Demonstration of Innovative Functional food production systems based on more sustainable value chains of marine and freshwater raw materials for conscientious EU consumers

NOVAFOODIES

1.0 Production techniques of marine and algae biomass in the context of sustainability

1.2 Main sector-specific ecological and sustainability aspects

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Agenda

- Introduction to sustainability
- Possible impacts of human activity on the environment
- Group exercise: Sustainability in fisheries and aquaculture
- Sustainability in marine and freshwater food production systems
- Life Cycle Assessment (LCA)
  - How to perform an LCA
  - Types of LCA
  - A critique of LCA
- Group exercise: “impromptu” LCA

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Main objective

- Evaluate relevant sustainability aspects in the fisheries and aquaculture sector

Learning outcomes

- Know the different aspects of sustainability with a focus on the production of marine and freshwater products/raw materials
- Describe a method to evaluate the ecological impact of a product

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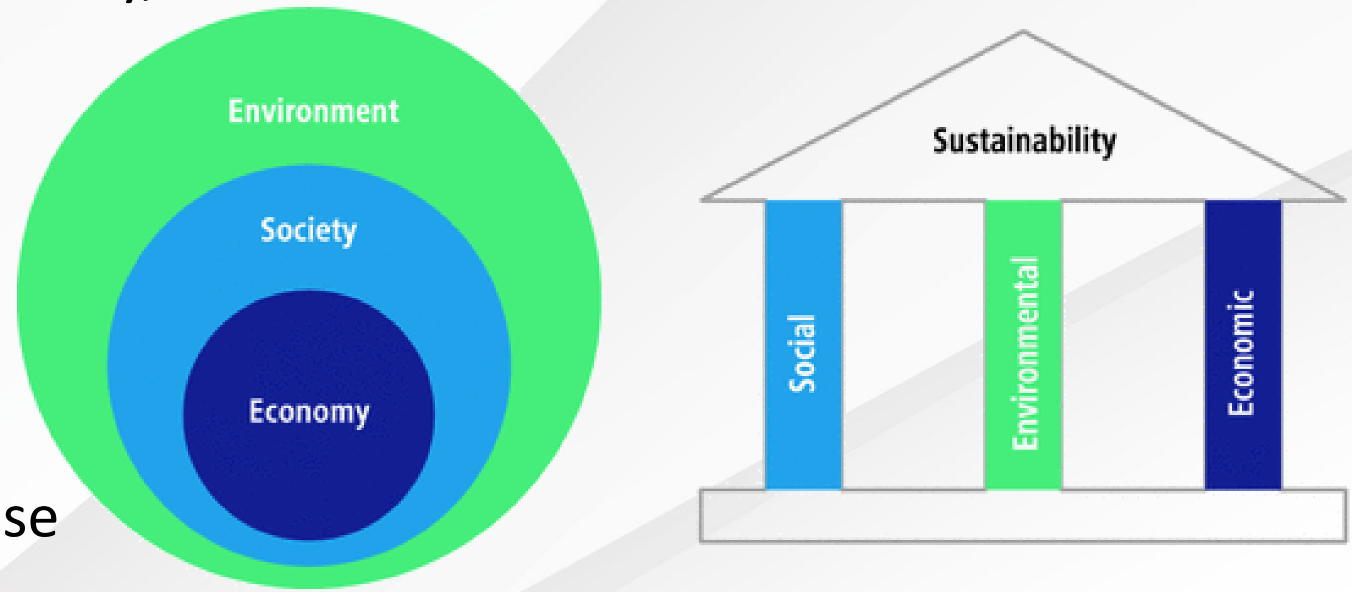
Perspectives on sustainability

- Embeddedness of systems vs. pillars of sustainability
- E.g. the ability to produce fish sticks presupposes the existence of a functioning ecosystem and the existence of a society, which in turn houses institutions such as markets.
- A complete collapse of the dimension *environment* causes both *society* and the *economy* to fail, not the other way around.
- Removing any one pillar does not necessarily cause the roof to collapse
- Weak vs. strong sustainability



The three-pillar versus embedded-system view of sustainable development (Göpel, 2016).

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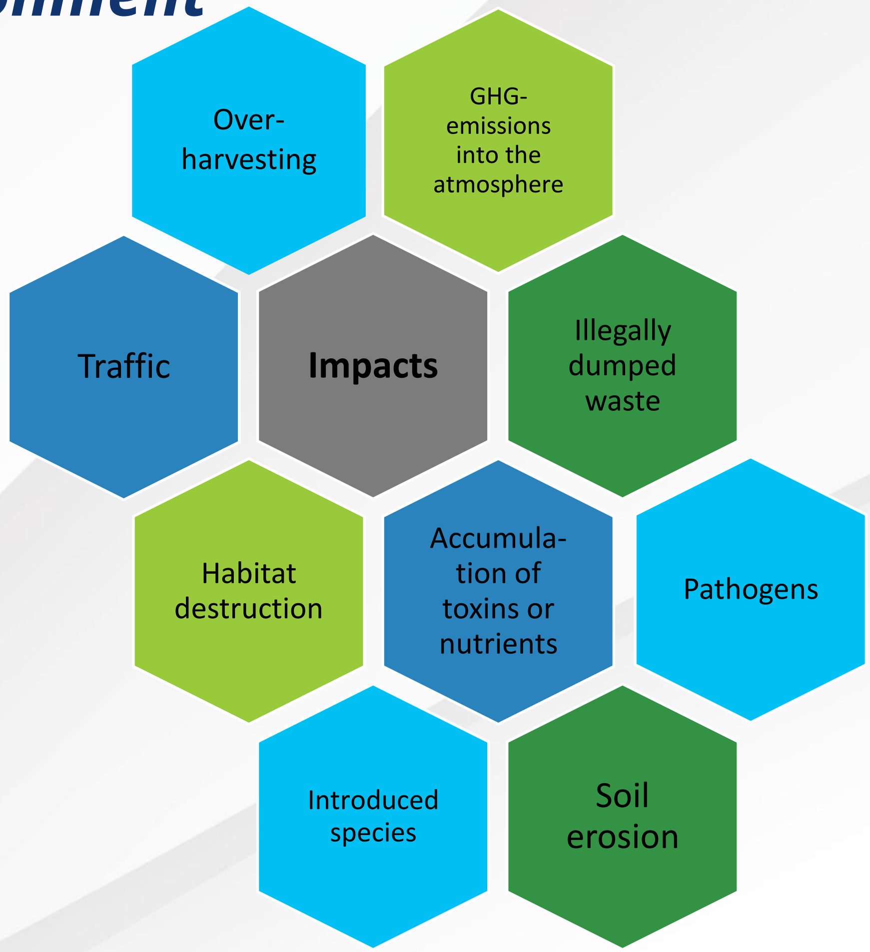
Possible influences and impacts on the environment

- Influences and impacts can be manifold and related in complex ways (session 1.1 wicked problems)
- Influences can be **overt or hidden** – both in terms of detectability through natural science research and by means of social institution
- How influences on the environment relate to sustainability is often an issue of **deliberation**: Certain actors will argue for the severity of an impact (e.g. greenhouse gas-[GHG-]Emissions) and the need for change, while others do not perceive the issue as relevant.



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Possible influences and impacts on the environment – some examples

34% of monitored fisheries are producing at unsustainable levels

Every third seafood meal is unsustainable

Over-harvesting

GHG-emissions into the atmosphere

Traffic

Impacts

Illegally dumped waste

Habitat destruction

Accumula-tion of toxins or nutrients

Pathogens

Introduced species

Soil erosion

In 2022, the EU per capita GHG footprint amounted to 10.7 tonnes of CO2eq

That's almost three round trips from Zurich to Singapore

Three-fourths of habitats assessed in 2020 have poor or bad conservation status.

At least 97 percent of the Baltic Sea region was assessed as eutrophic in 2011–2016

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Group exercise

Which aspects of sustainability would you consider for fisheries and aquaculture production?

- Form groups of 4-5 people
- Brainstorm on the topic for about 10 minutes
- Take the One Health approach into account: Human health, animal health and environmental health
- Outcome: One person per group gives a short summary of the collected input

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Time for your presentations!

- What aspects did you come up with?
- Are there any aspects you are not sure about?
- How do the aspects interact with each other?

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Sustainability in marine and freshwater ecosystems

- Marine ecosystems are among the largest of the planet and serve crucial roles for
  - Carbon sequestration
  - Regional climates
  - Coastal protection
  - Biodiversity
  - …
- Virtually all human activities impact our oceans:
  - Fishing, harvesting, hunting, etc.
  - Waste (e.g. Great Pacific Garbage Patch)
  - Deep Sea drilling
  - Off-shore wind power
  - …

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Sustainability in marine and freshwater food production systems (one health view)

Human Health	Animal Health	Ecosystem Health
Food Safety: Seafood free from contaminants and pathogens	Disease Prevalence: diseases in wild and farmed fish, shellfish, etc.	Nitrogen & Phosphorus Cycle: nutrient pollution and eutrophication
Nutritional Benefits: Providing essential nutrients like omega-3/6 fatty acids	Welfare Standards: Ensuring good treatment and welfare of aquatic animals	Carbon Sequestration: Marine carbon sinks
Disease Transmission: Zoonotic diseases can transfer from aquatic animals to humans	Genetic Diversity: Poor Genetic diversity in populations can lead to disease outbreaks	Climate Change Mitigation: practices to mitigate climate change impacts
Antibiotic Resistance: The use of antibiotics can lead to resistance in pathogens	Stress Prevalence: Human practices stress wild and farmed animals	Biodiversity: Protecting and enhancing biodiversity
Waterborne Diseases: Diseases that can spread through water	Nutrition: Adequate diets to promote health and growth in wild and farmed animals	Sustainable Harvesting: sustainable fishing practices to prevent overfishing
Occupational Health: Protecting the health of workers in aquaculture operations	Habitat Quality: Ensuring high-quality habitats for wild and farmed species	Pollution Control: Reducing chemical and plastic pollution
Mental Health: Supporting the mental well-being of communities dependent on aquaculture		Water Quality: Monitoring and maintaining water quality

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Sustainability in marine and freshwater food production practices

- Preferring circular production processes over linear ones: Waste utilization and nutrient recycling (fertilizer, bio-gas production, …)
- Improving resilience through the use of various species, i.e. polyculture (disease prevention)
- Increasing carbon sequestration by farming short lifespan plant mass
- Establishing Marine Protected Areas
- Keeping region-appropriate species
- Utilization of specialized fishing gear to prevent bycatch and habitat destruction
- Utilization of organic feed and the least possible amount of *medicine*
- Utilization of non-fossil energy sources and energy efficient farms

Example: IMTA (Integrated multi-trophic aquaculture)

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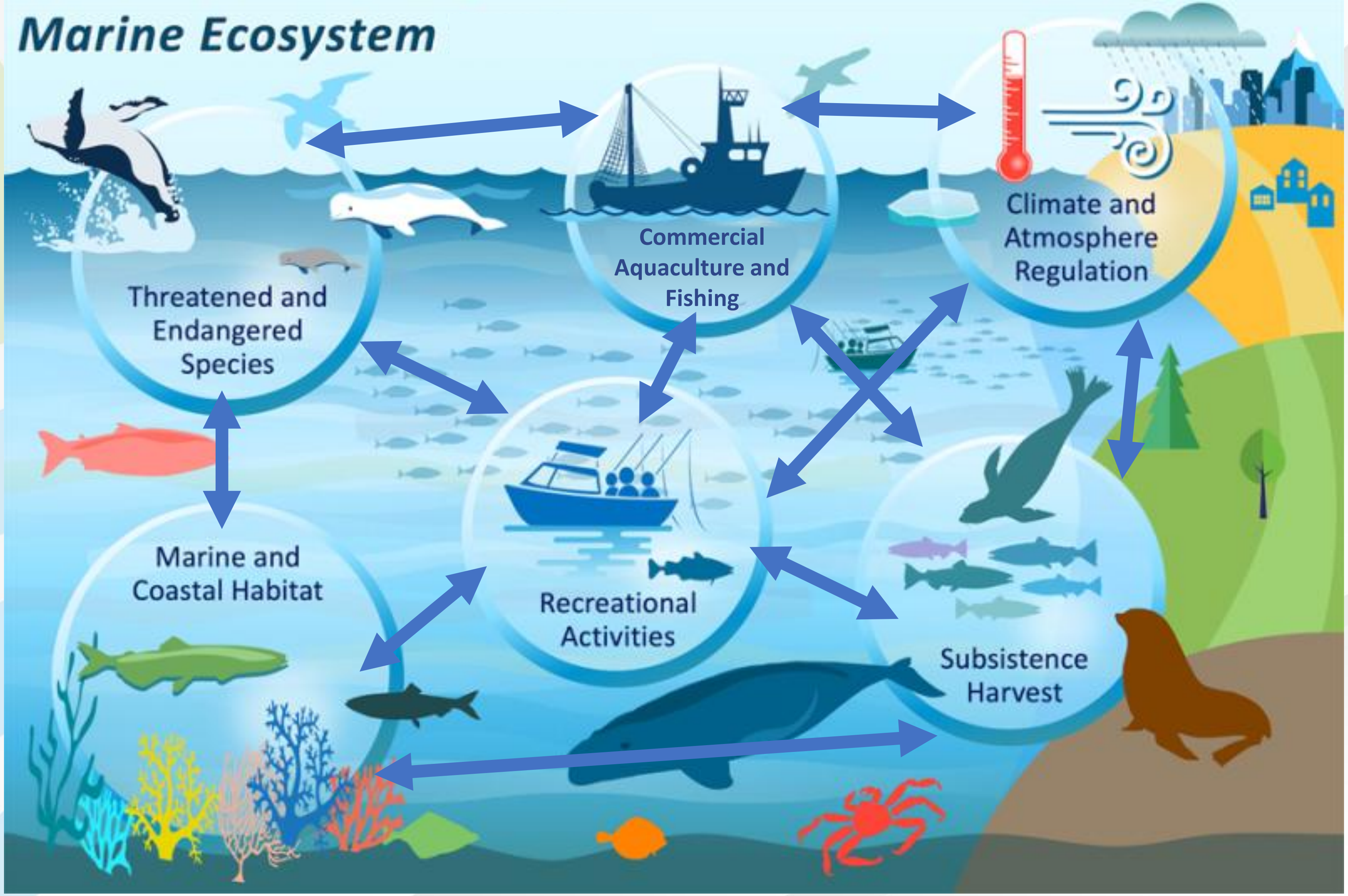

Interconnectedness of marine ecosystems (NOOA, modified)

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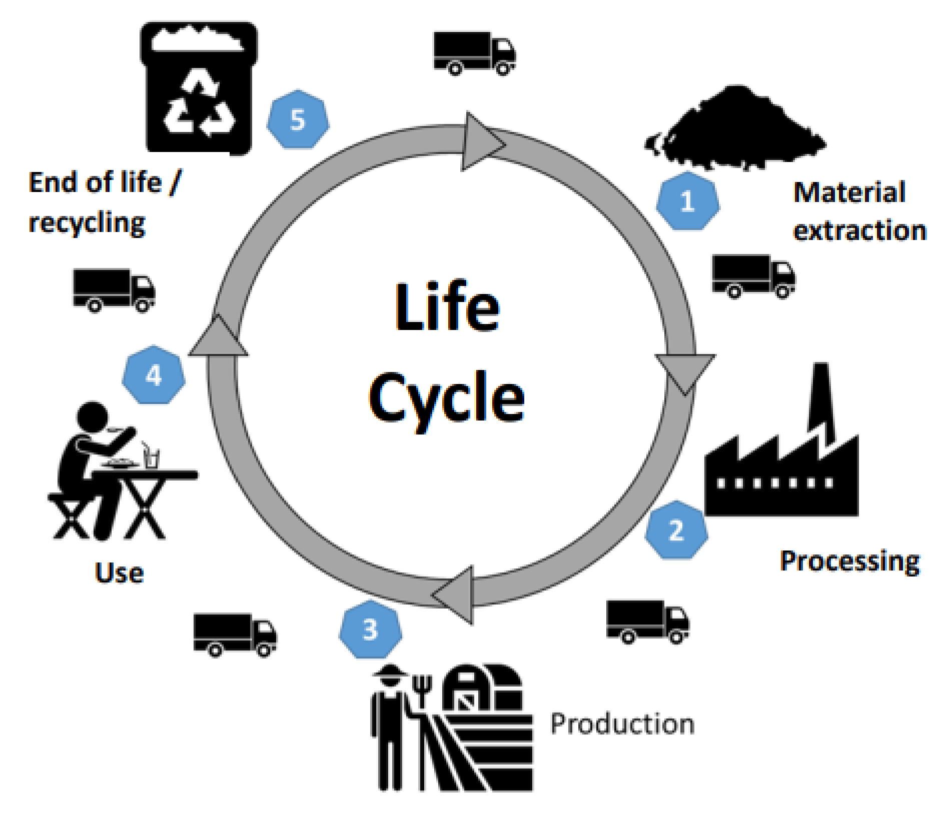
Life Cycle Assessment (LCA)

- LCA was developed to evaluate the environmental impacts associated with a product's life cycle. With a pioneering environmentnal impact study in 1969, Coca-Cola played a foundational role in the development of the LCA as we know it now.
- A typical LCA study can take into account the entire value chain (e.g. raw materials, processes, End of Life, etc.) involving the inputs and outputs of the utilized processes (energy, water, etc...).
- Generally, an LCA study consists of goal and scope definition, life cycle inventory, impact assessment and interpretation (ISO 14040).



Joël Aubin, INRAE, n.d.

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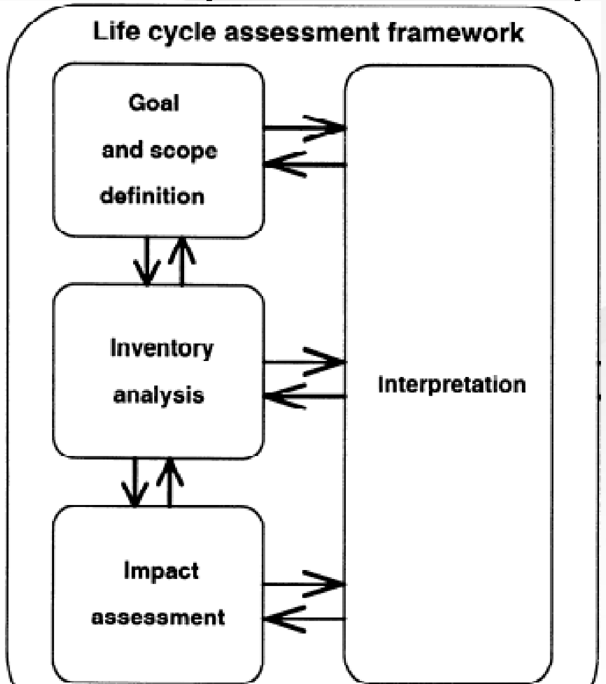
Doing Life Cycle Assessment

- Since it's first standardization, in 1997, LCA saw major updates in 2006
- ISO 14040 - This standard outlines the principles and framework for conducting LCA, providing a structured approach to ensure consistency and reliability in LCA studies.
  - Setting Goal and Scope
  - Life Cycle Inventory (LCI)
  - Life Cycle Impact Assessment (LCIA)
  - Life Cycle Interpretation
- ISO 14044 - This standard complements ISO 14040, by providing requirements and guidelines for each LCA phase.



LCA according to ISO 14040 (Caruso et al., 2017)

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1. Goal and Scope

- Objective: Define the purpose of the LCA study and its intended application.
- Scope: Determine the system boundaries, functional unit, and level of detail required.
- Key Elements:
  - **Functional Unit**: The quantified performance of a product system for use as a reference.
  - **System Boundaries**: The processes and stages included in the LCA (e.g., cradle-to-grave, cradle-to-gate).
- Assumptions and Limitations: making clear any assumptions made and identified/possible limitations of the study.

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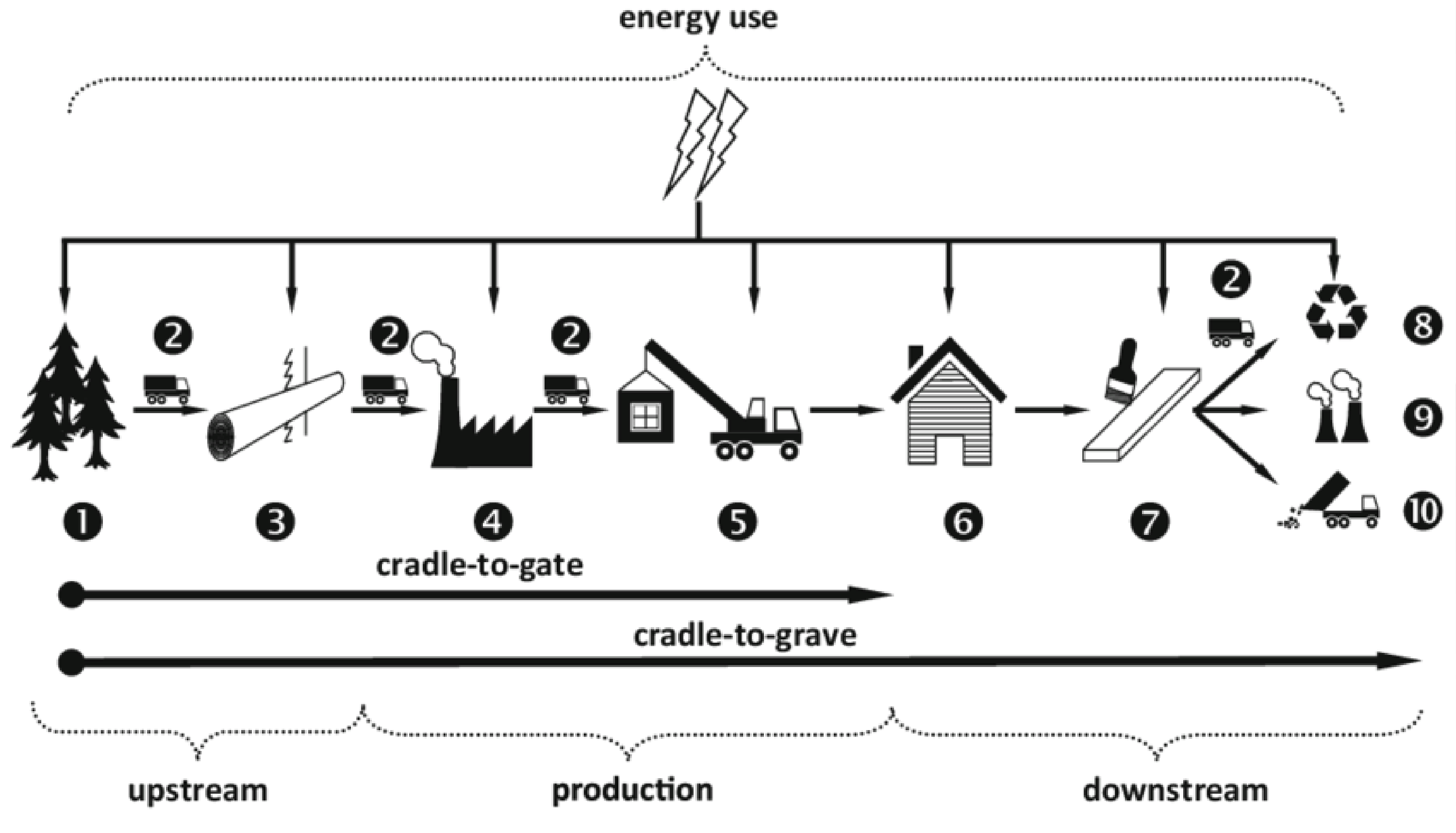
System Boundaries

- **Cradle-to-Grave:** raw material extraction (cradle) to disposal (grave).
- **Cradle-to-Gate:** raw material extraction to the point where the product leaves the manufacturing facility (gate.
- **Gate-to-Gate**: impacts of a specific process or stage within the production chain.
- **Cradle-to-Cradle**: focus on creating a closed-loop system
- **Well-to-Wheel**: impacts of fuel production and use, from extraction (well) to vehicle operation (wheel).



Sandak et al. (2019)

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2. Life Cycle Inventory

- Objective: Collect data on all inputs and outputs associated with the product system.
- Data Collection and Acquisition: Gather data on energy, materials, emissions, and waste for each process within the system boundaries.
- Key Elements:
  - **Data Quality**: Ensure data is accurate, reliable, and relevant.
  - **Data Sources**: Use primary data if possible (direct measurements) and secondary data (literature, databases).

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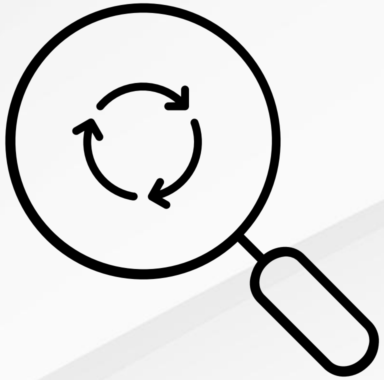
LCA: The issue of data

- The quality of an LCA is highly dependent on the used data
- Availability of data is often tied to paid databases / providers (e.g. ecoinvent, PEF, …)
- The collection of data is extremely costly and time intensive.
- The more specific the data, (e.g. amount of protein in fish feed used to produce a kg of fish filet) the better
- Generic and data full of estimates lead to low quality or even inaccurate LCAs



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3. Life Cycle Impact Assessment

- Objective: Evaluate the potential environmental impacts of the inputs and outputs identified in the LCI.
- Impact Categories: Select relevant impact categories (e.g., global warming potential, acidification).
- Key Elements:
  - Classification: Assign LCI results to impact categories.
  - Characterization: Quantify the contribution of each input/output to the impact categories.
  - Normalization and Weighting (optional): Compare results to a reference value and assign importance to different impacts.

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4. Life Cycle Interpretation

- Objective: Analyze the results, draw conclusions, and make recommendations.
- Key Elements:
  - Identification of Significant Issues: Highlight key findings and significant environmental impacts.
- Evaluation: Assess the completeness, sensitivity, and consistency of the results.
- Conclusions and Recommendations: Provide actionable insights and suggestions for improvement.

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Reporting and Critical Review

- Objective: Document the LCA study and ensure its credibility.
- Key Elements:
  - Reporting: Prepare a comprehensive report detailing the methodology, data, results, and conclusions.
  - Transparency: Ensure the report is clear and accessible to the intended audience.
  - Critical Review: Conduct an independent review to verify the study's accuracy and reliability.
  - Feedback: Incorporate feedback from the review to improve the study.

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Limitations and Conditions for Use

- Objective: Acknowledge the limitations of the LCA study and specify conditions for its use.
- Key Elements:
  - Limitations: Identify any constraints or uncertainties in the study.
  - Conditions for Use: Define the appropriate context and applications for the LCA results.
  - Transparency: Clearly communicate any limitations to the intended audience.
  - Future Research: Suggest areas for further investigation to address limitations.

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Versions of LCA

- **Process-Based LCA**: Bottom-up approach that involves detailed data collection for each process within the system boundaries.
- **Input-Output LCA (EIO-LCA): T**op-down approach that uses economic input-output tables to estimate environmental impacts based on economic transactions between sectors.
- **Hybrid LCA:** Combines elements of process-based LCA and input-output LCA.
- **Consequential LCA:** Focuses on the broader consequences of changes in a product system, including market effects and indirect impacts.
- **Dynamic LCA:** Incorporates temporal changes in environmental impacts over time.

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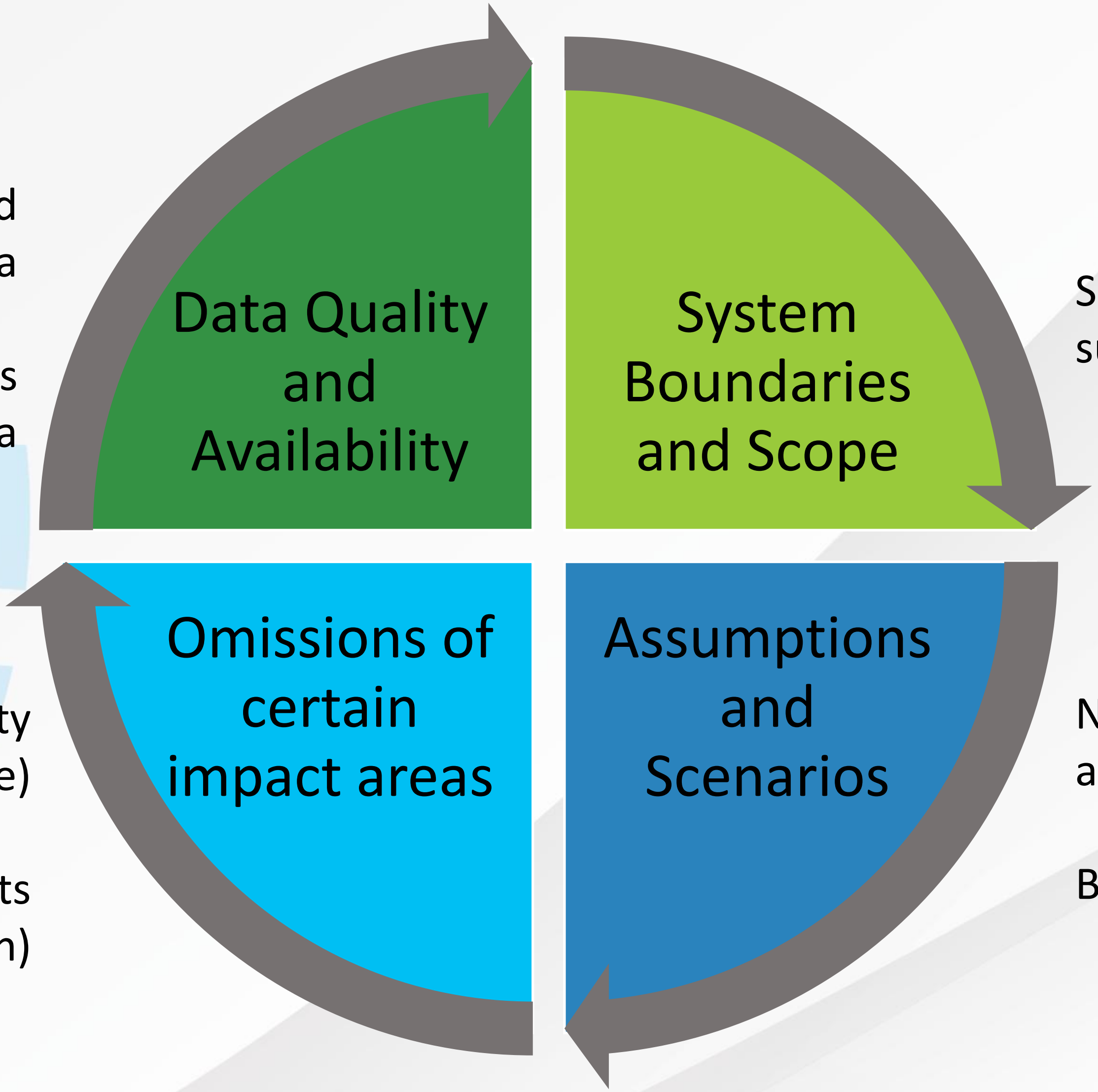
Critique of LCA

Mix of primary and secondary data

Misleading conclusions due to poor data



Setting of boundaries is subjective or inconsistent

Omission of Biodiversity (often hard to measure)

Omission of social impacts (intentional omission)

Non-transparent assumptions

Bias

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LCA is…

- a tool to describe the systems and understand the environmental hot spots of the aquaculture systems, i.e. it can help improving these systems.
- a means to go towards an ecodesign of the production systems.
- highly vulnerable to the quality of the used data.
- dependent on a clear analysis of the impacts so as to avoid mistakes and misinterpretations (even concerning the one undertaking the endeavor).
- a tool that is constantly undergoing change and improvement through the addition of new legislation that increases LCA's completeness and usefulness.

It is not meant to serve greenwashing campaigns or false advertising!

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Software

- LCA is performed with a range of Software, either open Source or for a subscription:
  - **SimaPro:** widely used, developed by PRé Sustainability. For conducting detailed and comprehensive life cycle assessments; supports various impact assessment methods along with extensive databases (e.g. Ecoinvent, Agri-footprint).
  - **GaBi:** developed by Sphera, offers a wide range of databases and impact assessment methods, making it a versatile tool for various applications.
  - **OpenLCA:** open-source, developed by GreenDelta. Flexible and cost-effective, making it accessible to a wide range of users, from small businesses to academic researchers.

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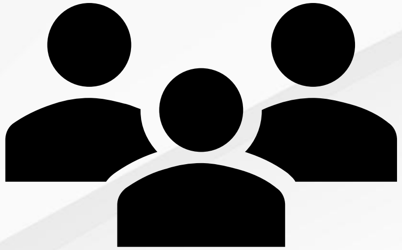
Group exercise – "impromptu" LCA

- Form groups of 4-5 people

First, choose a product from aquaculture, fishery, etc. (e.g. 1 kg of salmon steak, kelp, etc.)

Then, explore the resource streams and impacts of that product following the steps of LCA:

- Concerning the product, what are your system boundaries?
- Based on your experience with the product, what would you expect the LCA results to be?
- What data would you need or use to figure out the product's impact?
  - How would you go about collecting that data?
- What are the biggest factors that could contribute to the products impact?
- How could those results be interpreted?
  - What could be changed or improved in the production process to make it more sustainable?



- Discuss for about 15 minutes
- Outcome: One of each group presents their case in about 1 minute.
  Then discuss aspects that you perceived to be difficult or where questions remain.

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Time for your presentations!

- What product did you choose and why?
- What resource streams did you find?
- What impacts might those streams have?
- How do the aspects interact with each other?
- Are there open questions?

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Thank you very much for your attention!

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