.46	109	7.1
France	1,986.26	62	11.6
Iran (OPEC)	1,741.00	74	8.6
United Kingdom	1,709.66	61	10.1
Italy	1,639.01	60	10

The table shows the consumptions of crude oil of the first 15 consuming countries
(Source: US Energy Information Administration)



- ✓ Percentage of crude oil for transport 57.7
- ✓ The transport percentage is still divided as:
  - Automotive 80%
  - Aviation 13%
  - Ships 1.8%
  - Rail 1.4%

(Source IEA 2002)

The study

✓ **Typical day of work**: many workers go to work and eats in a canteen

✓ **Dietary** - Four different menus were proposed:

Beef Menu: rice (100g), beef steak (120g), carrots (150g), bread (50g)

Poultry Menu: rice (100g), poultry (120g), carrots (150g), bread (50g)

Pork Menu: rice (100g), pork steak (120g), carrots (150g), bread (50g)

Veg Menu: rice (100g), peas (120g), carrots (150g), bread (50g)

✓ **Transportation** - Different options were considered on the basis of an European average: public (bus, tram) and private (passenger car, considering both petrol and diesel fuelled car, and bicycle).

Impact indicators

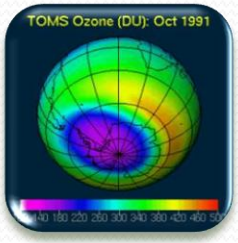
Software SimaPro

1 CED - Cumulative Energy Demand

It is referred to the energy use in the entire life cycle of the process. Results are commonly divided between renewable and non-renewable energy sources

2 GWP - Global Warming Potential

It is caused by increase of atmospheric temperature following the massive increase of greenhouse gases such as CO2 and water vapor which can absorb the radiation infrared emitted from the earth



3 ODP – Ozone Layer Depletion

Ozone is the gas that characterizes the stratosphere and its function is to shield the Earth from ultraviolet rays of the sun, CFCs affect the ozone molecules and over time have created the well known "Hole "

4 POCP - Photochemical Oxidation

Photochemical ozone production in the troposphere, also known as summer smog, is suspected to damage vegetation and material. High concentrations of ozone are toxic to humans.

5 AP - Acidification Potential

It consists in decrease of the pH of lakes, rivers, forests and soil: this leads to serious consequences for humans and environment. The main causes are emissions from fossil fuels combustion

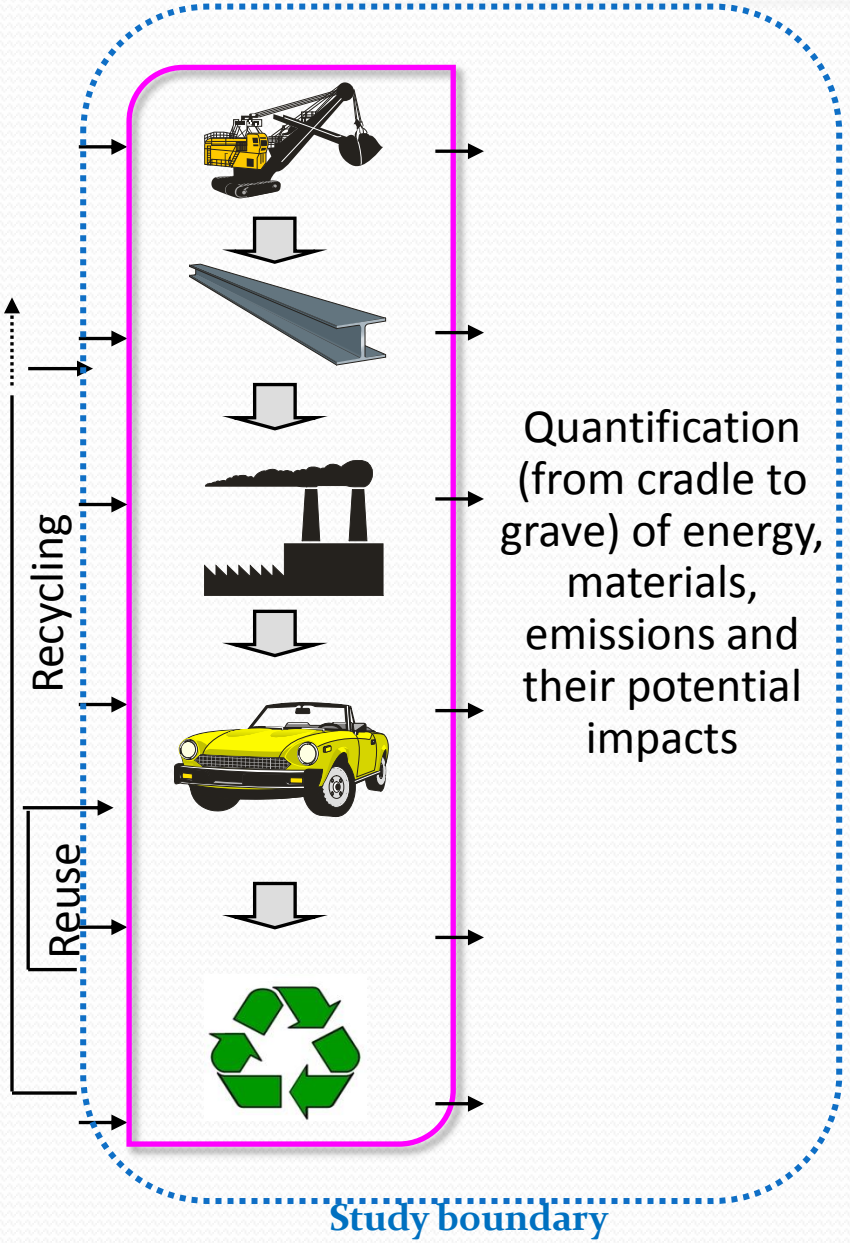
6 EP – Eutrophication Potential

The massive injection of substances such as phosphorus and nitrogen causes a decrease of oxygen content in soils and surface water lakes. Effect is evident due to the formation of supernumerary algae

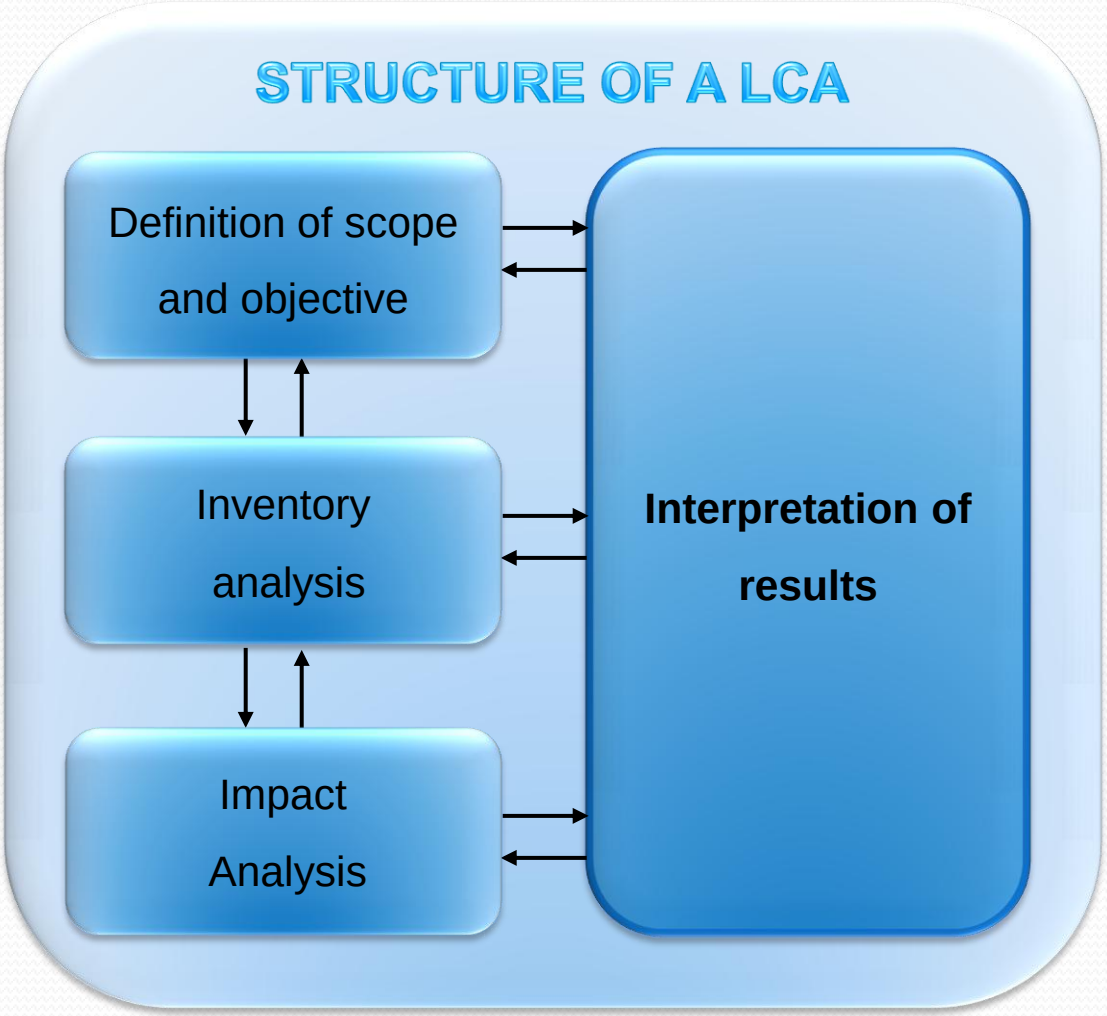
What is the LCA?

LCA is a tool for analysing and quantifying the environmental consequences of products (services) during all their life-cycle, from the extraction of raw materials, through industrial production, including the use phase and the end-of-life disposal "from-cradle-to-grave"

Environmental consequences of production/use systems include resource use as well as emissions harmful to human health and ecosystem quality



Structure of a LCA



This work aims to focalize its attention to the final stage (interpretation of results), proposing the evaluation of a **SUSTAINABILITY INDEX**: the environmental loads are characterized by a simple index that can be easily and quickly understood by decision makers and single consumers.

Sustainability Index

Index	Description	Percentage
1	Very low impact	0% - 15%
2	Low impact	16% - 40%
3	Medium impact	41% - 60%
4	High impact	61% - 85%
5	Very high impact	86% - 100%

It has been assumed that an impact achieving **1** or **2** as index can be considered as a sustainability promoter, **3** represent the sufficiency while **4** or **5** do not promote sustainability. In this case the indexes have been assigned on the basis of the percent values obtained dividing each impact value by the highest one of the same category.

Menus impacts

Menu	CED	GWP	ODP	POCP	AP	EP
	MJ	$kgCO_2eq$	kgCFC-11eq	kgC_2H_4eq	$kgSO_2eq$	$PO_4^{3-}eq$
beef menu	17.75	5.60	4.28 E-07	1.93 E-03	4.53 E-02	4.58 E-02
poultry menu	11.21	0.90	1.28 E-07	4.90 E-04	6.90 E-03	3.57 E-03
pork menu	10.83	0.93	1.56 E-07	5.73 E-04	7.62 E-03	4.54 E-03
veg menu	9.39	0.59	1.01 E-07	4.14 E-04	2.58 E-03	1.49 E-03
% beef menu	100	100	100	100	100	100
% poultry menu	63	16	30	25	15	8
% pork menu	61	17	37	30	17	10
% veg menu	53	11	24	21	6	3

Values of the single impacts associated to series of fully balanced menus that can be generally provided by a canteen, as well as the impact percentage.

Transport options impacts

Transport option	CED	GWP	ODP	POCP	AP	EP
	MJ	$kgCO_2eq$	kgCFC-11eq	kgC_2H_4eq	$kgSO_2eq$	$PO_4^{3-}eq$
passenger car (petrol)	31.42	1.82	2.14 E-07	2.95 E-03	4.93 E-03	1.41 E-03
passenger car (diesel)	28.83	1.65	2.07 E-07	1.65 E-03	4.77 E-03	1.50 E-03
Bus	16.78	1.04	1.52 E-07	1.54 E-03	6.07 E-03	1.58 E-03
Tram	11.90	0.26	1.96 E-08	1.73 E-03	1.10 E-03	6.23 E-04
Bicycle	0	0	0	0	0	0
% passenger car (petrol)	**100**	**100**	**100**	**100**	**81**	**89**
% passenger car (diesel)	**92**	**91**	**97**	**56**	**79**	**95**
% bus	**53**	**57**	**71**	**52**	**100**	**100**
% tram	**38**	**14**	**9**	**59**	**18**	**39**
% bicycle	**0**	**0**	**0**	**0**	**0**	**0**

Impact values and impact percentages of the proposed transport options referred to a travel route of 10 km.

Results - Menus

Menu	Average	CED	GWP	ODP	POCP	AP	EP
beef menu	5.00	5	5	5	5	5	5
poultry menu	2.00	4	2	2	2	1	1
pork menu	2.17	4	2	2	2	2	1
vegetarian menu	1.67	3	1	2	2	1	1

The above Table presents the **sustainability indexes** related to the fully-balanced menus of the canteen:

- ✓the *beef menu* can be totally rejected as promoter of sustainability
- ✓the *vegetarian menu* represents the best available option for the environment with a average mark of 1.67
- ✓between these two options there are the alternatives presenting *pork or poultry* in the menus, with sustainability index values around 2, that in the present work are still considered promoters of sustainability.

Results – Transport options

Transport option	Average	CED	GWP	ODP	POCP	AP	EP
passenger car (petrol)	5.00	5	5	5	5	5	5
passenger car (diesel)	4.50	5	5	5	3	4	5
Bus	3.83	3	3	4	3	5	5
Tram	1.83	2	1	1	3	2	2
Bicycle	1.00	1	1	1	1	1	1

The above Table reports the sustainability marks related to the transport options considered by this study:

- ✓the private fuelled-options (*petrol and diesel car*) can be rejected as promoter of sustainability
- ✓the *public options* represent a more eco-friendly alternative
- ✓in particular the *tram* represents a preferable option in comparison to the *bus*
- ✓the *bicycle* is the best option ever and its promotion in the town can be a very effective solution to sustain the environmental protection.

Results – Transport options

	beef menu	poultry menu	pork menu	veg menu
passenger car (petrol)	5.00	3.50	3.58	3.33
passenger car (diesel)	4.75	3.25	3.33	3.08
Bus	4.42	2.92	3.00	2.75
Tram	3.42	1.92	2.00	1.75
Bicycle	3.00	1.50	1.58	1.33

The above Table shows the sustainable behaviours of a hypothetical worker, combining menus and means of transportation:

- ✓the choice of the *beef* at lunch never implies a sustainable behaviour and only when supported by the use of the *bicycle* achieves the sufficiency
- ✓a *vegetarian* worker promotes the sustainability and, in particular when used together with *the bicycle*, produces a very low impact
- ✓between these two dietary options, there are the menus having on *poultry* and *pork*, that when combined with *public transport* or with the *bicycle* represents a sustainable option, while when they are associated to a *private car* do not constitute a virtuous behaviour.

Conclusion

The study proposed evaluates the sustainability of daily habits of individual workers taking into account dietary and transportation, assessing a **sustainability index** that resumes the results of a LCA analysis

- The results here presented show clearly how the possibility to prefer the use of public or ecological solutions, like tram or bicycle, as well as a wider diffusion of a vegetarian or at least beef-free dietary, can largely promote the environmental sustainability.
- This work proposes a simple and quick presentation of the LCA results with specific marks, which can facilitate the interpretation of the sustainability level of daily behaviours or industrial productions.
- The Authors proposed a scale to quantify the environmental burden resulting from a LCA analysis, believing how the establishment of internationally-accepted parameters defined by well known and respected institution, such as International environmental agencies, or governments agreement, will facilitate the penetration of the LCA adoption within companies and productive realities as well as increase the idea of sustainable development in the public opinion.
- It is important to underline that this paper has the aim to propose a method for simplifying LCA results interpretation and wants to be a baseline for further studies.

Thanks
for your attention

Don't eat meat *Ride the bike*

Rajendra Pachauri
Nobel Prize - Director of the IPCC