Life Cycle Assessment (LCA) and LC-MAP

Workshop on Life Cycle Assessment and GIS Tools for Energy planning (TW3-TW4)

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Siena
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AGENDA

• What is the Sustainable development
• Sustainability Indicators
• Life Cycle Assessment and Carbon Footprint
• From theory to practice: application to case studies in the olive oil sector
• Example of International Environmental labels
WHAT IS SUSTAINABILITY?

The SUSTAIN is the pedal that keeps constant the sound over time.
WHAT IS 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.

ref:  World Commission on Environment and Development (the Brundtland Commission) Our common future (1987)
WHAT IS SUSTAINABLE DEVELOPMENT?

“Meeting the needs of the future” depends on how we balance social, economic and environmental objectives (or needs) when making decisions today.

The three pillars of sustainability
WHAT IS SUSTAINABLE DEVELOPMENT?

“Meeting the needs of the future” is possible when:

social, economic and environmental systems are well balanced, in equilibrium

........ BUT ........

THE SOCIAL AND ECONOMIC SYSTEMS HAVE DIFFERENT AND FASTER DYNAMICS THAN THE ENVIRONMENTAL SYSTEM
Is it possible to measure the sustainability?

How do you feel?

• In the **ideal state** *(when you feel good)*, you **don’t measure** it

• **Out of the ideal state** *(I have a high temperature, I have a high cholesterol level, I have a high blood pressure, .... )* you can **measure** it!!!

• We use **indicators** to express **how much we are distant** to the ideal state
Is it possible to measure the sustainability?

It is possible to measure (evaluate) the distance to sustainability by using **Indicators**.
What are sustainability indicators?

• Sustainability Indicators are **tools** for the environmental management and communication that allow for the **environmental profiling of products** and showing clear and easily understandable outcomes.

• Sustainability Indicators are based on **environmental assessment methodologies** such as the **Life Cycle Assessment (LCA)**.
What is LCA?

The LCA - Life Cycle Assessment – is a method that assesses different environmental impact categories of a production process/system.

Based on international standards (ISO 14040-14044), the LCA allows for estimating potential environmental impacts in air, water and soil due to the lifecycle of a product “from cradle to grave”, that is from raw material drawing to the end-of-life, including all processes involved in the supply chain.
LCA OF COFFEE

THE LIFE CYCLE OF COFFEE

IMPACT ASSESSMENT

END-OF-LIFE OF THE CAPSULE
- 6%

MACHINE USE
- 21%

DISTRIBUTION
- 8%

MACHINE MANUFACTURING
- 8%

OTHER PACKAGING (MATERIAL AND MANUFACTURING)
- 12%

CAPSULE (MATERIAL AND MANUFACTURING)
- 12%

COFFEE CULTIVATION AND PROCESSING
- 33%
The LCA of products
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

1. **GOAL AND SCOPE DEFINITION**
2. **INVENTORY ANALYSIS (LCI)**
3. **IMPACT ASSESSMENT (LCIA)**
4. **INTERPRETATION**
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

1. **GOAL AND SCOPE DEFINITION**: it is of crucial importance because in this phase are defined e.g. the purposes, the product/system (reference flow called Functional Unit, FU), the intended audience of the study

2. **INVENTORY ANALYSIS (LCI)**

3. **IMPACT ASSESSMENT (LCIA)**

4. **INTERPRETATION**
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

2. INVENTORY ANALYSIS (LCI): • it starts from drawing a flowchart that easily describes the system under study
   • it accounts for input and output flows of materials, energy and water, from raw material extraction to EoL
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

2. **INVENTORY ANALYSIS (LCI):** • input and output data are quantified by firstly filling a questionnaire (with the producer) and then are organized in an excel sheet according to ISO rules
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

2. **INVENTORY ANALYSIS (LCI):** inventory data could be of two type

### FOREGROUND DATA

<table>
<thead>
<tr>
<th>Completed by:</th>
<th>Date of completion:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit process identification:</td>
<td>Reporting location:</td>
</tr>
<tr>
<td>Time period: Year</td>
<td>Starting month:</td>
</tr>
<tr>
<td>Description of unit process: (attach additional sheet if required)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material inputs</th>
<th>Units</th>
<th>Quantity</th>
<th>Description of sampling procedures</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### BACKGROUND DATA

Data from **international literature or database**

*e.g. Ecoinvent, Agrifootprint, USLCI*

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**Data sampled in field with producers**

**Data that derives from other certified studies**
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

3. IMPACT ASSESSMENT (LCIA): translates the inventoried data in environmental impacts based on indicators (they indicate the level of sustainability of a process/system)

The Impact Assessment needs a specific software to calculate results
Which indicators are based on LCA?

- CARBON FOOTPRINT (ISO 14067: 2013)
  (CO₂ eq)
- ACIDIFICATION
  (SO₂ eq – sulfur oxides eq)
- EUTROPHICATION
  (PO₄ eq – phosphate eq)
- ECOTOXICITY IN FRESHWATER AND SEA
  (1,4 DB dichlorobenzene eq)
- HUMAN TOXICITY
  (1,4 DB dichlorobenzene eq)
...
- WATER FOOTPRINT (ISO 14046: 2014)
Which indicators are based on LCA?

- The **Water Footprint** estimate the amount of water used directly or indirectly in a production chain, to produce good and services.
- It is regulated by **ISO 14046: 2014 Water Footprint**
Which indicators are based on LCA?

- The **Carbon Footprint** is the estimate of **direct and indirect greenhouse gas emissions** (e.g. CO\(_2\) carbon dioxide, CH\(_4\) methane, N\(_2\)O nitrous oxide...) in atmosphere generated by a production chain.

- These emissions are calculated in terms of **equivalent CO\(_2\)** (kg CO\(_2\)\,-eq).

- The estimate of **greenhouse gases**, emitted to obtain a product, is **indicative of the sustainability level** of a supply chain regarding an **environmental issue at global level**, that is the **global warming and climate change**.

- It is regulated by **ISO/TS14067: 2013**.
Which indicators are based on LCA?
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

4. **INTERPRETATION:** • it **organizes** the results of the previous three phases in a **comprehensible way** to have a **global view** on the lifecycle of product/systems

• it help to **point out hotspots** (processes with higher impacts) and **options for improvement** (impact mitigation)
LCA in four steps

According to ISO 14040, the LCA consists in four main phases:

4. INTERPRETATION: • it is called iterative process because in every moment you can come back to the previous phase, if the analysis is not consistent with objectives

• it is the base for communicate results and support the eco-labelling
Communication of LCA results

REPORTS:
Communication of LCA results

INFOGRAPHICS:

Carbon footprint of a can of Coca-Cola at a glance

1 Sunday roast (non-UK ingredients) = 10.5 x
1 kg of grapes from South Africa = 32.3 x
1 return flight to New York = 588 x

PRODUCT Carbon Footprint in the United Kingdom

In partnership with The Carbon Trust, we assessed the carbon footprint of some of our most popular beverages in the packaging sizes of a 330-mL can, 330-mL glass bottle, 500-mL PET plastic bottle and 2-liter PET plastic bottle. This chart shows the results of a 500-mL PET plastic bottle of Coca-Cola.

- Packaging: 43.1%
- Retailer/Vending (Refrigeration): 24.5%
- Ingredients: 14.0%
- Manufacturing: 11.0%
- Distribution: 6.7%
- Consumer Use and Disposal: 0.7%

To see the other carbon footprint calculations done in this evaluation, visit www.cokescorporateresponsibility.co.uk/carbontrust.
Communication of LCA results

**INFOGRAPHICS:**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Ecological Footprint</th>
<th>Carbon Footprint (GWP)</th>
<th>Water Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1/ almond production</td>
<td>9.2</td>
<td>795</td>
<td>1.586</td>
</tr>
<tr>
<td>Phase 2/ processing</td>
<td>0.1</td>
<td>54</td>
<td>0</td>
</tr>
<tr>
<td>Phase 3/ packaging</td>
<td>0.6</td>
<td>128</td>
<td>2</td>
</tr>
<tr>
<td>Distribution</td>
<td>0.8</td>
<td>273</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>10.9 (global m/kg)</td>
<td>1.332 g CO₂/kg</td>
<td>1.592 liters/kg</td>
</tr>
</tbody>
</table>

How much is the Carbon Footprint of Ricciarelli (50g)?

- **100g CO₂eq**
- (≥ 300 m by car)

**Ricciarelli di Siena IGP**

- phase 1/ almond production
- phase 2/ processing
- phase 3/ packaging
FROM THEORY TO PRACTICE
LCA OF OLIVE OIL

1. GOAL AND SCOPE DEFINITION

The aim of the study is to demonstrate if organic olive oil represent a better choice both for consumers and producers in terms of environmental loadings.
LCA OF OLIVE OIL

1. GOAL AND SCOPE DEFINITION: identify the main phases

- Olive grove
- Field management
- Harvesting
- Transport
- Milling
- Oil extraction
- Bottling and storage
LCA OF OLIVE OIL

1. GOAL AND SCOPE DEFINITION: simplified flowchart
## LCA OF OLIVE OIL

### 2. INVENTORY ANALYSIS (LCI):

#### FOREGROUND DATA

<table>
<thead>
<tr>
<th>INPUT PHASE 1</th>
<th>unit/UF</th>
<th>conventional</th>
<th>organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>machineries</td>
<td>kg</td>
<td>1.08E-01</td>
<td>3.54E-01</td>
</tr>
<tr>
<td>machineries, tyres</td>
<td>kg</td>
<td>5.04E-02</td>
<td>3.59E-01</td>
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<tr>
<td>fertilizers</td>
<td>kg</td>
<td>7.87E-01</td>
<td>2.96E-03</td>
</tr>
<tr>
<td>pesticides</td>
<td>kg</td>
<td>1.90E+00</td>
<td>8.00E-02</td>
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<tr>
<td>water</td>
<td>kg</td>
<td>3.42E+02</td>
<td>5.08E+02</td>
</tr>
<tr>
<td>diesel</td>
<td>J</td>
<td>6.36E+06</td>
<td>1.50E+08</td>
</tr>
<tr>
<td>electricity</td>
<td>J</td>
<td>1.71E+07</td>
<td>2.40E+07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT PHASE 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>machineries</td>
<td>kg</td>
<td>3.62E-02</td>
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<tr>
<td>cast iron</td>
<td>kg</td>
<td>1.31E-03</td>
<td>1.36E-04</td>
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<tr>
<td>alluminium</td>
<td>kg</td>
<td>4.83E-02</td>
<td>5.00E-03</td>
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<tr>
<td>pig iron</td>
<td>kg</td>
<td>8.69E-02</td>
<td>9.00E-03</td>
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<tr>
<td>glass</td>
<td>kg</td>
<td>1.30E+01</td>
<td>1.35E+00</td>
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<tr>
<td>water</td>
<td>kg</td>
<td>4.55E+01</td>
<td>4.71E+00</td>
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<tr>
<td>transport, steel</td>
<td>kg</td>
<td>1.08E-02</td>
<td>1.02E-01</td>
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<tr>
<td>transport, tyres</td>
<td>kg</td>
<td>9.20E-01</td>
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<tr>
<td>diesel</td>
<td>J</td>
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<td>electricity</td>
<td>J</td>
<td>1.94E+06</td>
<td>1.94E+06</td>
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#### BACKGROUND DATA

<table>
<thead>
<tr>
<th>Phases</th>
<th>Sub-processes</th>
<th>Data</th>
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<tbody>
<tr>
<td>Agricultural phase</td>
<td></td>
<td>• Ecoinvent and SimaPro data base</td>
</tr>
<tr>
<td>OMW spreading</td>
<td></td>
<td>• Literature data (Rana et al., 2003; Roig et al., 2006); Vlyssides et al., 2004)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ecoinvent and SimaPro data base</td>
</tr>
<tr>
<td>Fertilization</td>
<td></td>
<td>• Estimation from (Brentrup et al., 2000)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ecoinvent and SimaPro data base</td>
</tr>
<tr>
<td>Pest treatment</td>
<td></td>
<td>• Estimation from (Birkved et al. 2006)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ecoinvent and SimaPro data base</td>
</tr>
<tr>
<td>Oil production</td>
<td>Olive oil production</td>
<td>• Literature data (Caputo et al., 2002; De Gennaro et al., 2005; Roig et al., 2006; Vlyssides et al., 2004)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ecoinvent and SimaPro data base</td>
</tr>
</tbody>
</table>
3. IMPACT ASSESSMENT (LCIA):
LCA OF OLIVE OIL

4. RESULTS INTERPRETATION AND COMMUNICATION:

Organic extra virgin olive oil
How much is the Carbon Footprint of 15g of oil?
(3 spoons)

CO$_2$ saving
466 g CO$_2$-eq = 1.3 km by car

-72% vs conventional

phase 1/ olive grove

phase 2/ oil milling

phase 3/ bottling

82%

11%

8%
LCA APPLIED TO RES
(BIOFUEL FROM LIGNOCELLULOSIC AND ALGAL BIOMASS)

1. GOAL AND SCOPE DEFINITION: which biomass is more sustainable to produce biofuel?

Main phases

CULTIVATION   HARVESTING   BIOETHANOL / BIOGAS PRODUCTION

Flowchart
LCA APPLIED TO RES
(BIOFUEL FROM LIGNOCELLULOSIC AND ALGAL BIOMASS)

2. INVENTORY ANALYSIS (LCI)
3. IMPACT ASSESSMENT (LCIA)
4. INTERPRETATION
LCA APPLIED TO RES
(BIOFUEL FROM LIGNOCELLULOSIC AND ALGAL BIOMASS)

3. IMPACT ASSESSMENT (LCIA)

4. INTERPRETATION

THE BEST BIOMASS TO PRODUCE BIOFUEL IN TERMS OF CARBON FOOTPRINT (PER JOULE OF BIOETH.)
LC-MAP
THE LIFE CYCLE ASSESSMENT (LCA) EXPLAINED IN A C-MAP
Il modo migliore per iniziare è fare un monitoraggio lca

1. Let’s make our planet great again!
ENJOY YOUR STAY IN SIENA!!!
THANK YOU

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