


CONSEQUENTIAL MODELLING

- IN LIFE CYCLE INVENTORY ANALYSIS

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Overview of videos

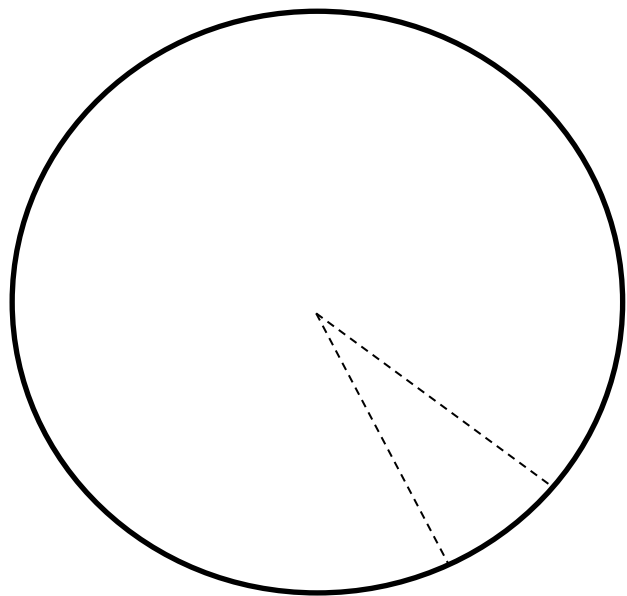
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- 1) Attributional and consequential responsibility
 - 2) ISO 14040/44: A standard for consequential LCA
 - 3) Fully reflecting physical and monetary causalities
 - 4) Temporal issues in LCA
 - 5) Learning from non-intuitive results
 - 6) *The comparability algorithm*: Defining the functional unit
 - 7) *The linking algorithm*: Composing a consumption mix
 - 8) Identifying determining products
 - 9) *The co-product algorithm*
 - 10) Errors in background databases

The authoritative definitions of the terms attributional and consequential

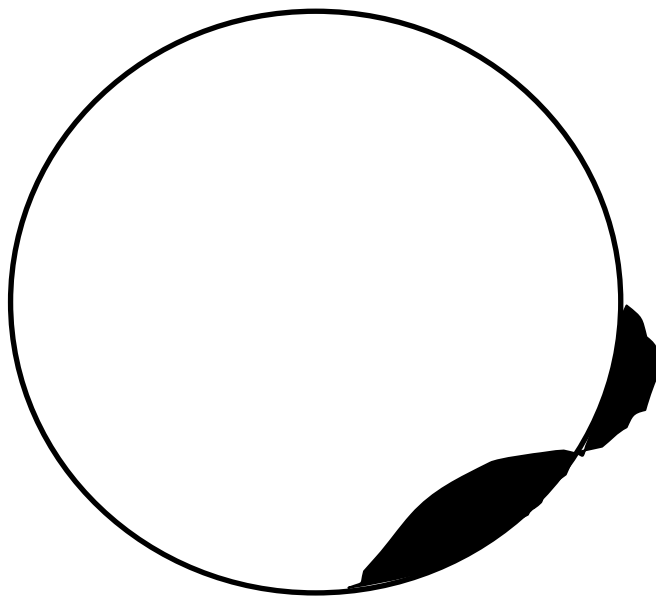
- UNEP/SETAC (2011). Shonan LCA database guidance principles:
 - **Attributional approach:** System modelling approach in which **inputs and outputs are attributed** to the functional unit of a product system by linking and/or partitioning the unit processes of the system **according to a normative rule**.
 - **Consequential approach:** System modelling approach in which activities in a product system are linked so that **activities are included in the product system** to the extent that they are expected to change **as a consequence of a change in demand** for the functional unit.



Attributional or consequential?



Attributional



Consequential

LCA – a matter of social responsibility

- LCA is regulated in the **ISO 14000 series** on environmental management systems, particularly **ISO 14044**
- **Social responsibility** is fundamental to the ISO 14000 series: That actors should be **responsible for the consequences (impacts) of their production or consumption actions**



LCA – a matter of social responsibility

- Social responsibility refers to an organisation's “**sphere of influence**”, defined as the:
 - “range/extent of political, contractual, economic or other relationships through which an organization has the ability to affect the decisions or activities of individuals or organizations” (ISO 26000:2010, Clause 2.19)
- Ruggie (2008; Clause 12): The concept conflates two very different meanings of “influence”:
 - “**Impact**”: Falls squarely within social responsibility
 - “**Leverage**” that the organisation may have over actors that are causing harm or could prevent harm: May only fall within social responsibility in particular circumstances

Ruggie J. (2008). *Clarifying the Concepts of “Sphere of influence” and “Complicity”*. Report of the Special Representative of the Secretary-General on the Issue of Human Rights and Transnational Corporations and other Business Enterprises, to the UN General Assembly Human Rights Council Eighth session, Agenda item 3. Document A/HRC/8/16.

Three system types

- representing three different responsibility paradigms:

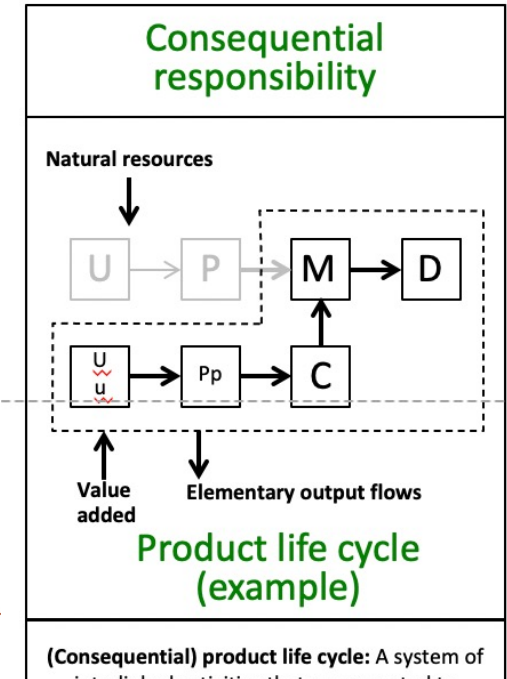
Consequential responsibility (for impacts)	Value chain responsibility (leverage ?)	Supply chain responsibility (leverage ?)
<p>Natural resources</p> <p>Value added Elementary output flows</p> <p>Product life cycle</p>	<p>Natural resources</p> <p>Value added Elementary output flows</p> <p>Value chain</p>	<p>Natural resources</p> <p>Waste before or after consumption</p> <p>Supply chain</p>
<p>(Consequential) product life cycle: A system of interlinked activities that are expected to change as a consequence of a change in demand for a product</p>	<p>Value chain: A system of interlinked activities that contribute value added to a product</p>	<p>Supply chain: A system of interlinked activities that contribute one or more specified and intrinsically linked physical properties to a product</p>
Consequential modelling	Attributional modelling	

- This distinction is often not made clear
- Leading to confusion and even mixing of the three types of models

Based on Weidema B P, Pizzol M, Schmidt J, Thoma G (2018). *Attributional or consequential Life Cycle Assessment: A matter of social responsibility*. Journal of Cleaner Production 174:305–314.

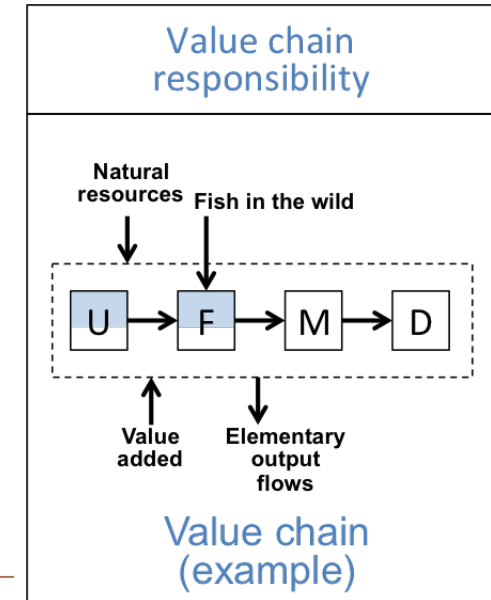
The (consequential) product life cycle in practice

- Identified by tracing each required product input, physical or monetary, to the long-term marginal suppliers of each product, i.e., the suppliers that will change their production capacity in response to an accumulated change in demand for the product
 - The resulting product life cycle is thus demand-driven and based on consumption responsibility
 - All physical *and* economic balances remain intact
 - A product life cycle will therefore reflect *both* the physical and economic causalities of purchasing a product



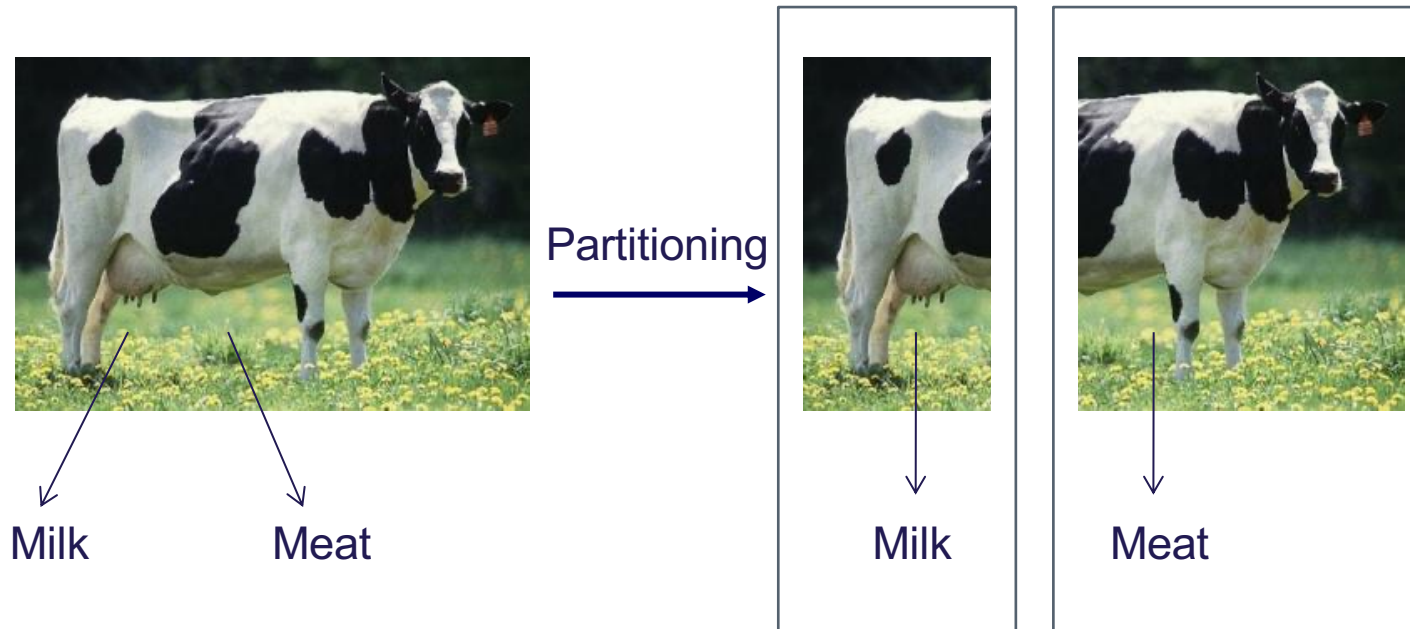
The value chain

- Term coined by Porter (1985) in the context of analysing competitive advantage
- A "value chain" is *a system of interlinked activities that contribute value added to a product*
- and implicitly "Value chain responsibility" is the responsibility taken for this system
- To obtain the value chain for a single product, joint production activities are partitioned
- The accounting balance (cost = revenue) is maintained by partitioning each input proportionally to the share that each joint product has in the overall revenue
- In LCA jargon this is known as "revenue allocation"



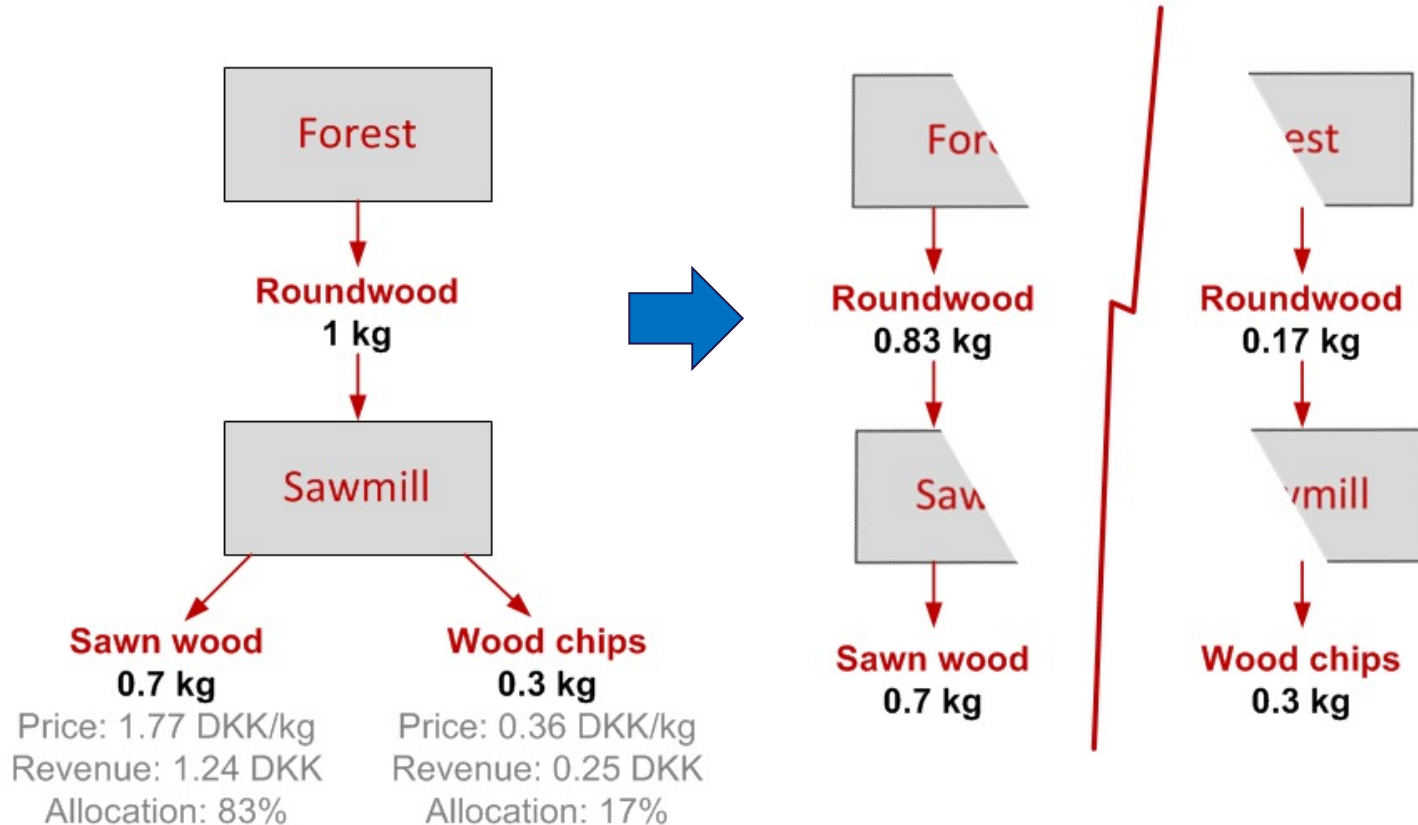
Allocation = Partitioning

– *non-existing processes are created*



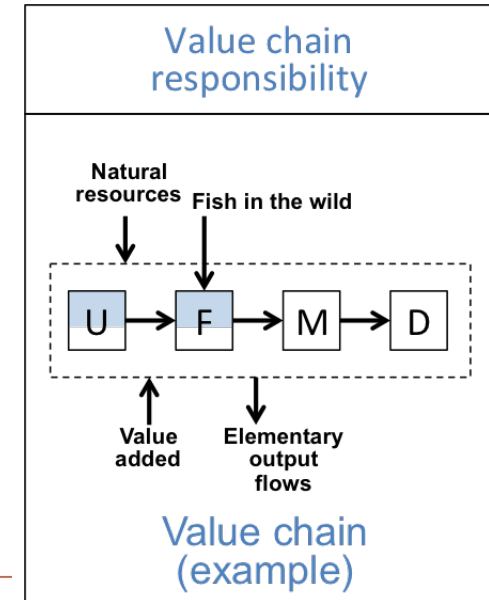
Allocation → Partitioning

- *Mass balances are not preserved*



The value chain in practice

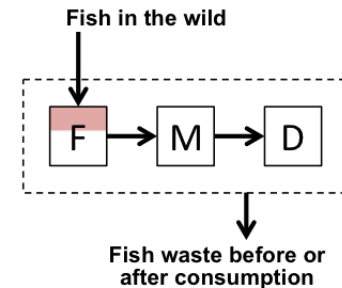
- Unless the joint products have the same price per physical unit, the resulting systems will not be physically balanced (although balances can be artificially re-constructed through allocation corrections)
- A value chain reflects the **economic reality** of the production and consumption of an **average** unit of the product, but **not the physical** reality
- Being based on averages and revenue allocation, a value chain does **not** reflect physical nor economic **causalities** of purchasing a product



Supply chain

- Sometimes used as synonym for value chain
 - More strictly: The logistic chain of suppliers to an activity
 - Increasingly being used in relation to traceability, where a customer wishes to know the exact origin of a product
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- Supply chains vary depending on the chosen property (e.g., dry mass, wet mass, water mass, carbon, energy), unless the properties are intrinsically linked
 - For an unambiguous identification, a supply chain must be specified in terms of the physical properties it supplies
 - Several supply chains can be overlaid, if the decision maker wishes to take responsibility for several properties

(Mass) supply chain responsibility



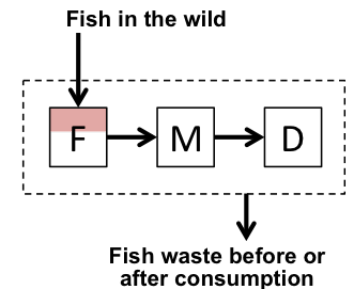
Mass supply chain (example)

Supply chain: A system of interlinked activities that contribute one or more specified and intrinsically linked physical properties to a product

The **mass** supply chain in practice

- When joint production activities are partitioned to obtain the **supply** chain for a single product, the **mass** balance is maintained by partitioning each input proportionally to the share that each joint product has in the overall **mass output**
- In LCA jargon this is known as “**mass allocation**”
- The **accounting balance** (cost = revenue) and balances of other properties **are lost**, unless proportional
- A **supply** chain does **not** reflect physical nor economic **causalities** of purchasing a product

(Mass) **supply chain responsibility**



Mass **supply chain** (example)

Supply chain: A system of interlinked activities that contribute one or more specified and intrinsically linked physical properties to a product

Social responsibility – for what?

- Your value chain (→ economic allocation)
- Your physical supply chain (→ e.g. mass allocation)
- The consequences of your actions (→ consequential system)

No right or wrong system!

...but:

- LCA always assesses the consequences (impacts) of the system, whatever system you may choose to be responsible for
- It is **not consistent** to take responsibility for the consequences of actions of **others** (in your value chain or supply chain) and **not** to take responsibility for the consequences of your own actions (the consequential system)
- **Thus**, the system we take responsibility for must always be the consequential product system, but may *additionally* include consequences of other activities in our value or supply chains

Talking 'supply chain' or 'life cycle'

- Currently, the terms 'supply chain' and 'traceability' more frequently pops up when talking about LCA
- So, we need to stress that:
 - The Supply chain is *not* the Product life cycle
 - Supply chain analysis and traceability are only relevant when you want to know what a specific product *contains* or *where it was produced*
 - However, there *are* elements of supply chain analysis that are relevant in consequential LCA

Relevance of supply chain in consequential LCA

- **When** would the supply chain matter in a consequential LCA?
- When the **consequences (impacts)** are related to the product *content or the location it comes from*
- Example: **Invasive species**
 - Caused mainly by transports that do not control for biological **contamination** and has an **origin** in similar climates
 - How can a change in demand for a product influence invasive species?
 - By analysing the risk from a **supply chain** perspective and requiring contamination control for goods from specific origins
 - In contrast to **external pollution** from production, where it is the source of the **additional** production that matters

Note that the logic in both cases is consequential...

LCA is limited to the system it analyses

- Assessments of products (whether as value chains, supply chains, or product life cycles) are **not adequate** for identifying important issues or improvement options outside the narrow system boundaries of these assessments
- **Once** an issue or improvement option has been identified within the system you have **chosen** to be responsible for (value chain, supply chain, product life cycle, or the whole world), consequential LCA is relevant to compare the consequences of the improvement options and to choose the one with the least impacts

THANKS FOR YOUR ATTENTION