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UP FARMING

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“UP-FARMING - Updating sustainability application and communication in the livestock farming sector”

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LCA: fundamentals, principles and characteristics

Simone Blanc

Content

- Definition of LCA
- Life cycle concept
- Principles and scientific foundations of LCA
- LCA as a model
- LCA as a procedure
- Strengths and weaknesses
- Why do LCA

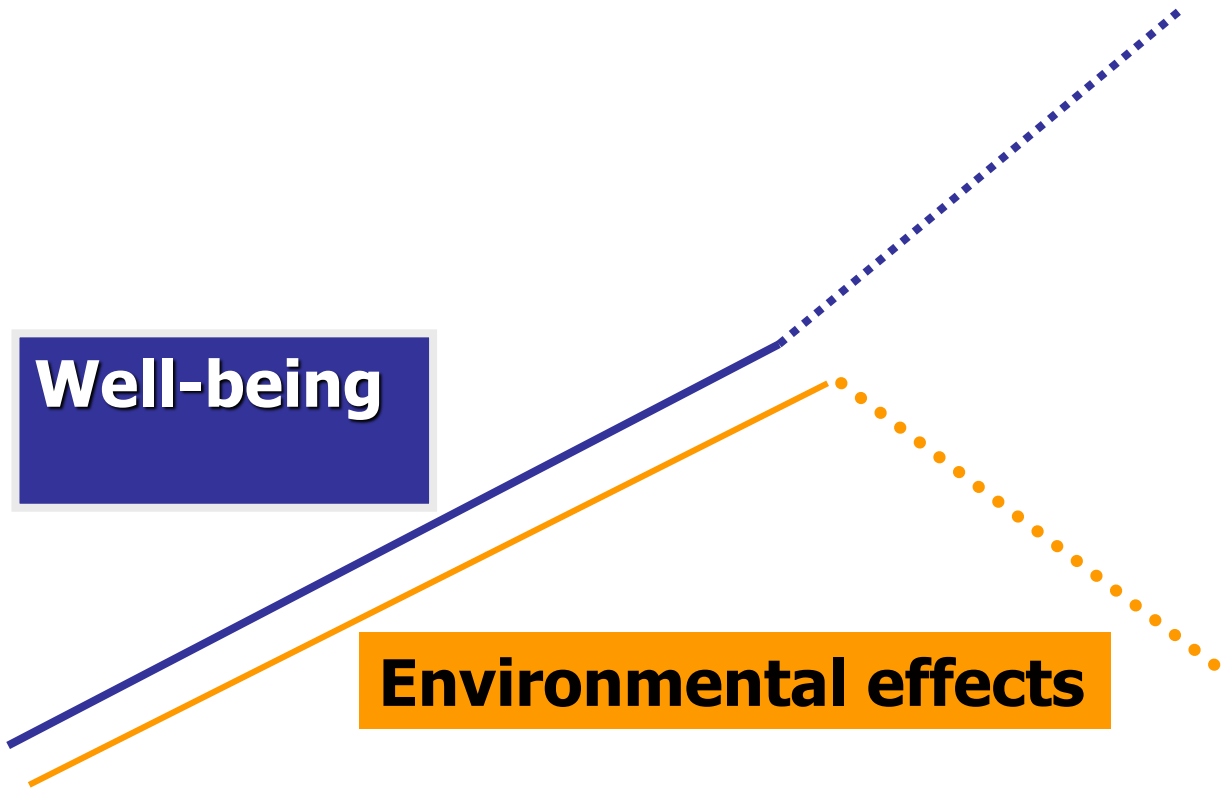
Lesson objectives

Illustrate the basic principles of LCA:

- fundamentals,
- models,
- standards,
- procedure,
- values,
- limitations.

Understand the main strengths and limitations of the method.

Sustainability goal: decoupling welfare growth from environmental degradation



United Nation Environment Programme Sustainable Development Goals

Where LCA can support

Definition of LCA

- ISO: compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system through its life cycle

- ILCD (International Life Cycle Data system): a compilation process and....

- https://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf

The life cycle concept

- The life-cycle approach is now considered central to the topic of sustainability: the use of LCA methodologies is in some cases already mandatory, in others recommended, in any case it is a qualifying element in all fields where a sustainability assessment is required (eco-innovation, strategic choices, research projects and technologies, etc.)

Examples of European policies adopting the life-cycle approach

Table 1 Overview of the most relevant policies and communications classified, starting from the year 2000

Regulations
REACh (EC 2006); EMAS (EC 2009b); Ecolabel (EC 2010a); Construction products (EC 2011); European statistical programme (EC 2017a); Sustainable investments (EC 2020a).
Directives
End-of-life vehicles (EC 2000); Waste framework (EC 2008); Ecodesign (EC 2009a); Energy Labelling (EC 2010b); Public procurement (EC 2014a, b, c); Biofuel (EC 2015a); Packaging and packaging waste (EC 2018a); Renewable Energy Directive REDII (EC 2018b); Promotion of clean and energy-efficient road transport vehicles (EC 2019a); Single use plastic (EC 2019b).
Decisions
Best environmental practices for the waste management sector (EC 2020b).
Recommendations
Use of common methods to measure and communicate the life cycle environmental performance of products and organisations (EC 2013a).

Sala, S., Amadei, A.M., Beylot, A. et al. The evolution of life cycle assessment in European policies over three decades. Int J Life Cycle Assess 26, 2295–2314 (2021). https://doi.org/10.1007/s11367-021-01893-2

Examples of European policies adopting the life-cycle approach

Communications

Integrated Product Policy (CEC 2003);
Stimulating technologies for sustainable development (CEC 2004);
Thematic Strategy on Prevention and Recycling of Waste (CEC 2005b);
Thematic Strategy on the Sustainable Use of Natural Resources (CEC 2005a);
Green Public Procurement (CEC 2008a);
Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan (CEC, 2008b);
Resource efficiency flagship (CEC 2011a, 2011b);
Strategy for the sustainable competitiveness of the construction sector and its enterprises (CEC 2012a);
Proposal for a General Union Environmental programme to 2020 (CEC 2012b);
Bioeconomy (CEC 2012c); (CEC 2018b)
Building the Single Market for Green Products (CEC 2013a);
EU Action plan for the Circular Economy (CEC, 2015a);
Better Regulation (CEC 2015b);
Accelerating Clean Energy Innovation (CEC 2016a);
Proposal for a Regulation related to the establishment of a framework to facilitate sustainable investment (CEC 2018a);
Proposal for a Regulation on low carbon benchmarks and positive carbon impact benchmark (CEC 2018b);
Proposal for a Regulation on establishing the InvestEU Programme (CEC 2018c);
The European Green Deal (CEC 2019a)
The new Circular Economy Action Plan (CEC 2020a);
The EU Biodiversity Strategy for 2030 (CEC 2020b);
The EU Farm to Fork Strategy (CEC 2020c);
The Chemical Strategy for Sustainability (CEC 2020d).

Why the life cycle and system approach?

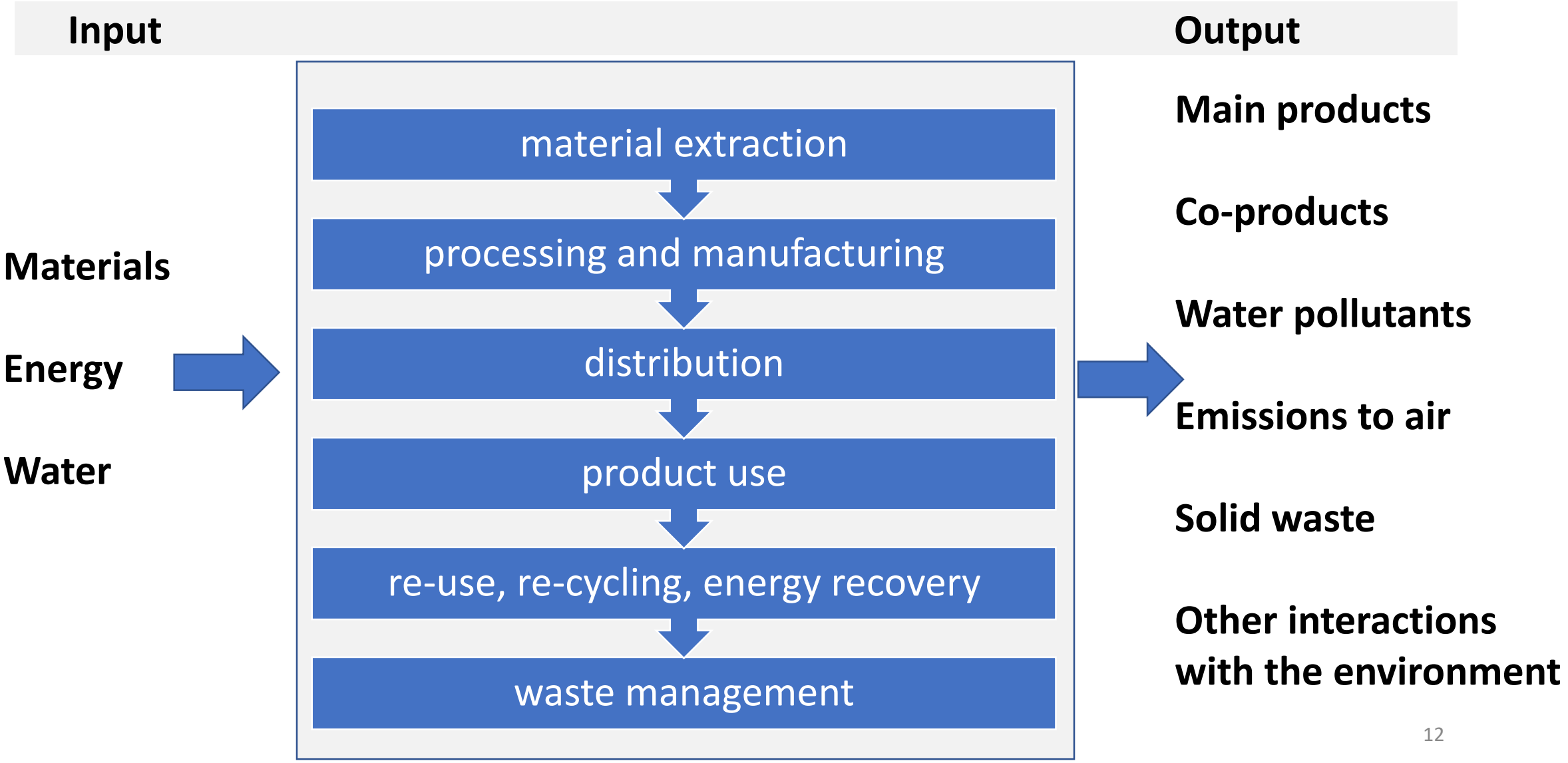
- Avoid shifting problems from one phase to another

- Avoids shifting problems from one impact category to another

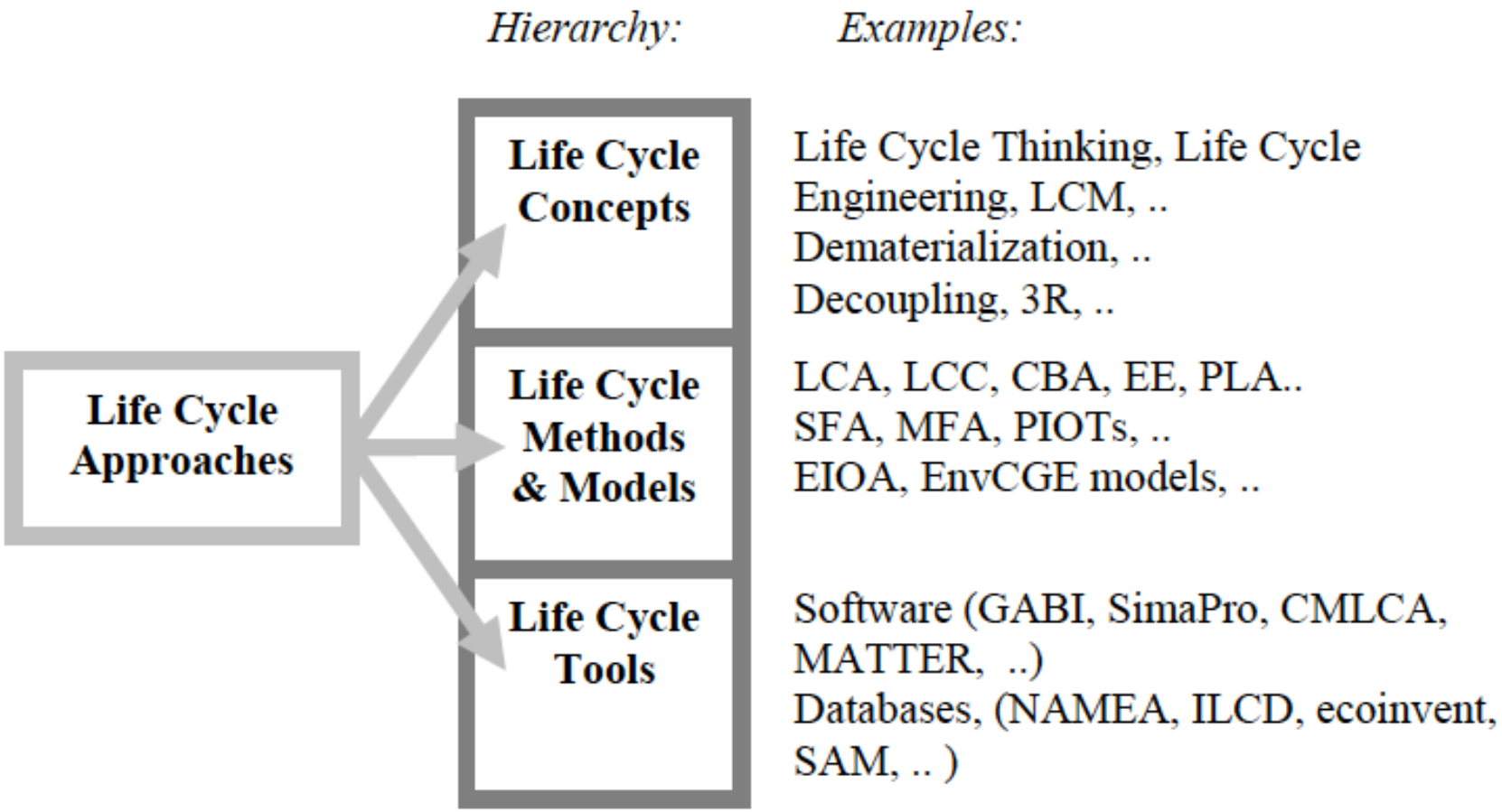
Example: biofuels reduce CO2 emissions but require more land for their production, are responsible for other climate-changing emissions such as nitrous oxide, may have toxic emissions due to pesticide use

- understand the complexity of a product, however simple it may be.

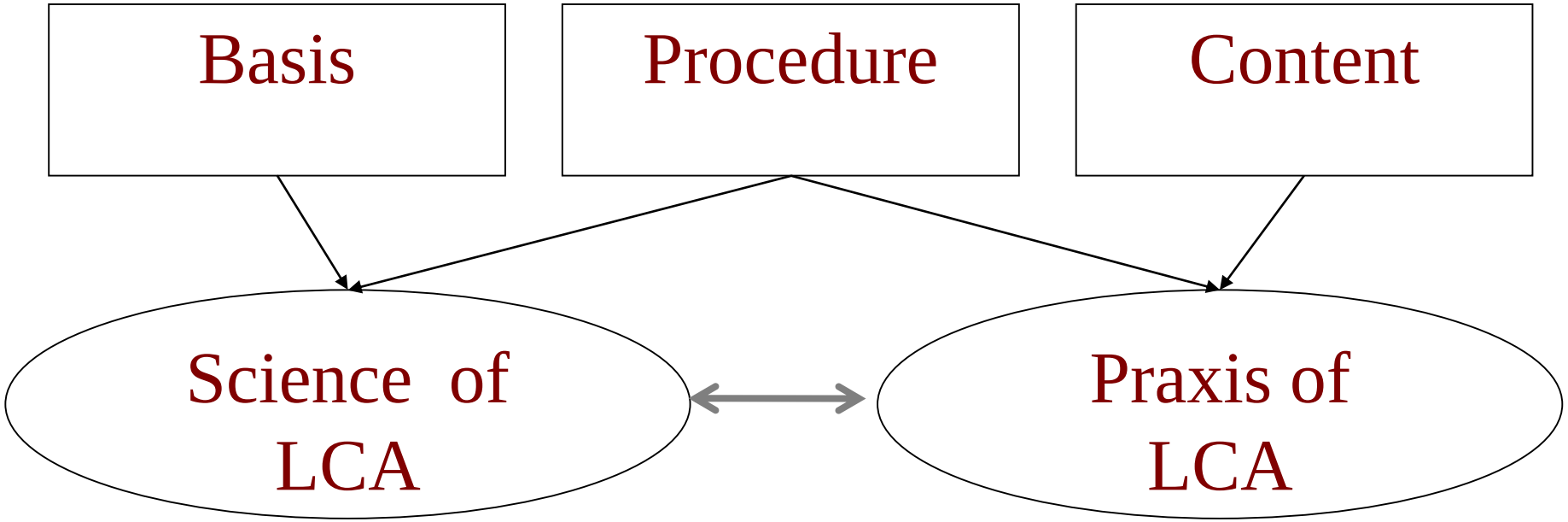
The structure of the LCA



Concepts, methods and models, tools

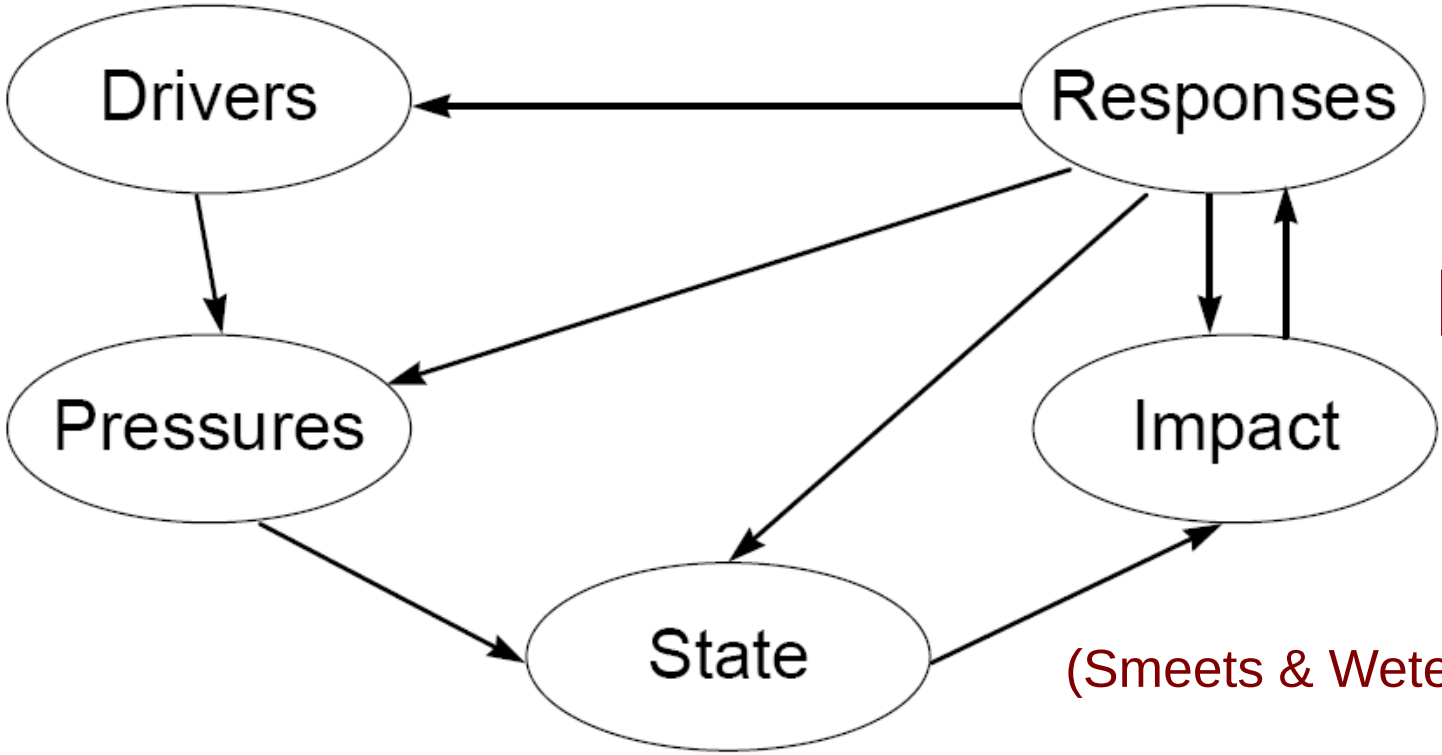


Ingredients of the LCA



Scientific Foundations

I=PAT (Ehrlich & Holdren, 1971)



DPSIR

(Smeets & Weterings 1999)

Basic Structure

$$I = P \times A \times T$$

Impact = Population x Consumption x Technology

- Example: CO_2 emissions from energy consumption

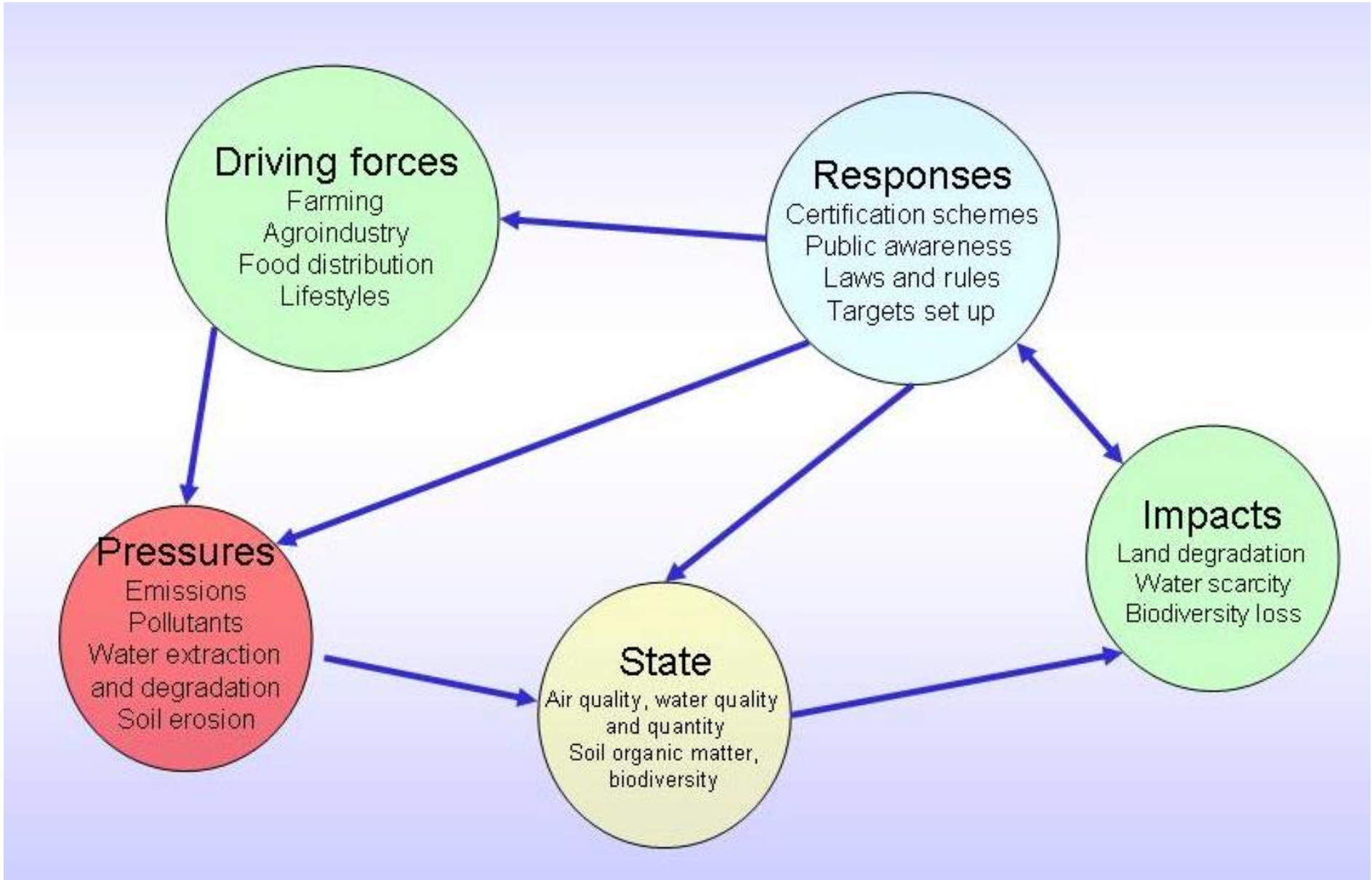
CO_2tot = (N of people) x (kWh/person) x (CO_2/kWh)

Basic Structure

DPSIR

- (D) are the drivers e.g.: industry, consumers, governments;
- (P) is the pressure on the environment e.g.: emissions, extraction, land use;
- (S) is the state of the environment e.g. concentration of pollutants, presence of species;
- (I) impact, examples: mortality, disappearance of forests;
- (R) society's response, e.g. innovations, taxes, information, standards, legislation, etc.

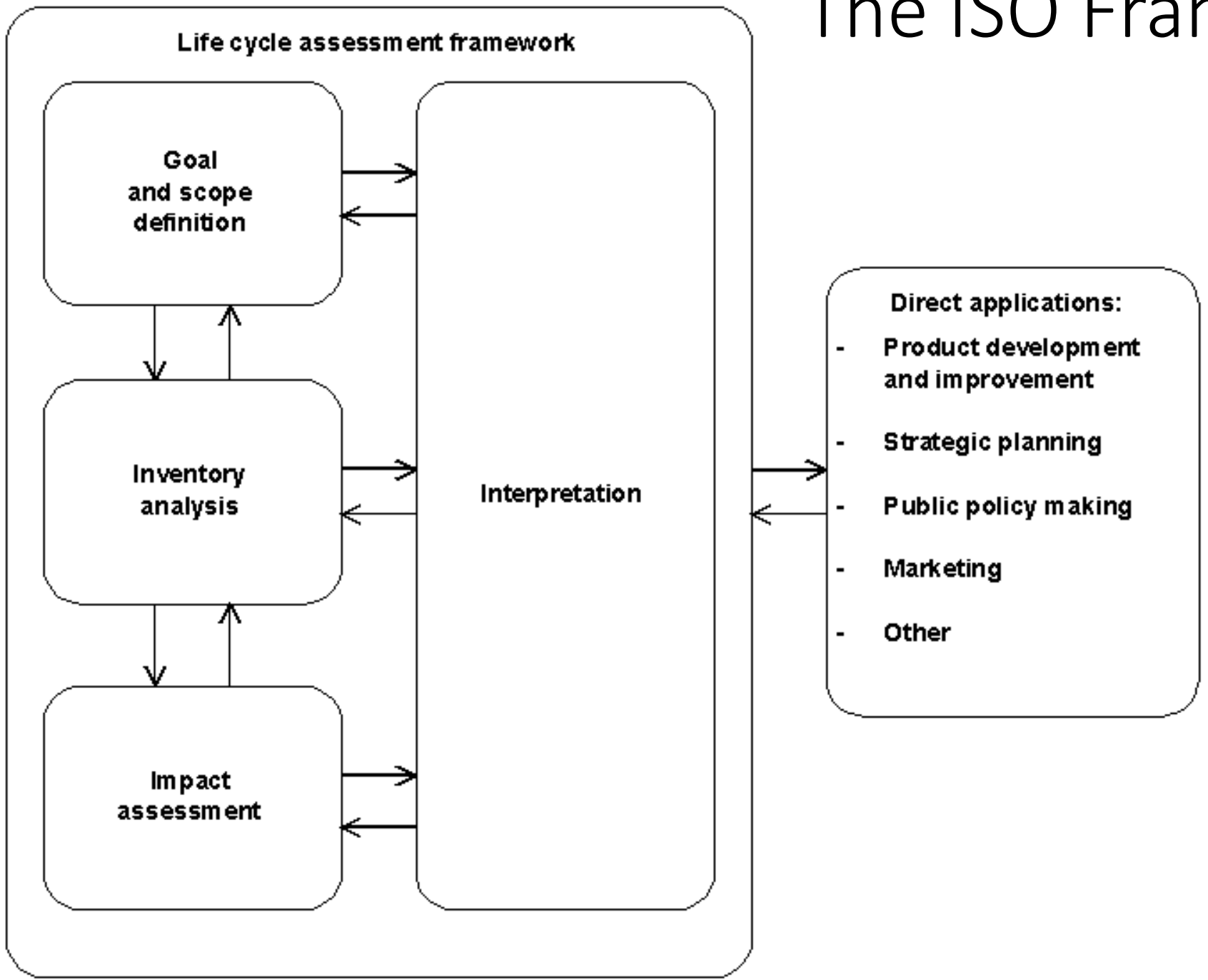
DPSIR in the agri-food industry



The ISO framework

- LCA as the result of an international consensus process, starting with the scientific stimulus of SETAC (Society of Environmental Toxicology and Chemistry)
- Standardisation is the major driver of LCA success
- Many current applications go beyond the ISO standard

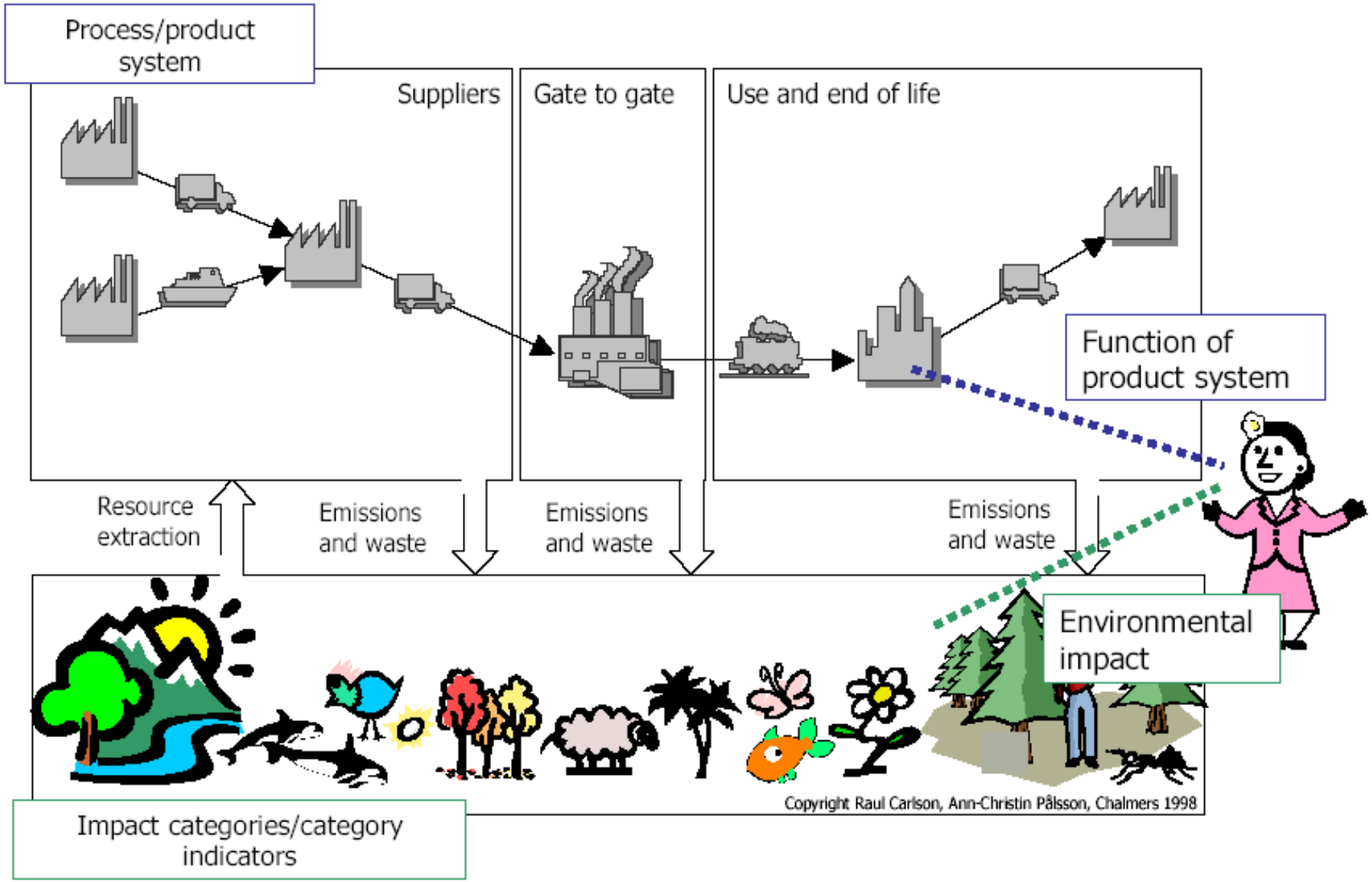
The ISO Framework



Direct applications:

- Product development and improvement
- Strategic planning
- Public policy making
- Marketing
- Other

LCA: technological relationships and environmental mechanisms



LCA: technological relationships and environmental mechanisms

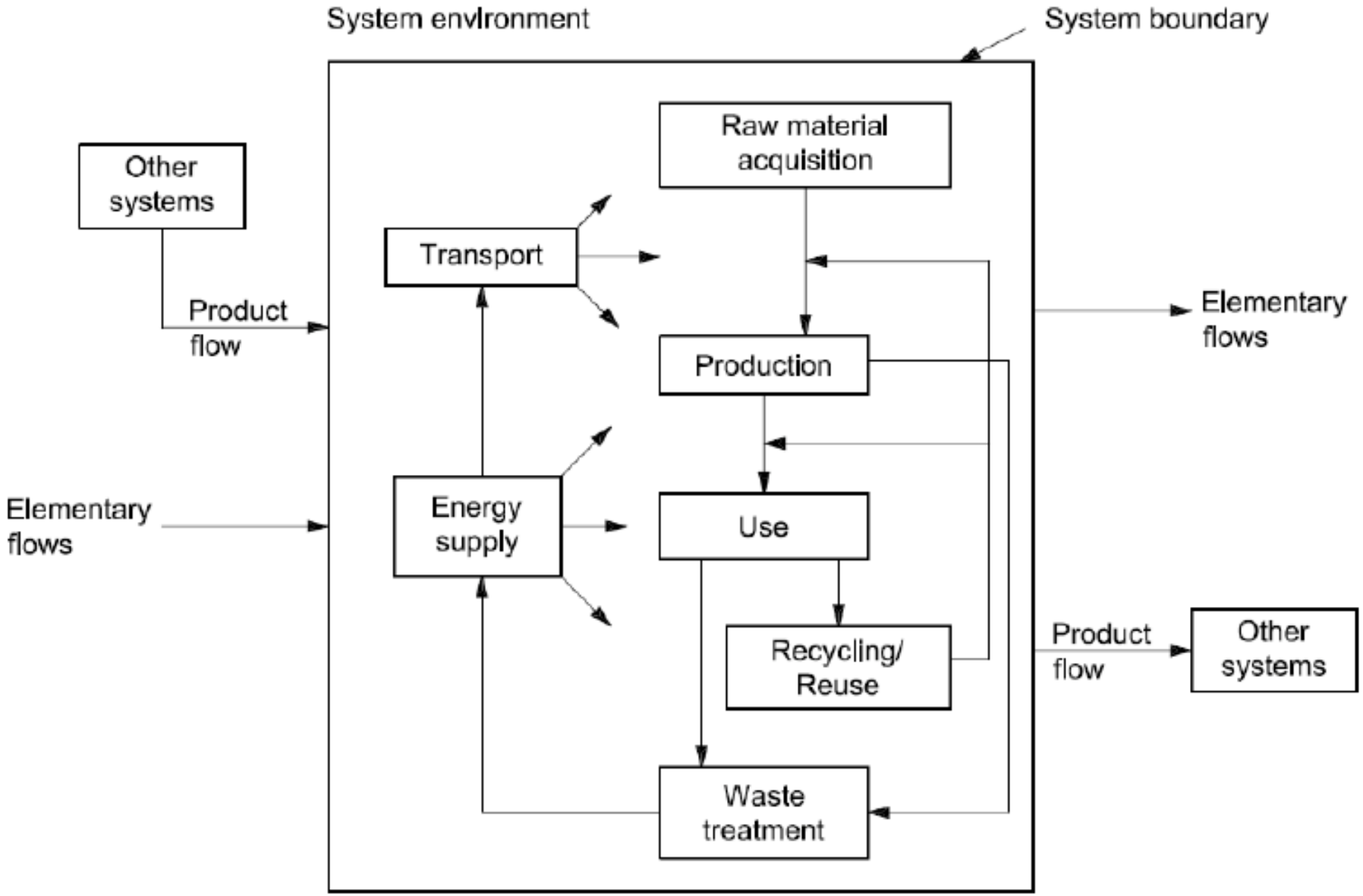
Technology system model:

- Activities (process units)
- Processes linked by physical exchanges (**flows**) of materials, components, products, energy, within the technosphere (**through market relations**)
- Physical exchanges, material and non-material, between the technosphere and the environment (**elementary flows**)

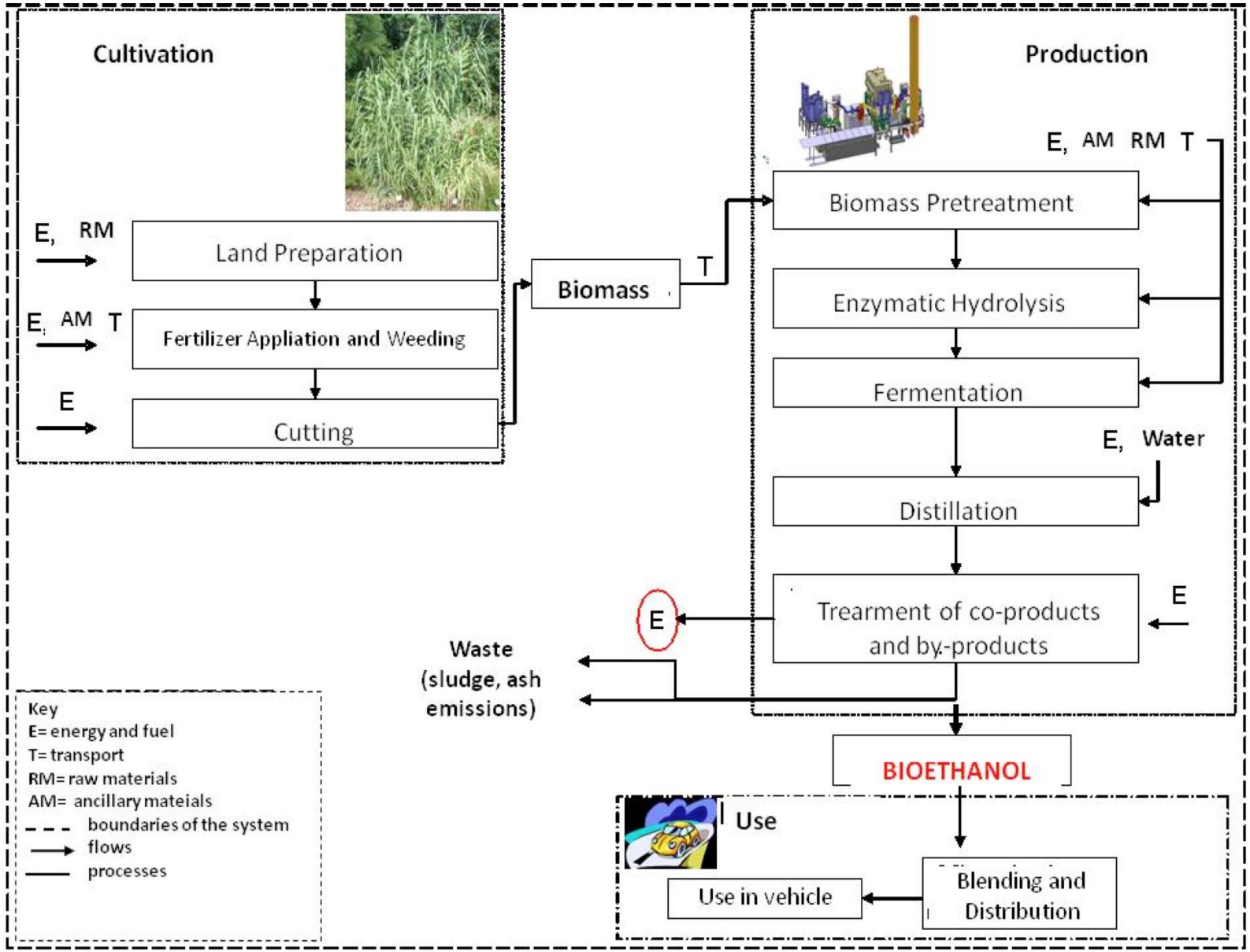
Environmental models

- Evaluation of the effects of physical exchanges between the environment and the technosphere
- Environmental models based on cause - effect chains

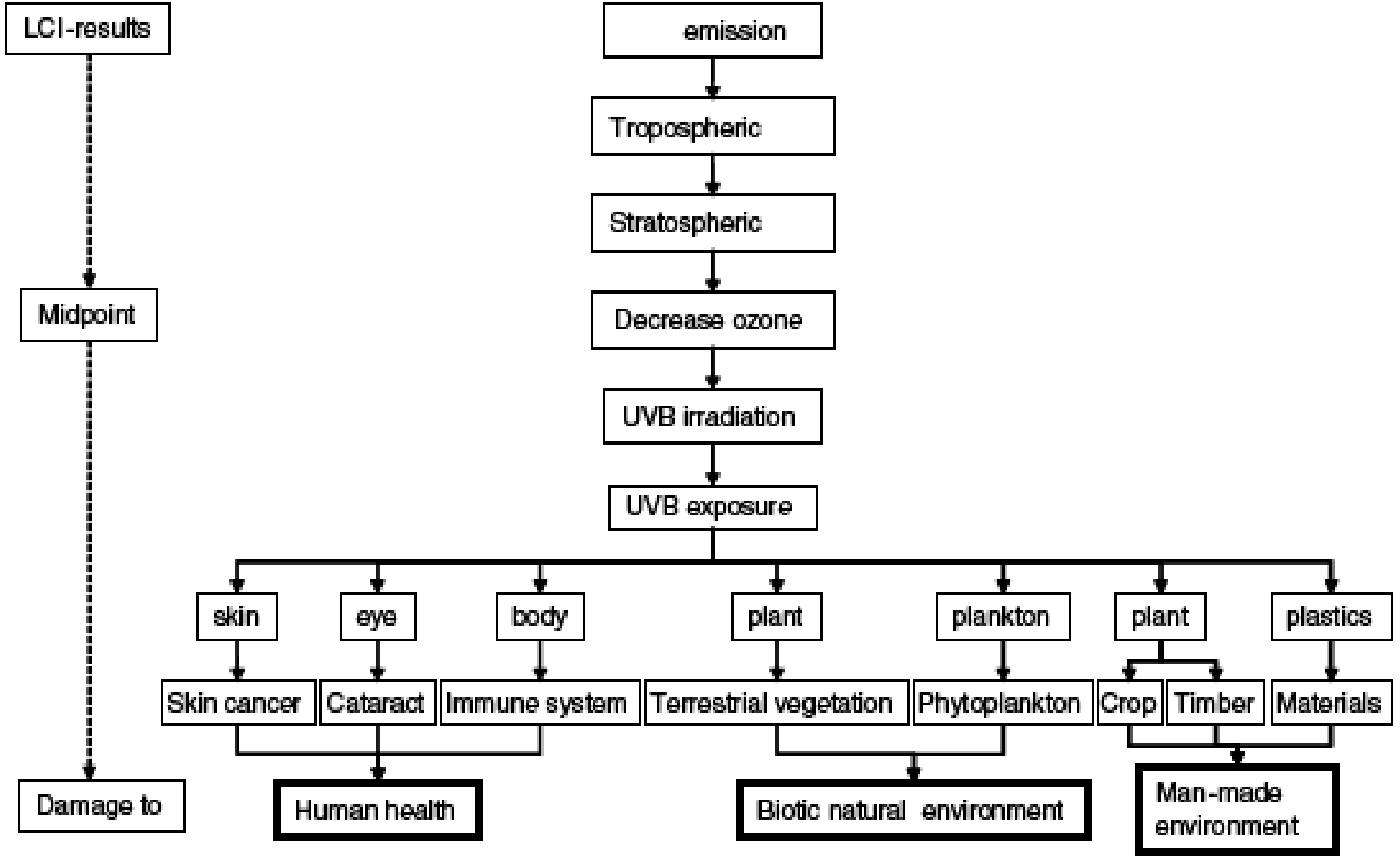
Technological model



An example of technological relations



Example of cause-effect relationships in an environmental model



What skills are needed to do LCA

- Engineering - technology (technology model development)
- Economics (market relations, scenario analysis)
- Environmental science (environmental models)
- Matrix and stochastic calculus (uncertainty analysis, hybrid analysis)

Responsible Research and Innovation (**RRI**)

"Science is the basis for a better future and the bedrock of a knowledge-based society and a healthy economy….(omissis) Research and innovation must respond to the needs and ambitions of society, reflect its values, and be responsible."

Máire Geoghegan-Quinn, former European Commissioner for Research, Innovation and Science

Features of RRI in Europe

Responsible Research and Innovation (RRI) refers to the **comprehensive approach** of proceeding in research and innovation in ways that allow all **stakeholders** that are involved in the processes of research and innovation at an **early stage:**

1. to obtain relevant **knowledge on the consequences** of the outcomes of their actions and on the range of options open to them and
2. to effectively evaluate both **outcomes** and **options** in terms of **societal needs** and **moral values** and
3. to use these considerations as functional requirements for **design and development of new research, products and services**.

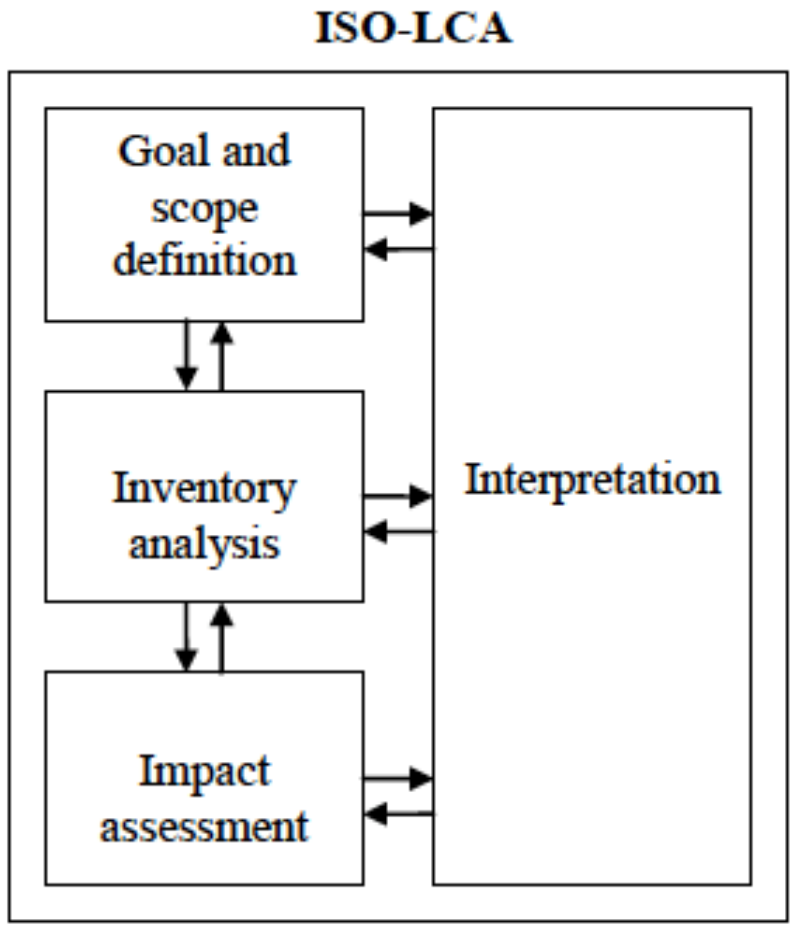
(source: Options for Strengthening Responsible Research and Innovation. van den Hoven et al 2013)

What RRI should have/do

- A comprehensive approach
- Involvement of stakeholders
- Prospective analysis
- Assessment of the consequences
- Integration of normative positions (values and needs)
- Provision of criteria for design of new research and products

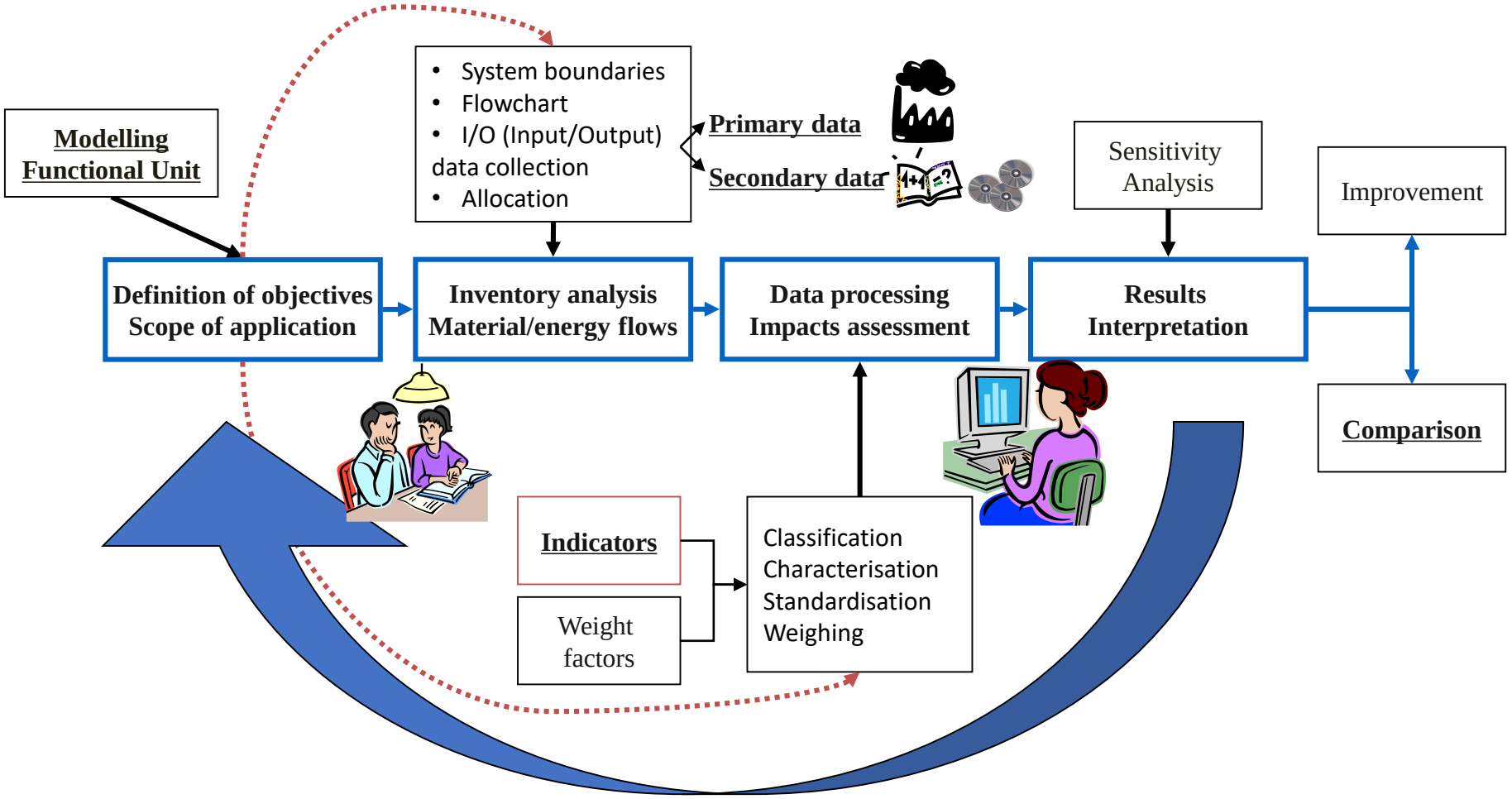
ALL THESE ASPECTS CAN BE SUPPORTED BY LCA

The LCA procedure



- 5-step iterative procedure with data and information flows (the arrows)
- Linear modelling
- Time and space not modelled
- Only technological relationships and environmental mechanisms modelled
- Environmental mechanisms linked to technological relationships through simple characterisation factors of elementary flows

Phases of an LCA study



Strengths of the LCA

- Avoids problem displacement (Avoids shifting the problem)
- Puts the system function at the centre of the analysis
- Allows comparisons between different ways of satisfying the same function
- Standard procedure with simple and sound scientific basis
- Simple, linear models
- Allows a high degree of analysis detail
- Allows a large amount of data and environmental information to be managed in a rational framework
- Excellent tool for continuous improvement

Weaknesses of the LCA

- Impossibility of experimental verification of results (common to all environmental analysis models)
- In the case of systems with relevant market interactions, the linearity of technological modelling cannot correctly represent complexity
- Complexity: needs a solid methodological basis on the part of the analyst
- Quality of input data not always well documented and not always truly representative of the process to be modelled
- Difficulty of a true comparison between different products even with similar function
- Difficulty in communicating results in a simple but scientifically correct manner

Why do the LCA

- Never forget the real reason for this type of analysis: to contribute, with robust and verifiable quantitative data, to guide decision-makers' choices towards solutions that significantly reduce environmental impacts so as to decouple welfare growth from environmental degradation.

Objective: decoupling growth and environmental degradation