INSTITUT FÜR ENERGIE- UND UMWELTFORSCHUNG HEIDELBERG

COSMOS
ADDING VALUE TO CAMELINA AND CRAMBE OIL

Independence Day? Are Camelina and Crambe sustainable alternatives to imported tropical plant oils?

Nils Rettenmaier, Guido Reinhardt, Tobias Wagner, Heiko Keller, Frank Wellenreuther

2nd International Bioeconomy Congress Baden-Württemberg, Stuttgart, 12 – 13 September 2017

The ifeu

- In 1971, professors and students founded the AGU:

  Working Group on Environmental Protection at the University of Heidelberg

  – Focus on current environmental policy issues, including a report about a proposed nuclear power plant in Wyhl.
- The need for independent environmental research led to the foundation of ifeu as a non-profit organisation in 1978.
- In 1992, ifeu became a GmbH (limited liability company) with non-profit status as of 1999.
- At present, ifeu has a staff of about 60 scientists who work as an interdisciplinary team with a broad variety of expertise on current environmental topics.
- The institute is committed to the goal of a sustainable society.

20 Jahre ifeu-Institut, M. Schmidt, U. Höpfner (Hrsg.), 1998, Heidelberg

Areas of Work

- Waste Management and Resource Conservation
- Environmental Education
- Energy (and Renewable Energies)
- Industry and Products
- Food and Biomass
- Sustainability
- Life Cycle Assessment (LCA)
- Risk Assessment
- Environmental Impact Analysis (EIA)
- Strategic Environmental Assessment (SEA)
- Traffic and Transport
- …. and many others

Agenda

1. Overview on the COSMOS project
2. Life Cycle Assessment (LCA): methods and results
3. Life Cycle Environmental Impact Assessment (LC-EIA): methods and results
4. Conclusions

Main aim of the COSMOS project

To **reduce Europe's dependence on imported tropical oils** (palm kernel, coconut, castor) as sources for medium-chain-length oleochemical surfactants, lubricants, polymers and other high-value products, **by turning camelina and crambe into profitable oilseed crops**.

COSMOS
ADDING VALUE TO CAMELINA AND CRAMBE OIL

COSMOS: Portrait of camelina and crambe

Camelina:

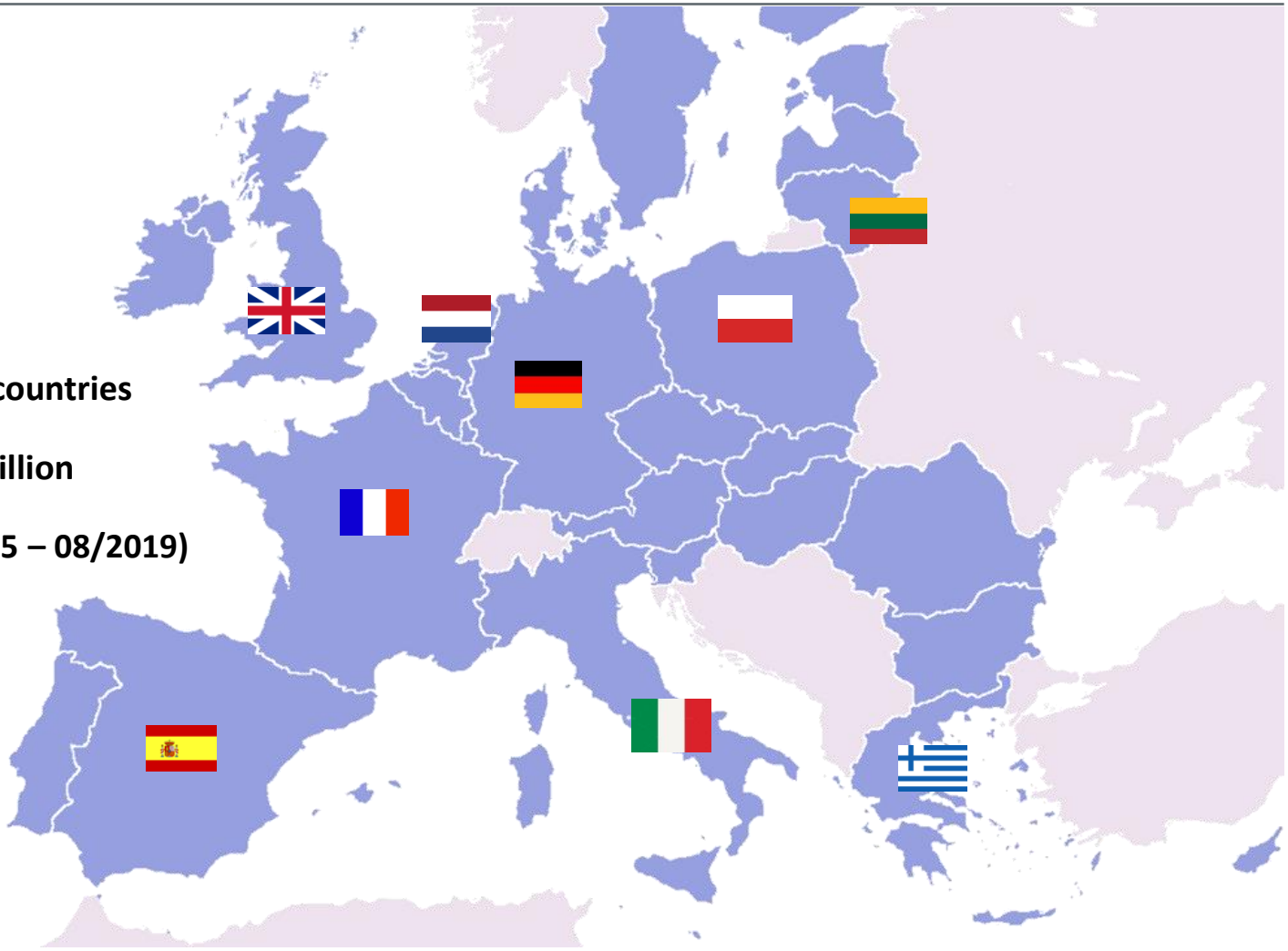
Name(s): camelina, gold-of-pleasure, false flax
(*Camelina sativa* (L.) CRANTZ)
Family: Brassicaceae
Fruit: Capsule (seeds in pods)
Yield: 2-3 t ha^{-1} yr^{-1} (2025: 3.3 t ha^{-1} yr^{-1})

Crambe:

Name(s): crambe
(*Crambe abyssinica* HOCHST. EX R.E.FR.)
Family: Brassicaceae
Fruit: Capsule (seeds in hull)
Yield: 2-3 t ha^{-1} yr^{-1} (2025: 4.0 t ha^{-1} yr^{-1})

Photo credits: Christina Eynck and Debbie Puttick (Linnaeus Plant Sciences), Robert van Loo and Rolf Blaauw (Wageningen UR)

COSMOS: Partners, budget and duration

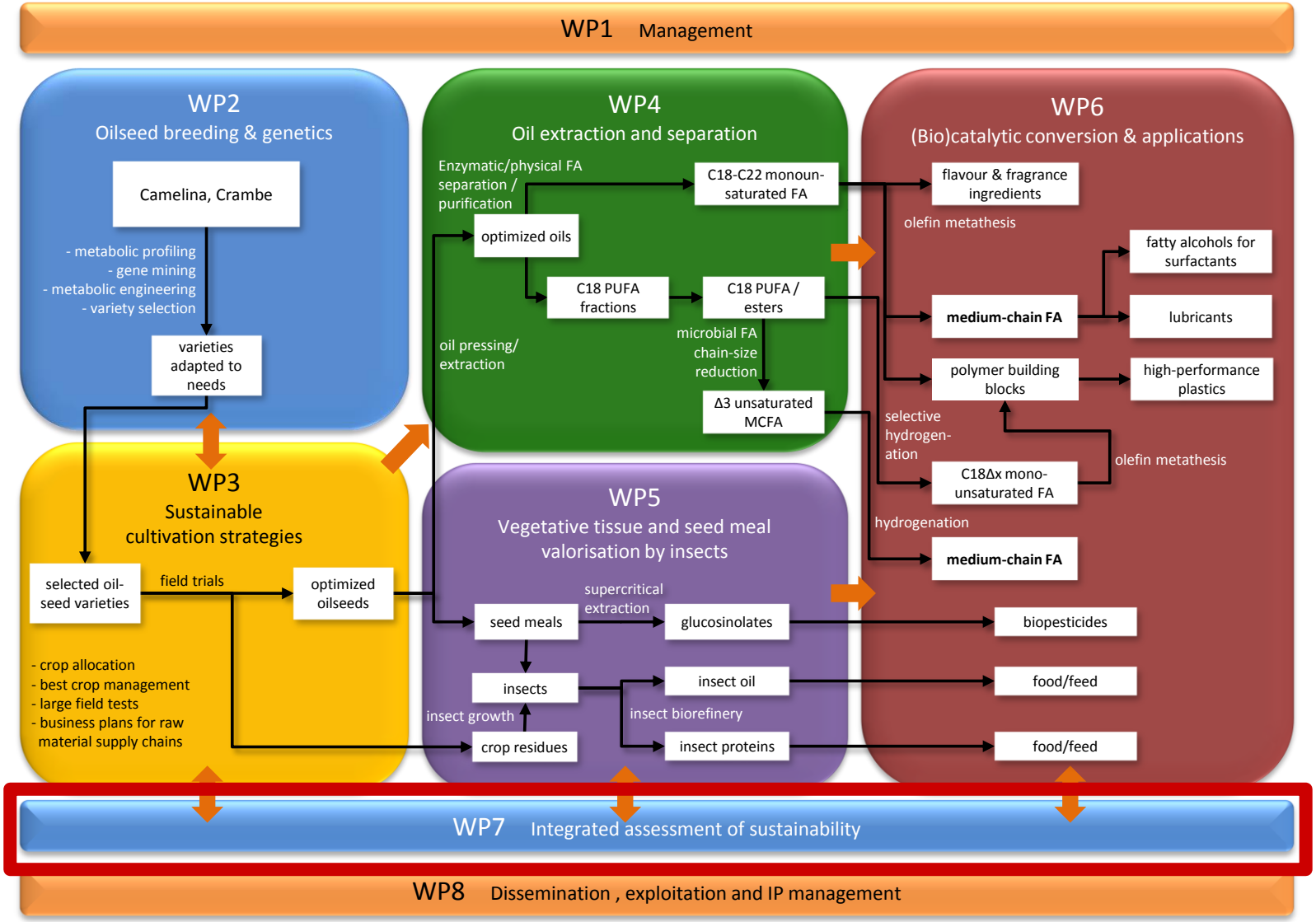


18 partners in 9 countries

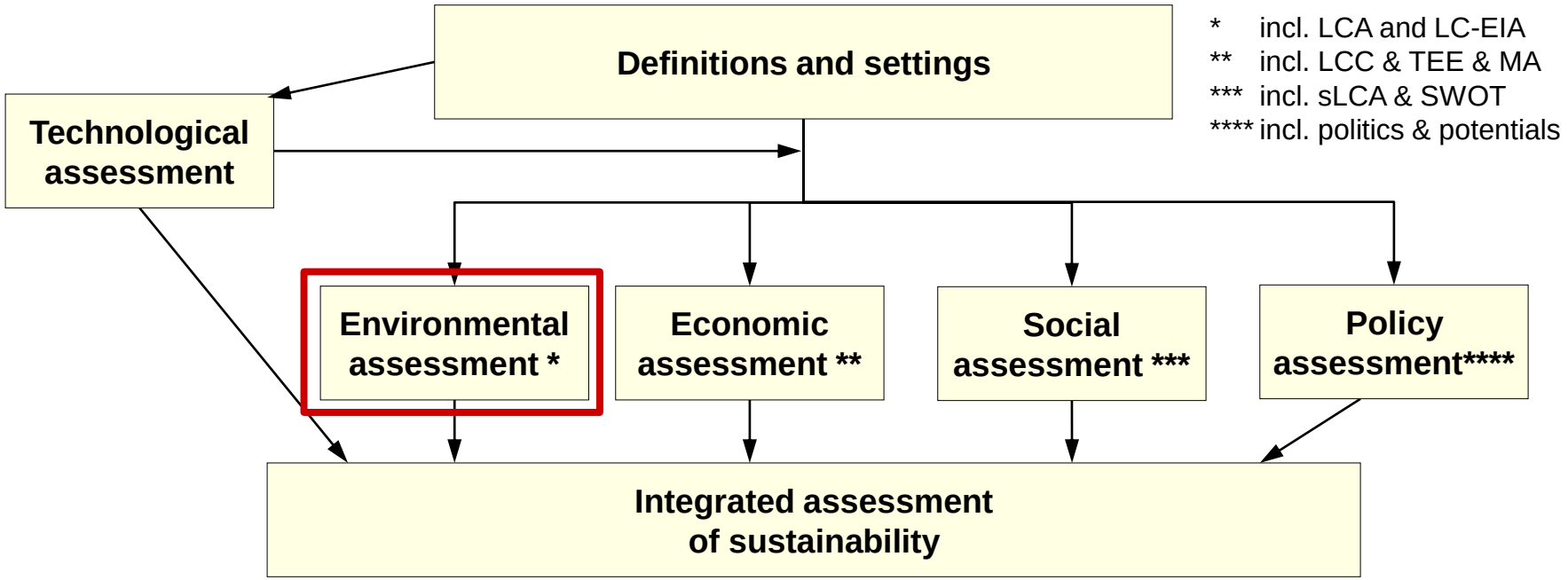
Budget: € 10.8 million

4.5 years (03/2015 – 08/2019)

COSMOS: Project structure

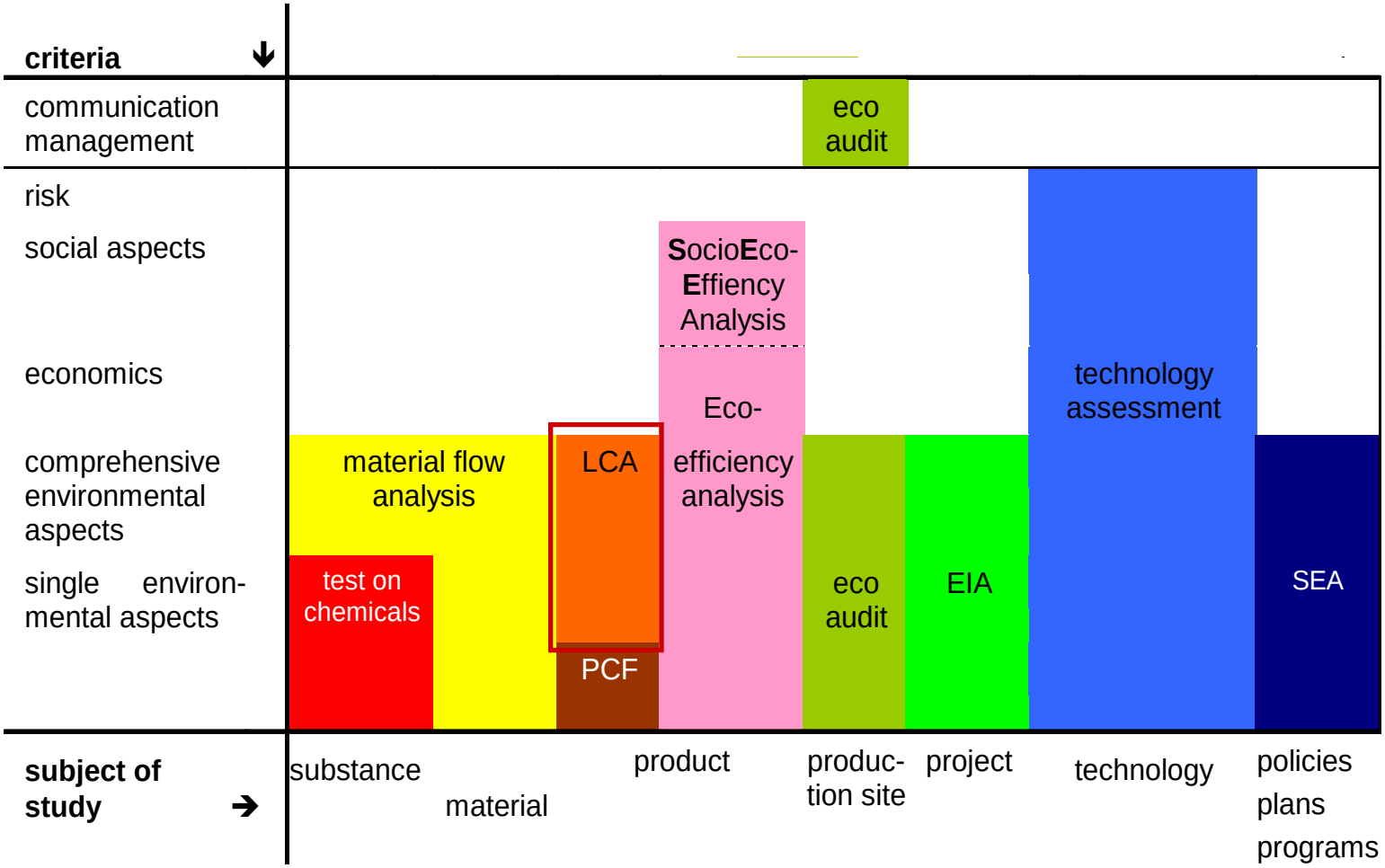


COSMOS: Sustainability assessment



Source: IFEU, own compilation

Environmental management tools



Source: IFEU, own compilation

LCA overview: Purpose

LCA addresses

- the environmental aspects and **potential environmental impacts** (e.g. use of resources and the environmental consequences of releases)
- **throughout the life cycle** from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. **cradle-to-grave**)
- of a **product** (*any* good or service).


INTERNATIONAL STANDARD ISO 14040

Environmental management — Life cycle assessment — Principles and framework


INTERNATIONAL STANDARD ISO 14044

Environmental management — Life cycle assessment — Requirements and guidelines

Source: ISO 14040

Environmental assessment

- Environmental impacts occur at different spatial scales

Climate change	**Global**	Stratospheric ozone depletion
Extraction of abiotic resources	↕	Extraction of biotic resources
Acidification		Nutrification / eutrophication
Human toxicity		Eco-toxicity
Photo-oxidant formation	**Local**	Land use

- State-of-the-art: Life cycle assessment (LCA)
  - Methodological developments regarding local environmental impacts (e.g. water and land use) still ongoing

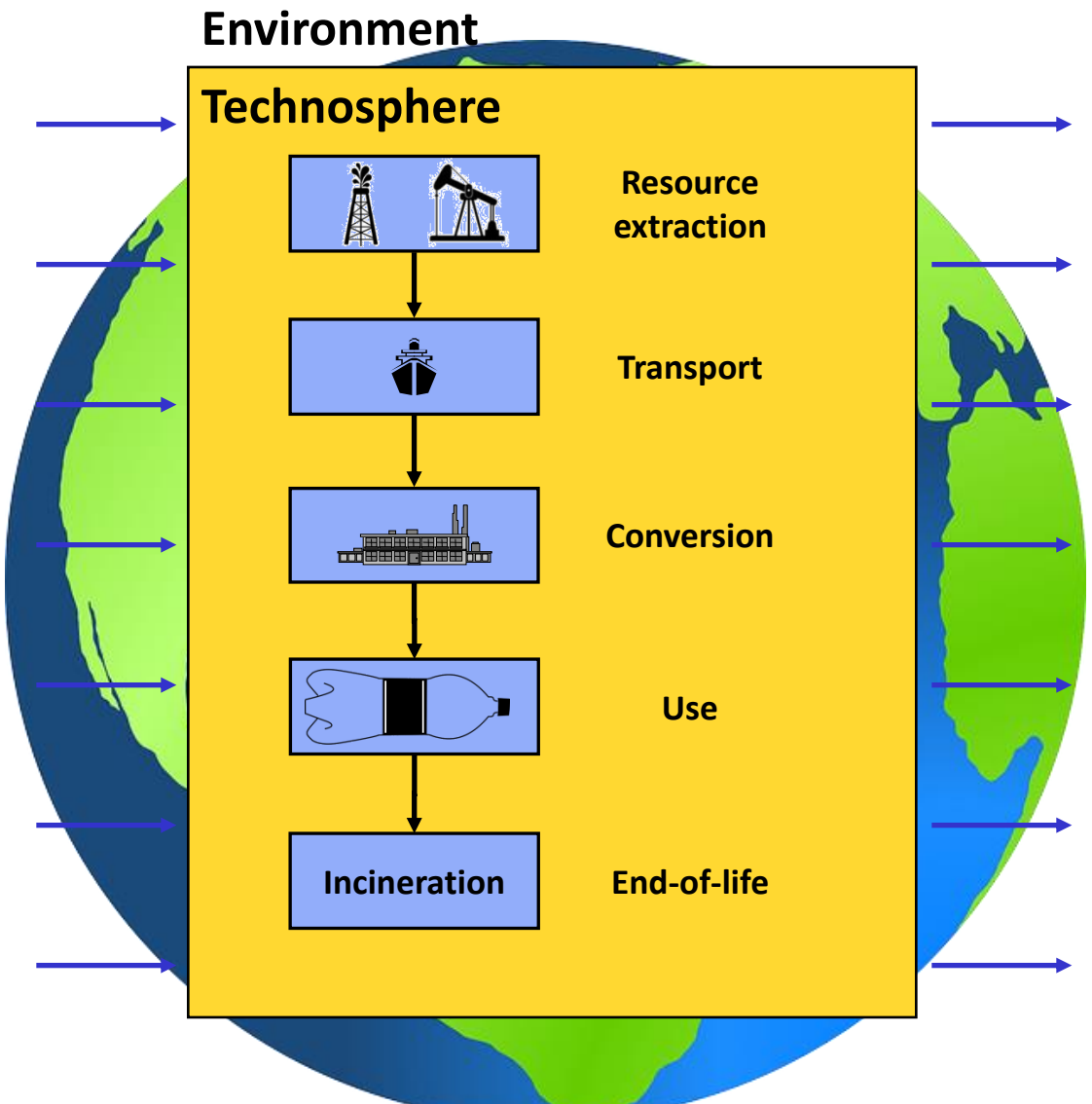
- Our approach: LC-EIA as a supplement to LCA
  - 'Life Cycle Environmental Impact Assessment' (LC-EIA)
  - Qualitative risk assessment; uses elements from EIA

LCA overview: Scope

Resources

e.g.:

- natural gas
- crude oil
- lignite
- hard coal
- uranium
- water
- ores
- minerals



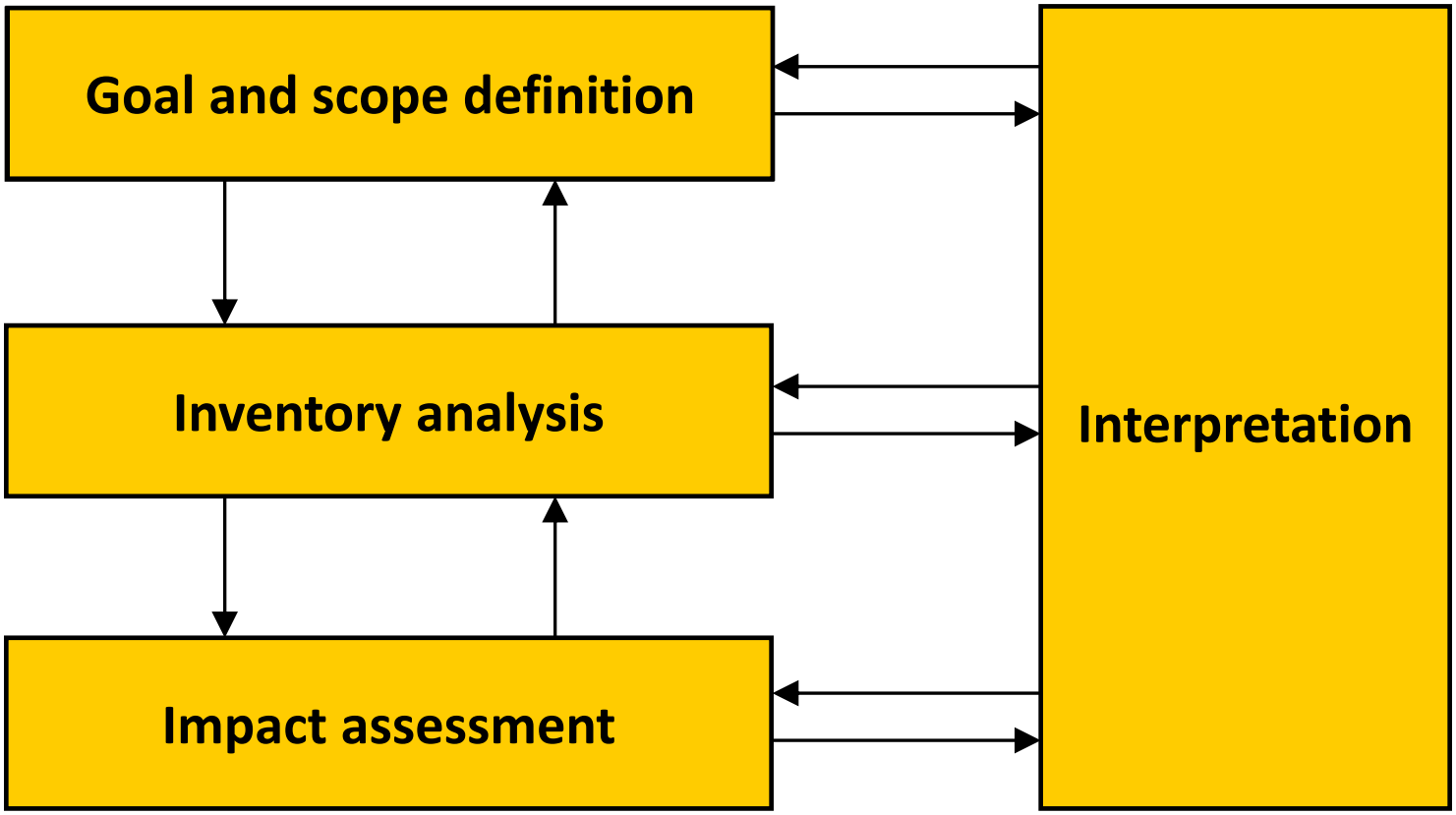
Releases

e.g.:

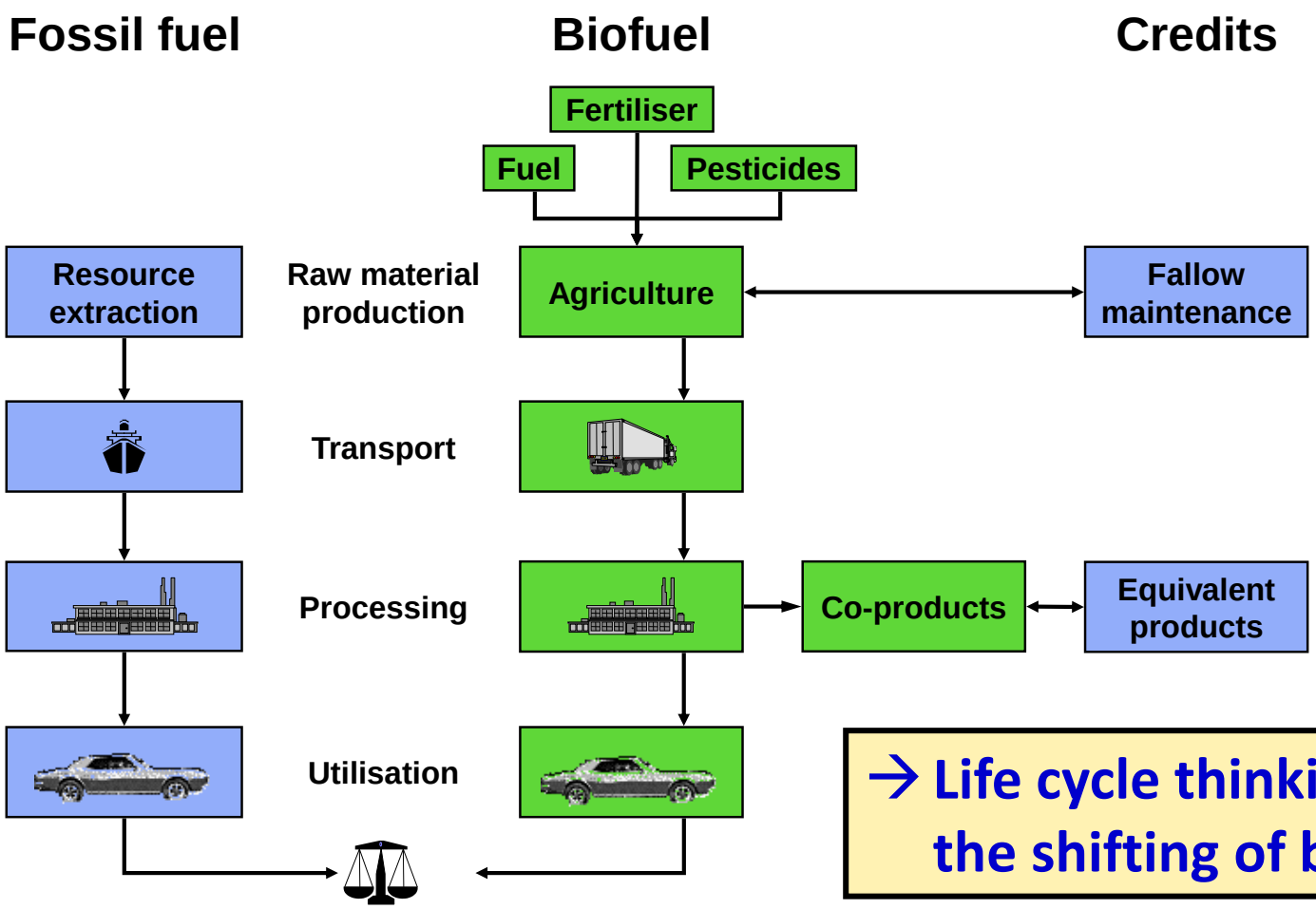
- CO_2
- SO_2
- CH_4
- NO_x
- NH_3
- N_2O
- HCl
- CO
- C_6H_6
- VOC

LCA overview: The four (iterative) phases

Structure following ISO standards 14040 & 14044

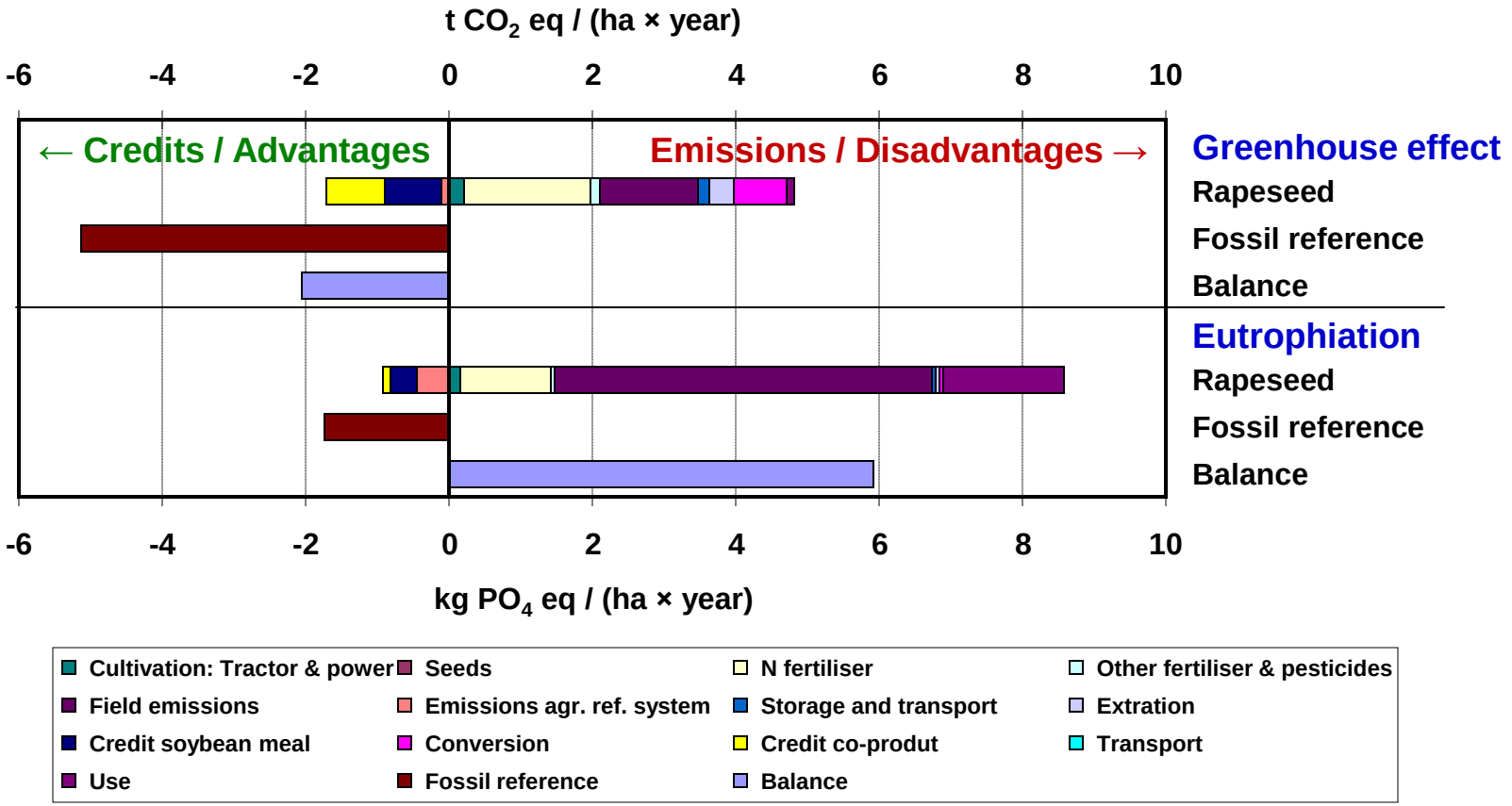


LCA overview: Life cycle comparison



→ Life cycle thinking avoids the shifting of burdens

Example: Rapeseed biodiesel vs. diesel



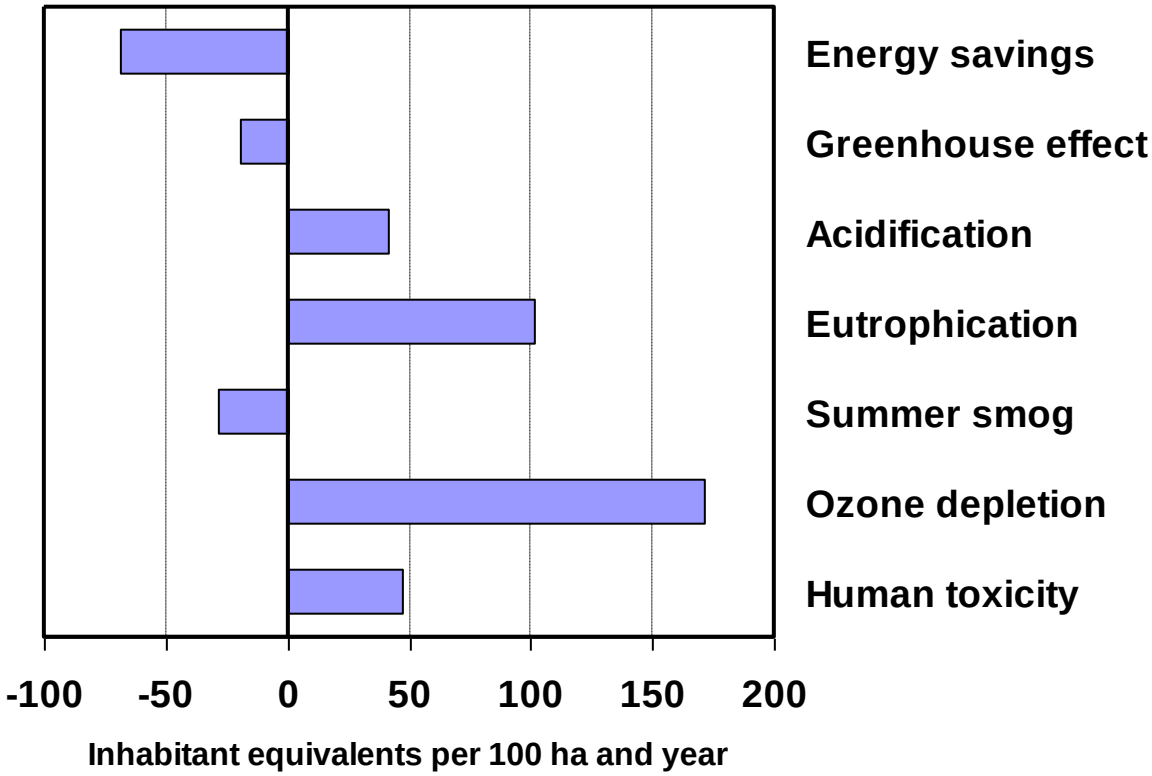
→ Impacts of life cycle stages differ between categories

Source: IFEU 2017

Example: Rapeseed biodiesel vs. diesel

← Advantages for biodiesel Advantages for diesel →

Rapeseed

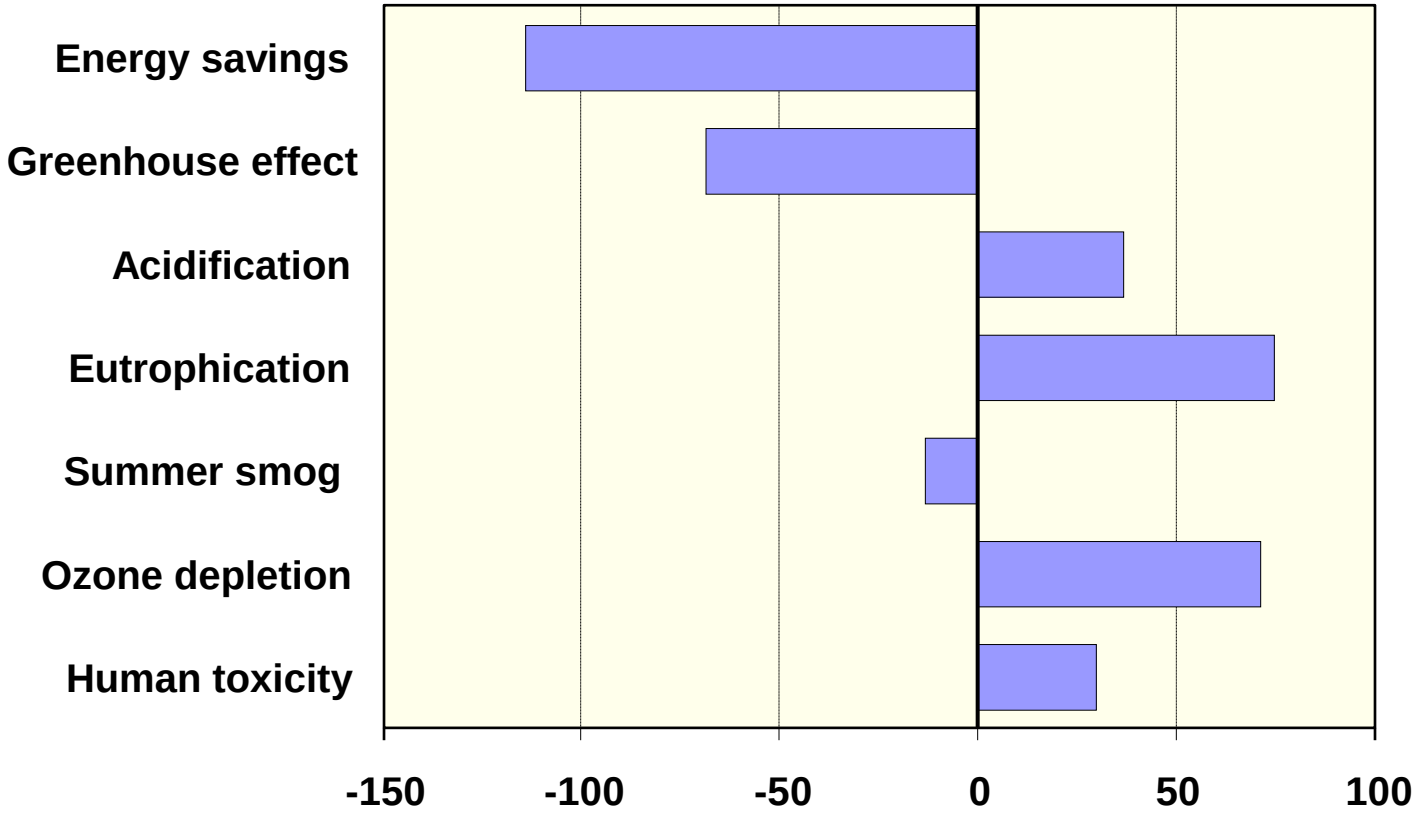


→ Characteristic pattern of advantages and disadvantages

Source: IFEU 2017

Example: Sugar beet bioethanol vs. gasoline

← Advantages for bioethanol Advantages for gasoline →

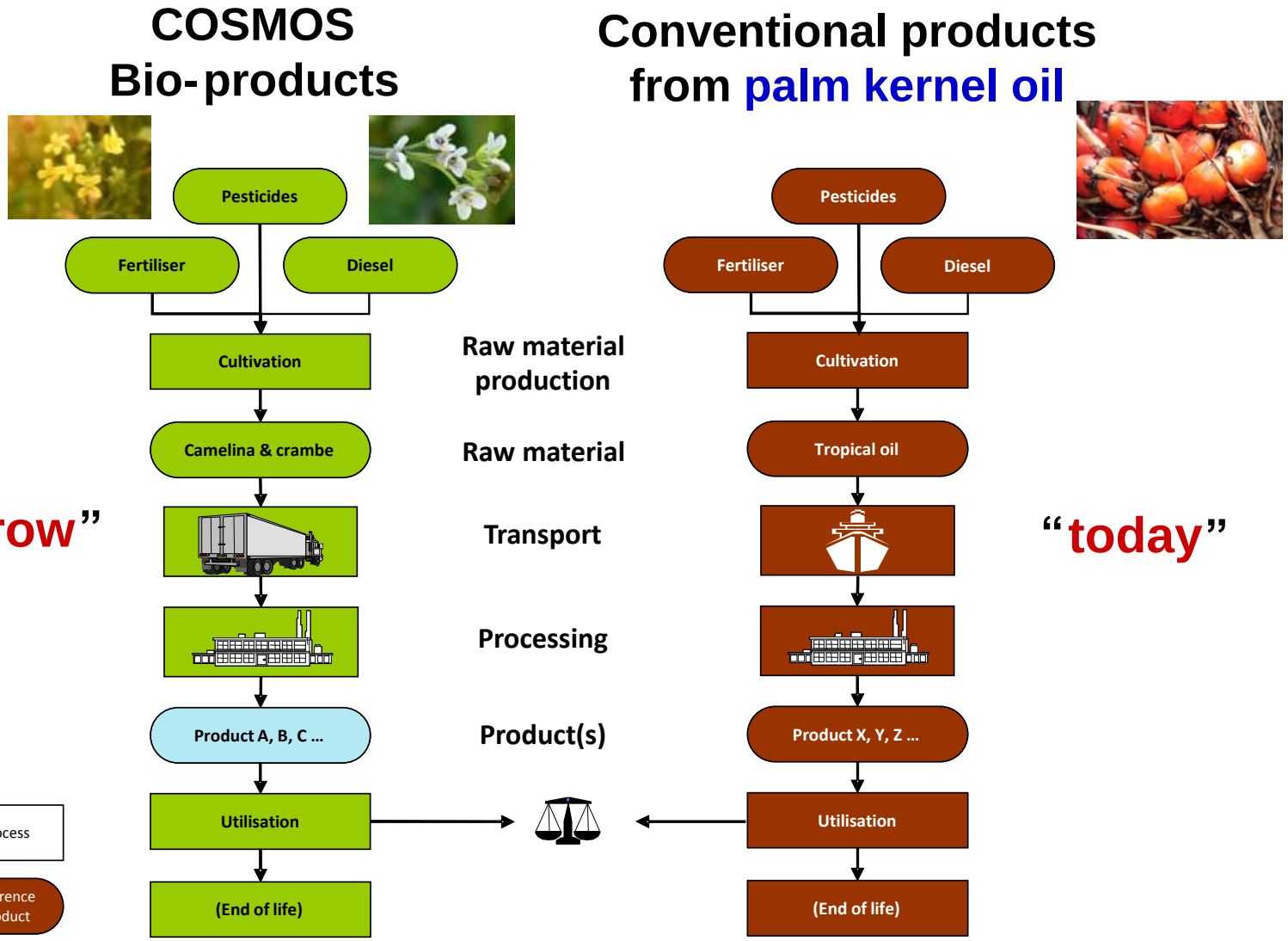


Sugar beet

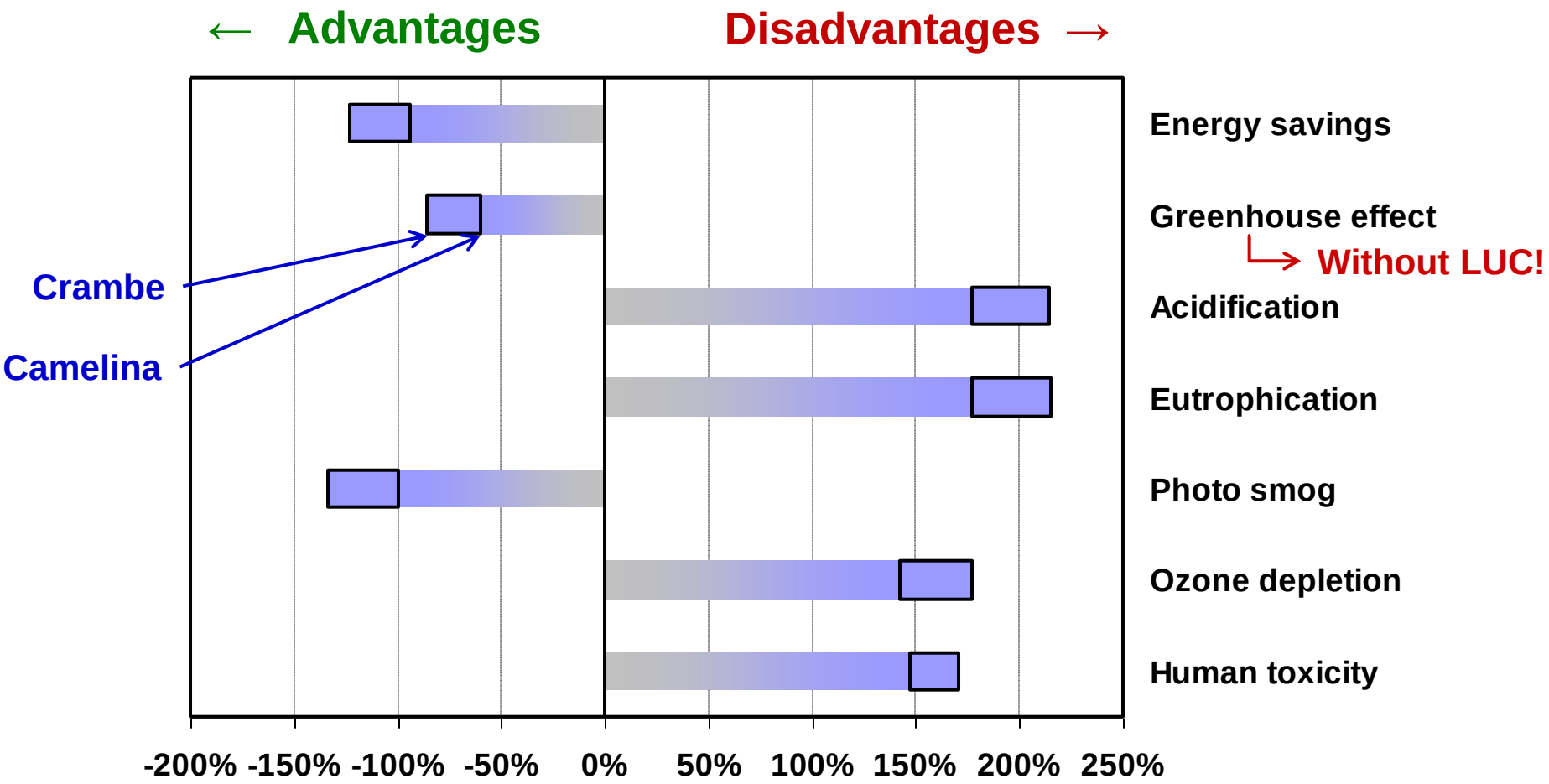
Inhabitant equivalents per 100 ha and year

Source: IFEU 2013

COSMOS: Simplified life cycle comparison



Interim results:
Camelina and crambe vs. rapeseed

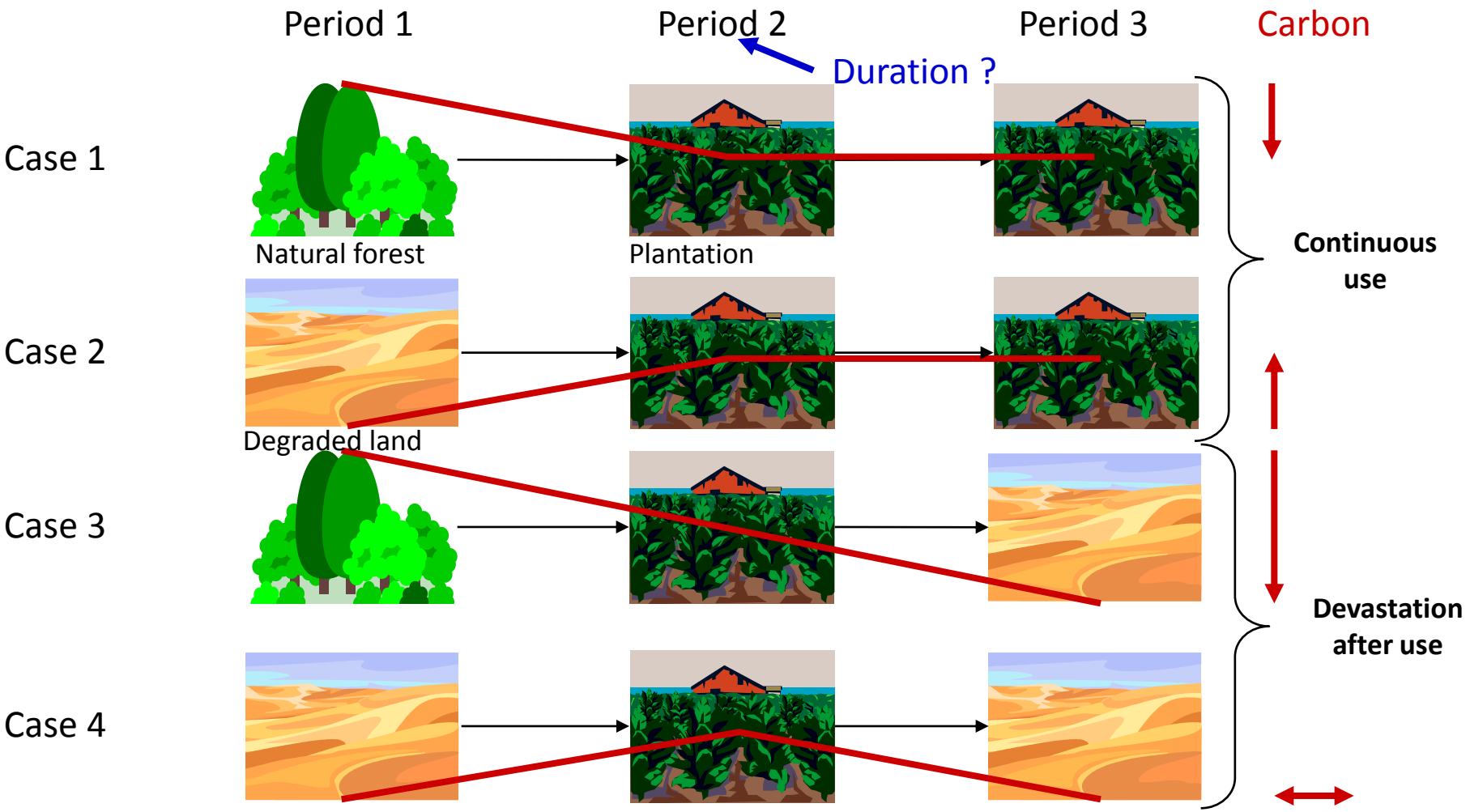


Source: IFEU 2017

Land use change (LUC)

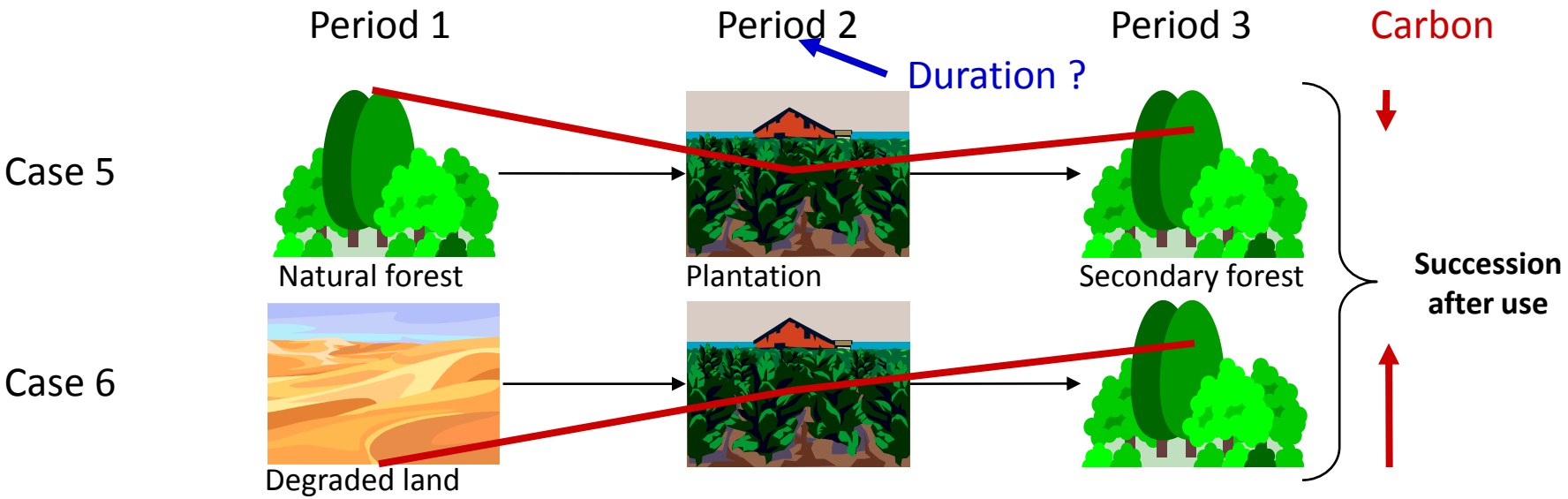
- Definition: Transition from one land use category to another, e.g. forest land to cropland.
  - Direct land use change (dLUC)
  - Indirect land use change (iLUC)
- Environmental implications:
  - Loss of biodiversity
  - GHG emissions due to carbon stock changes
- Social / socio-economic implications
  - Displacement of indigenous people
  - …

Carbon stock changes



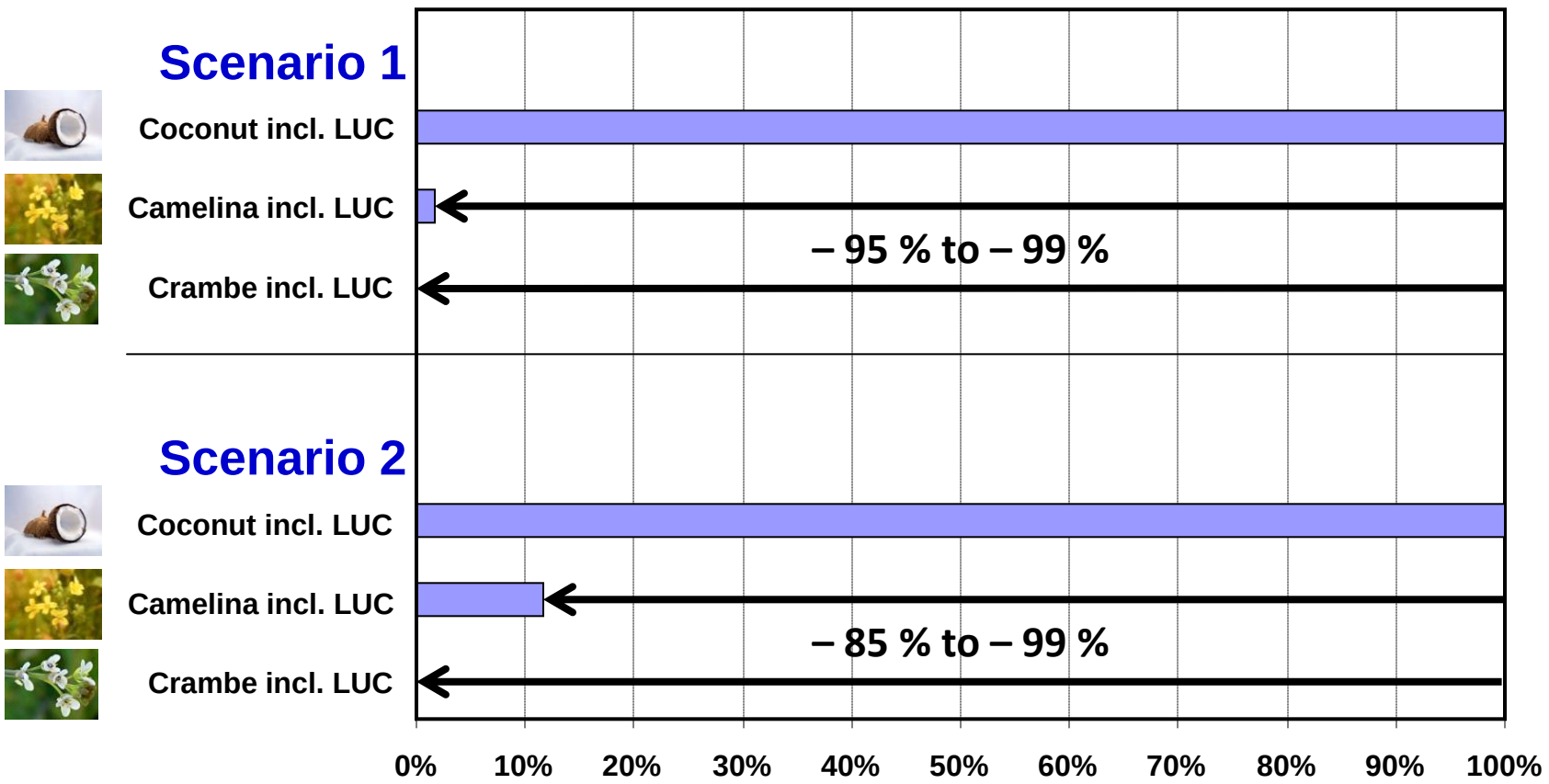
Source: IFEU, own compilation

Carbon stock changes II



Source: IFEU 2006

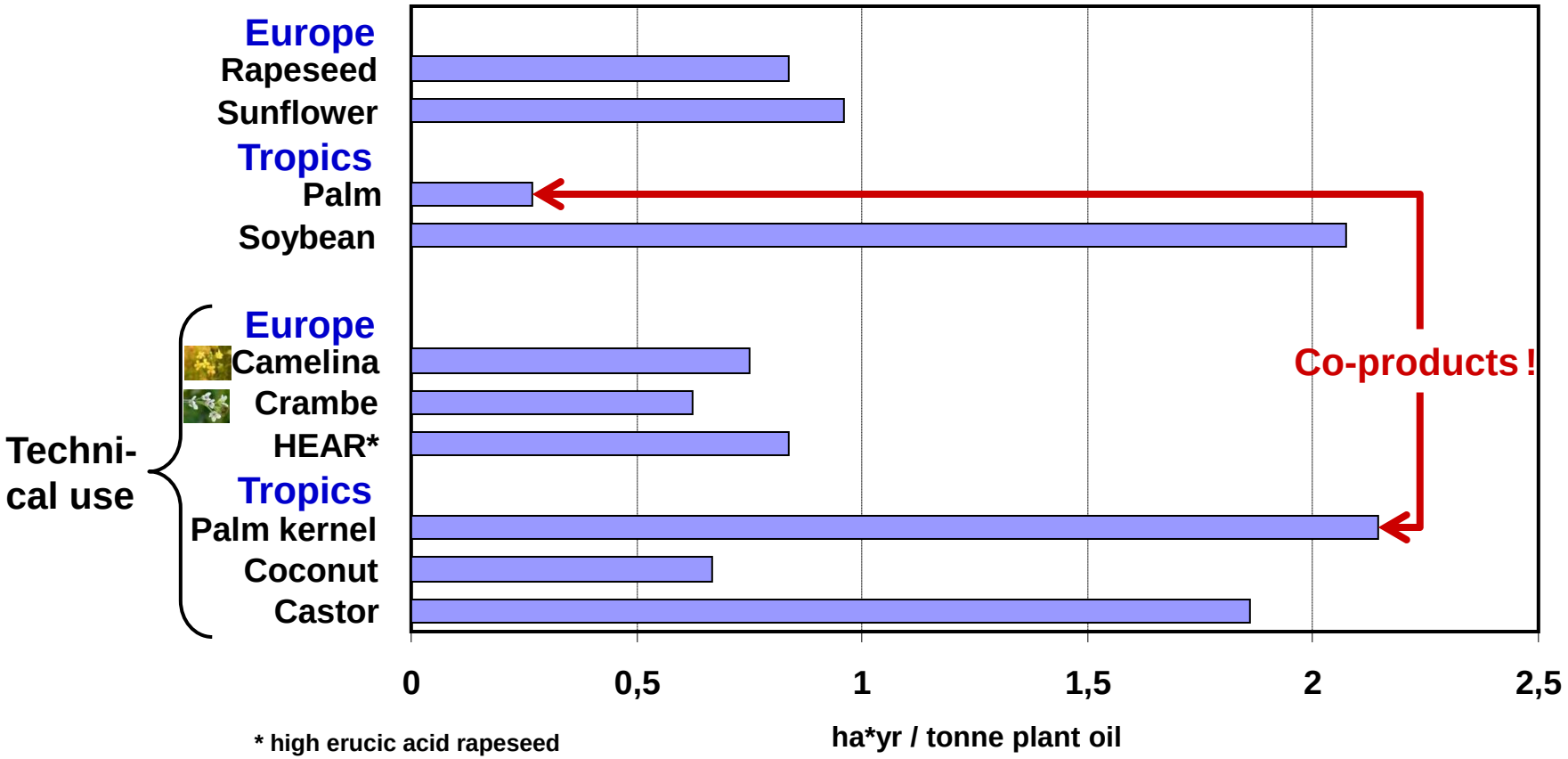
Interim results:
GHG emissions related to land use changes



→ Enormous reduction potential by replacing tropical plant oils

Source: IFEU 2017
Coconut by By Robert Wetzlmayr, via Wikimedia Commons

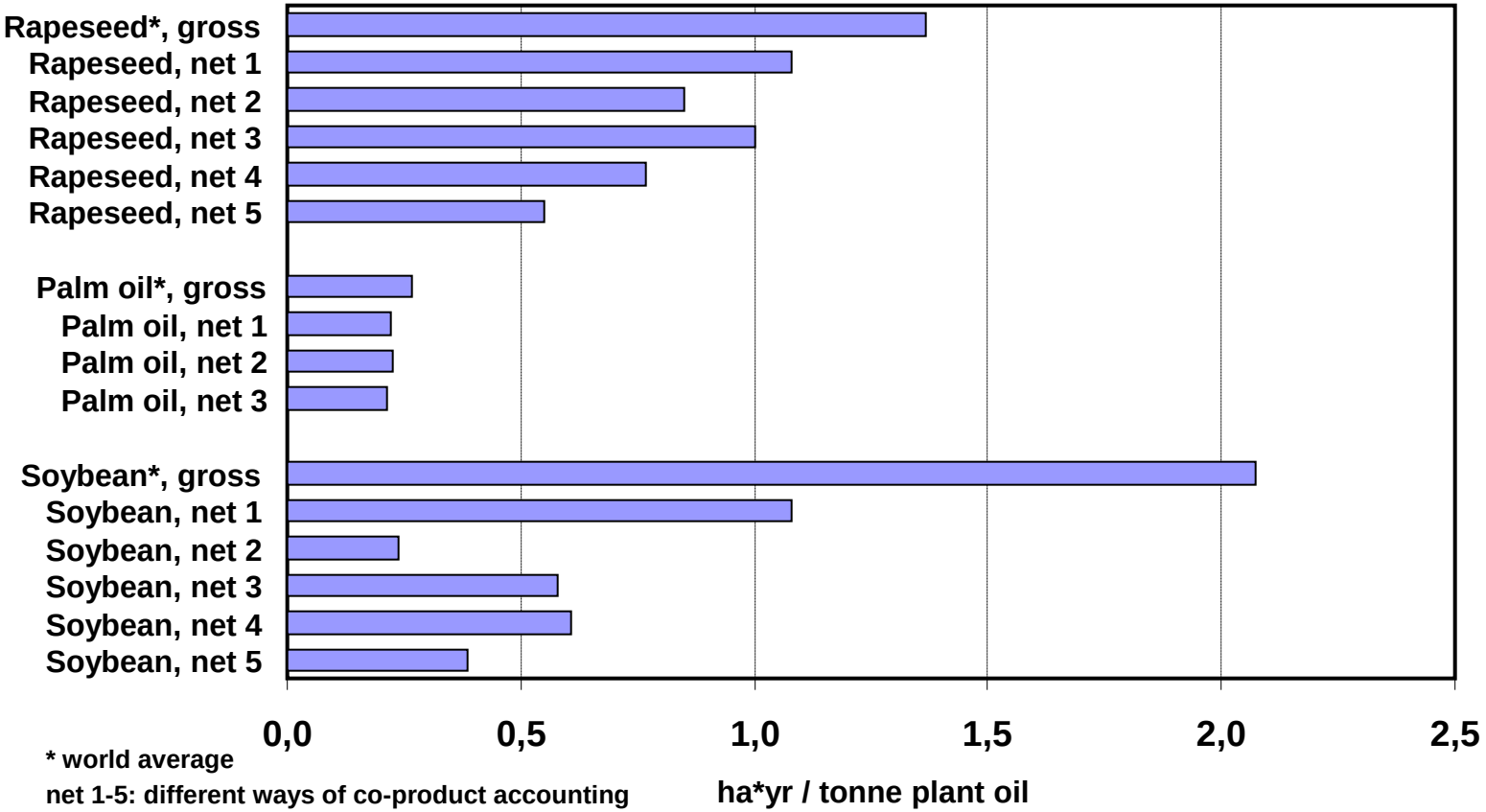
Interim results: Gross land footprint of plant oils



→ Large differences between crops; gross numbers not appropriate

Source: IFEU 2017

Interim results:
Gross vs. net land footprint of plant oils



* world average

net 1-5: different ways of co-product accounting

→ Net numbers lower; way of co-product accounting often decisive

Source: IFEU 2017

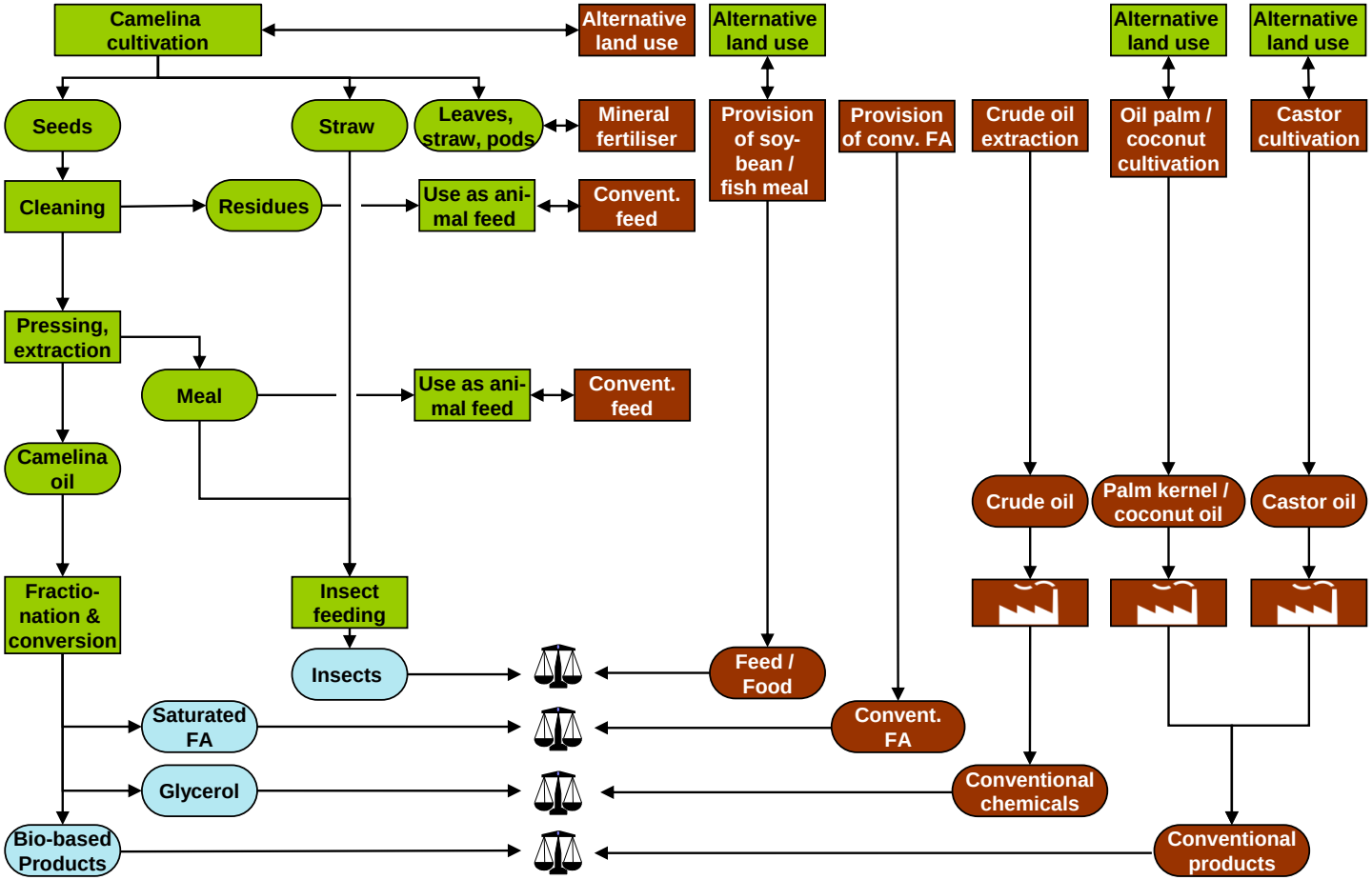
Soybean field by Mlabar, via Wikimedia Commons

COSMOS: Detailed life cycle comparison

©: Fornax / Wikimedia Commons

COSMOS: Camelina

Reference System



Interim conclusions on LCA

- LCA results for products from energy / industrial crops show environmental advantages and disadvantages. The same characteristic pattern applies to most applications.
- Biofuels / bio-based products are not environmentally friendly *per se*, just because they are derived from (renewable) biomass.
- LCA is a suitable tool to *identify* environmental implications of a product and to *optimise* its environmental performance.
- Interim LCA results for camelina and crambe are similar to rape-seed. There is an enormous potential to reduce GHG emissions related to land use changes by replacing tropical plant oils.
- Their land footprint is dependent on co-product use options (and accounting). These are currently being studied in COSMOS.

Environmental assessment

- Environmental impacts occur at different spatial scales

Climate change	**Global**	Stratospheric ozone depletion
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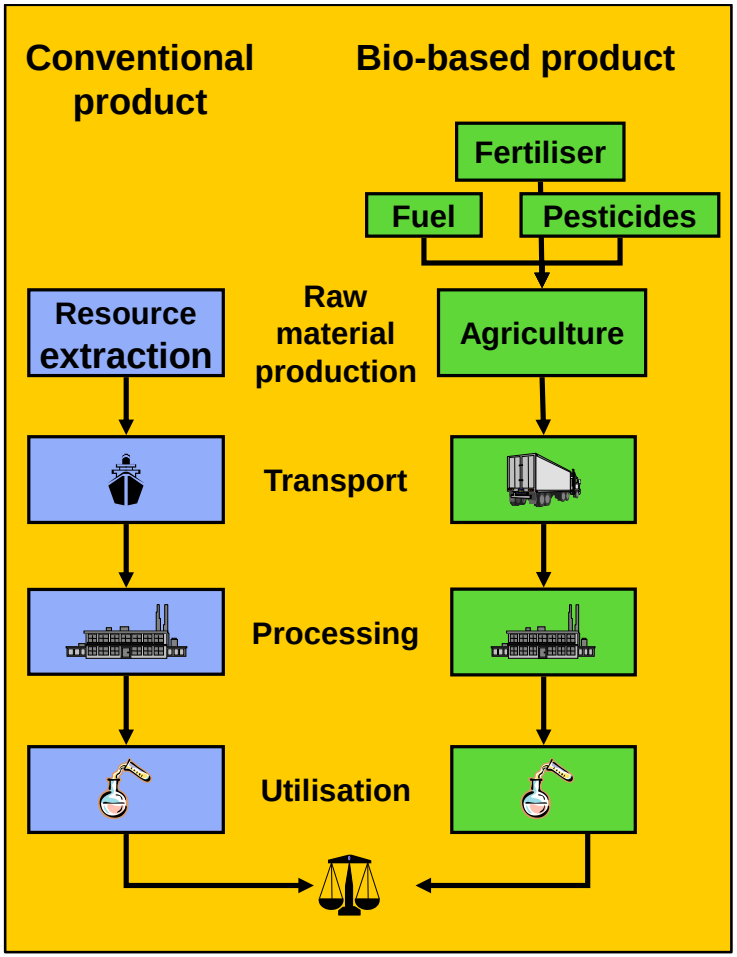
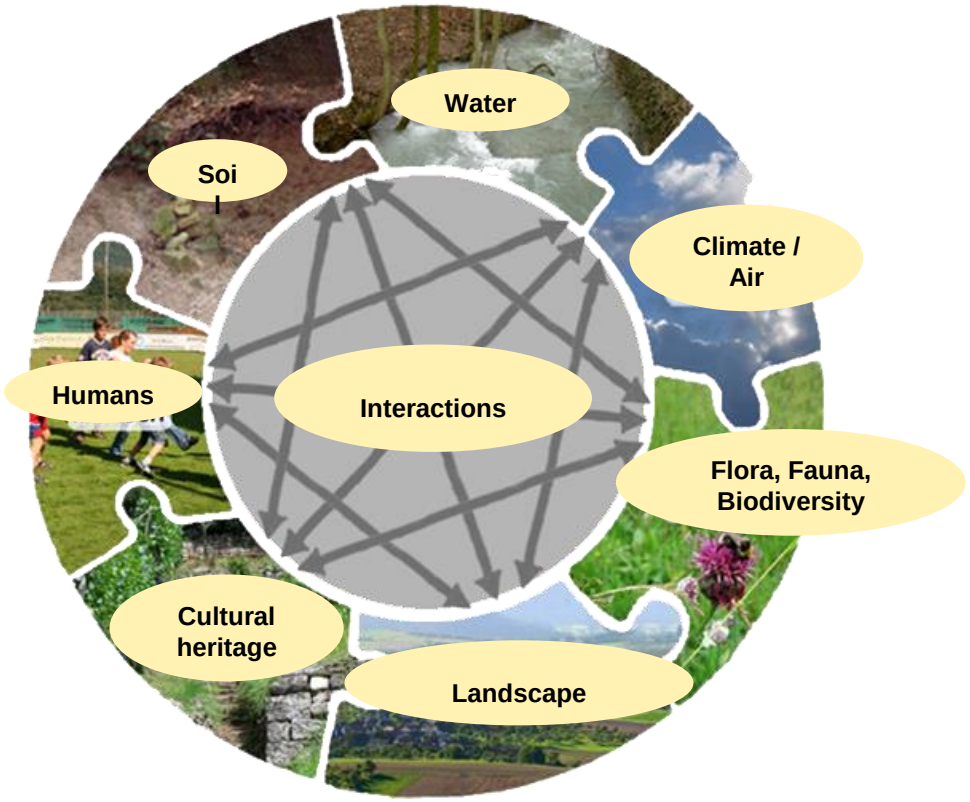
Life Cycle Environmental Impact Assessment





Interim results on LC-EIA:
Camelina vs. rotational fallow land

Type of risk	Affected environmental factors								
	Soil	Ground water	Surface water	Plants / Biotopes	Animals	Climate / Air	Land-scape	Human health and recreation	Bio-diversity
Soil erosion	neutral / negative[1]		negative						
Soil compaction	negative	negative		negative	negative				negative
Loss of soil organic matter	neutral / negative[1,2]			neutral / negative[1,2]	neutral / negative[1,2]				neutral / negative[1]
Soil chemistry / fertiliser	negative	negative							
Eutrophi-cation	negative	negative	negative	negative	negative				negative
Nutrient leaching		negative	negative						
Water demand		negative		negative	negative				neutral
Weed control / pesticides		negative	negative	negative	negative				negative
Loss of landscape elements				neutral	neutral	neutral	neutral	neutral	neutral

Source: IFEU 2017

→ **Cultivation of camelina shows mainly negative local environmental impacts compared to rotational fallow land**

Interim results on LC-EIA:
Tropical rainforest vs. oil palm

Type of risk	Affected environmental factors								
	Soil	Ground water	Surface water	Plants / Biotopes	Animals	Climate / Air	Land-scape	Human health and recreation	Bio-diversity
Soil erosion	positive		positive						
Soil compaction	positive	positive		positive	positive				positive
Loss of soil organic matter	positive			positive	positive				positive
Soil chemistry / fertiliser	positive	positive	positive						
Nutrient leaching	positive	positive							
Eutrophi-cation	positive	positive	positive	positive	positive				positive
Water demand		positive	positive	positive					positive
Weed control / pesticides		positive	positive	positive	positive				positive
Loss of landscape elements				positive	positive	positive	positive	positive	positive

Source: IFEU 2017

→ **Avoiding land use change from tropical rainforest to oil palms would result in positive local environmental impacts.**

Conclusions

1. The COSMOS value chains involves the production and replacement of a multitude of products. Implementing them could cause substantial changes in the EU and in other world regions, e.g. Asia.
2. Thus, it is important to investigate all conventional reference products as thoroughly as the COSMOS products.
3. Special emphasis should be put on the assessment of all involved co-products as well as on the quantitative and qualitative land footprint. These can significantly influence the results and are currently being studied in COSMOS.
4. Whether camelina and crambe in the end are more environmentally friendly also depends on the emissions of the process steps necessary to convert the raw plant oils. These can be lowered if breeding techniques targeting the oil composition are successful.

Conclusions

5. **LCA is a very suitable tool and interim LCA results show that there is an enormous potential to reduce GHG emissions related to land use changes (LUC) by replacing tropical plant oils.**

6. **However, since LCA is not (yet) able to address local environmental impacts, it needs to be supplemented by a separate life cycle environmental impact assessment (LC-EIA). Interim results point at advantages for camelina and crambe (in case of LUC avoidance).**

7. **Economic and social aspects such as job creation, impacts on indigenous people etc. are important to complete the comprehensive sustainability assessment in COSMOS which aims at ensuring an overall benefit for environment, economy and society.**

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Thank you very much for your attention!

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