Life Cycle Assessment: A simple overview of a complex process

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Everything is Connected

Source: R. E. Ricklefs' Economy of Nature
Everything is changing
Every process has inputs and outputs
The more processes, the more complexity

- Raw Materials
- Manufacturing Process
  - Energy
  - Water
  - Gas Waste
  - Liquid Waste
  - Solid Waste
- Energy
- Water
- Solid Waste
- Liquid Waste
- Gas Waste
- End Product
Life Cycle Assessment quantifies processes

**Goal:** Quantify inputs and outputs for a system in terms of a standardized unit of measure.

The scope and structure of the LCA are directly dependent upon the unit of measure (functional unit):
1. Energy embodied in a single product;
2. Green house gasses produced per unit product;
3. Tons of carbon produced per volume of product;
4. Volume of water consumed per mass of product…

Goal and Scope of LCA must be formulated at the outset of the project, and the **functional unit must be defined**.

LCA Process is described in ISO 14040 and 14044 Standards.
Four Phases of a Life Cycle Assessment

- Phase 1: Goal Definition and Scope
- Phase 2: Life Cycle Inventory
- Phase 3: Life Cycle Impact Assessment
- Phase 4: Assessment/Scenario Analysis
Life Cycle Assessment: Reconciling Functional Units

Greenhouse Gas Potentials

1 g CO$_2$ = 1 g CO$_2$-equiv.

1 g CH$_4$ = 25 g CO$_2$-equiv.

1 g NO$_2$ = 310 g CO$_2$-equiv.
Cotton LCA Case Study
Phase 1: Goal Definition and Scope

- **Develop** a model

- **Estimate** the energy embodied in a unit (metric ton or 480 lb bale) of cotton produced (lint plus seed)

- **Compare** the total energy (MJ) required over varying cotton production strategies
### Cotton LCA Case Study

**Phase 2: LCA Inventory**

<table>
<thead>
<tr>
<th>Region</th>
<th>Production Strategy</th>
<th>Irrigation</th>
<th>Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America East</td>
<td>Mechanized</td>
<td>Med</td>
<td>High</td>
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<tr>
<td>Africa - Non Mech</td>
<td>Non-Mechanized</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
Africa Cotton Production: Organic Fertilizer and Non-Irrigated
Cotton LCA Case Study
Phase 3: Impact Assessment
North America: Eastern United States

Field Preparation | Mechanical
---|---
Planting | Mechanical
Irrigation | Mechanical
Pest Control | Mechanical

Weed Control | Mechanical
Fertilization | Mechanical Application
Embodied Chemical
Harvesting | Mechanical
Yield | MJ/Tonne of Cotton
Cotton LCA Case Study
Phase 4: Assessment/Scenario Analysis

Embodied Energy of Cotton Production MJ/Tonne

North America East
North America West
South America Mechanized
South America Non-Mech
Australia
Mediterranean Mech
Mediterranean Non-Mech
Asia Mech
Asia Non-Mech
Africa Non-Mech
Life Cycle Assessment Case Study: Carbon Equivalent GHG of Fluid Milk

Production → Processing → Distribution → Consumption
Life Cycle Assessment Case Study: Carbon Equivalent GHG of Fluid Milk