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# Life cycle assessment of chitin and chitosan production in India and Europe

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# What is LCA and why do we need it?

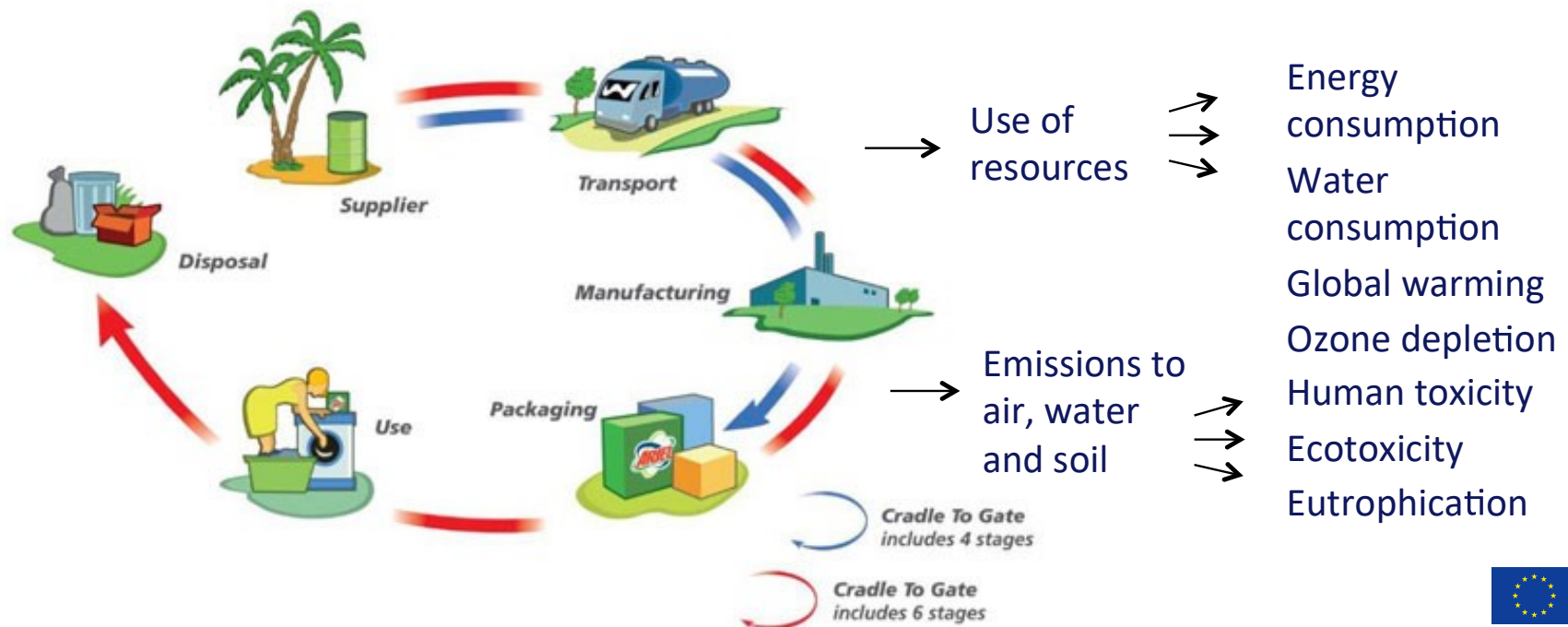
- Increasing interest in understanding the environmental impacts of human activities
- Need to move from “end of pipe” mindset to a more holistic approach: “life cycle thinking”



Source: Procter & gamble

# What is LCA and why do we need it?

- ≡ Life cycle thinking is meant to prevent problem shifting
- ≡ LCA is a tool to put life cycle thinking in actual numbers
- ≡ According to ISO 14040 LCA is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle



## LCA of chitin and chitosan

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- ≡ Few LCA studies on chitin/chitosan. None based on primary data from actual producers
- ≡ In the FP7 project Nano3bio a full workpackage was devoted to the LCA of chitosan
- ≡ We present the results of applying LCA to two chitin/chitosan supply chains:
  - ≡ Chitin/chitosan produced from **shrimp shells** in **India, general purpose**
  - ≡ Chitin/chitosan produced from **snow crab** in **Europe, medical applications**
- ≡ The functional unit is demanding 1 kg of chitin and 1 kg chitosan
- ≡ The system is “cradle to gate” (use and end of life excluded)

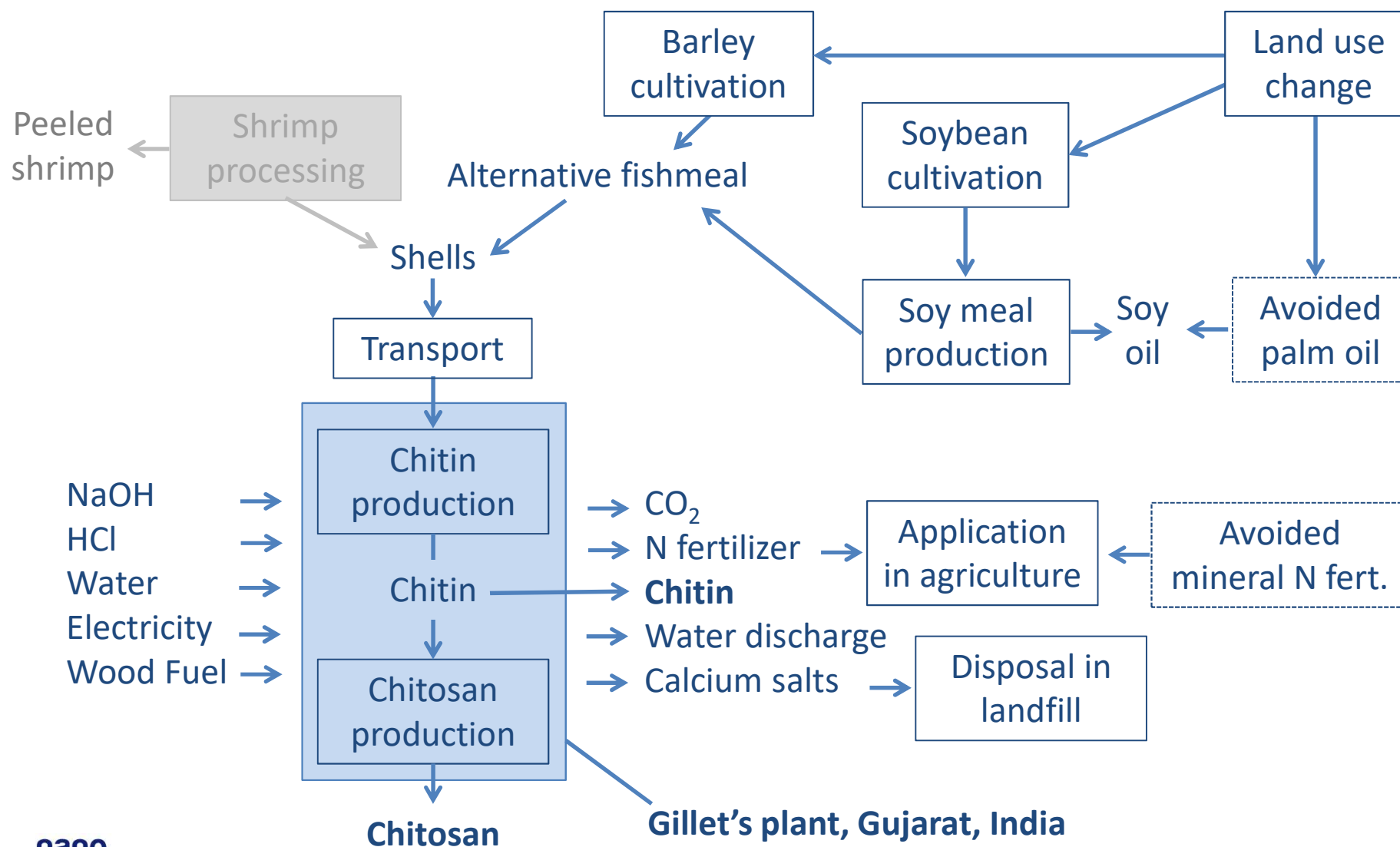
# The chitin and chitosan product system: **INDIA**

Shrimp shells  
from wild catch  
in the Arabian  
sea





# The chitin and chitosan product system: **INDIA**

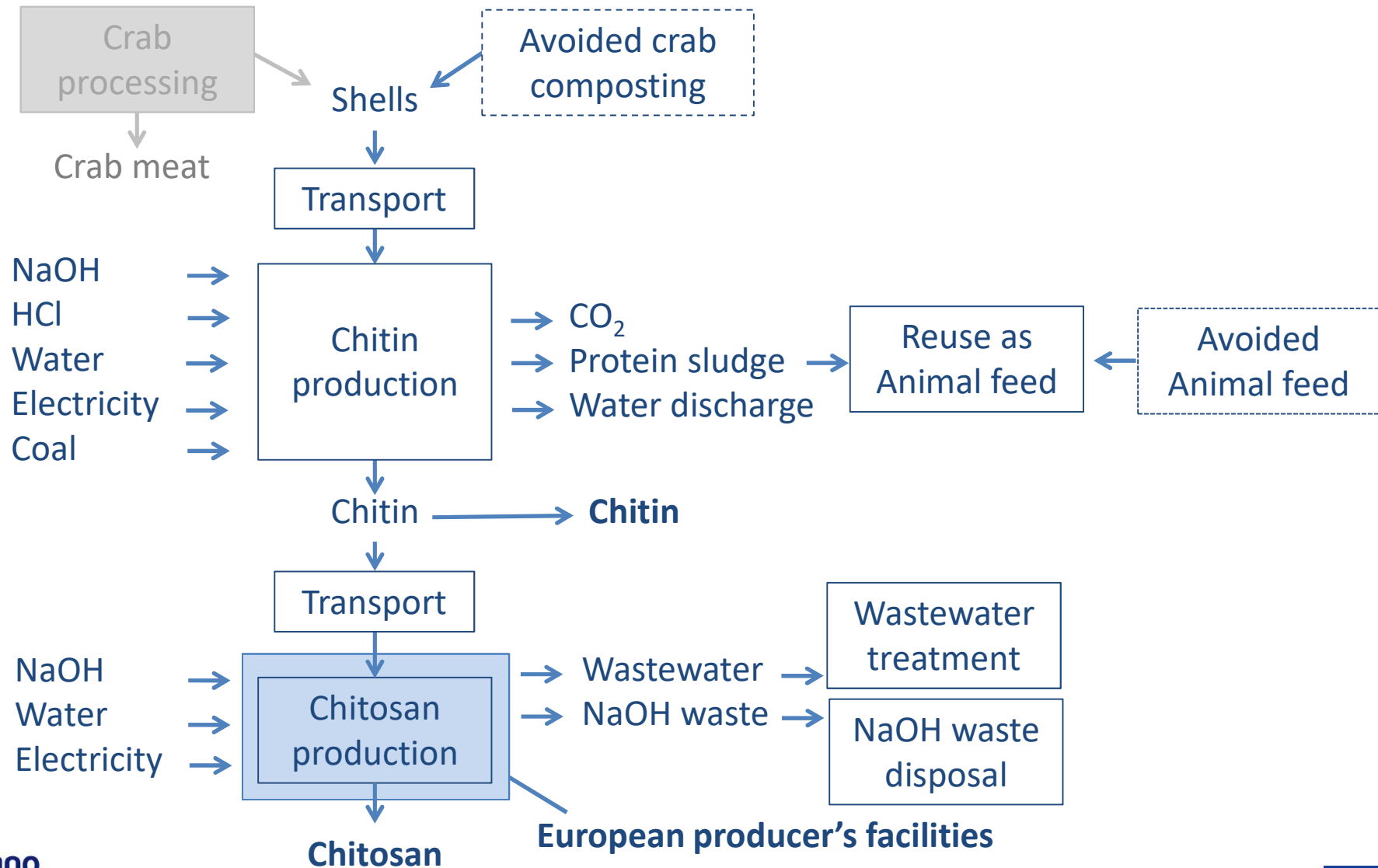


# The chitin and chitosan product system: **EUROPE**

Snow crab shells  
from Canada



# The chitin and chitosan product system: **EUROPE**





# Inventory analysis

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- ≡ Consists of a mass and energy balance of the system under study
- ≡ Three main data sources:
  - ≡ Chitosan producers:
    - Their inputs and outputs from/to the production process
  - ≡ Literature and own models:
    - Composting, crop production, land use change...
  - ≡ LCA databases
    - Production of electricity, chemicals, fuels...
- ≡ All data are implemented in an LCA software (SimaPro)

# Inventory analysis

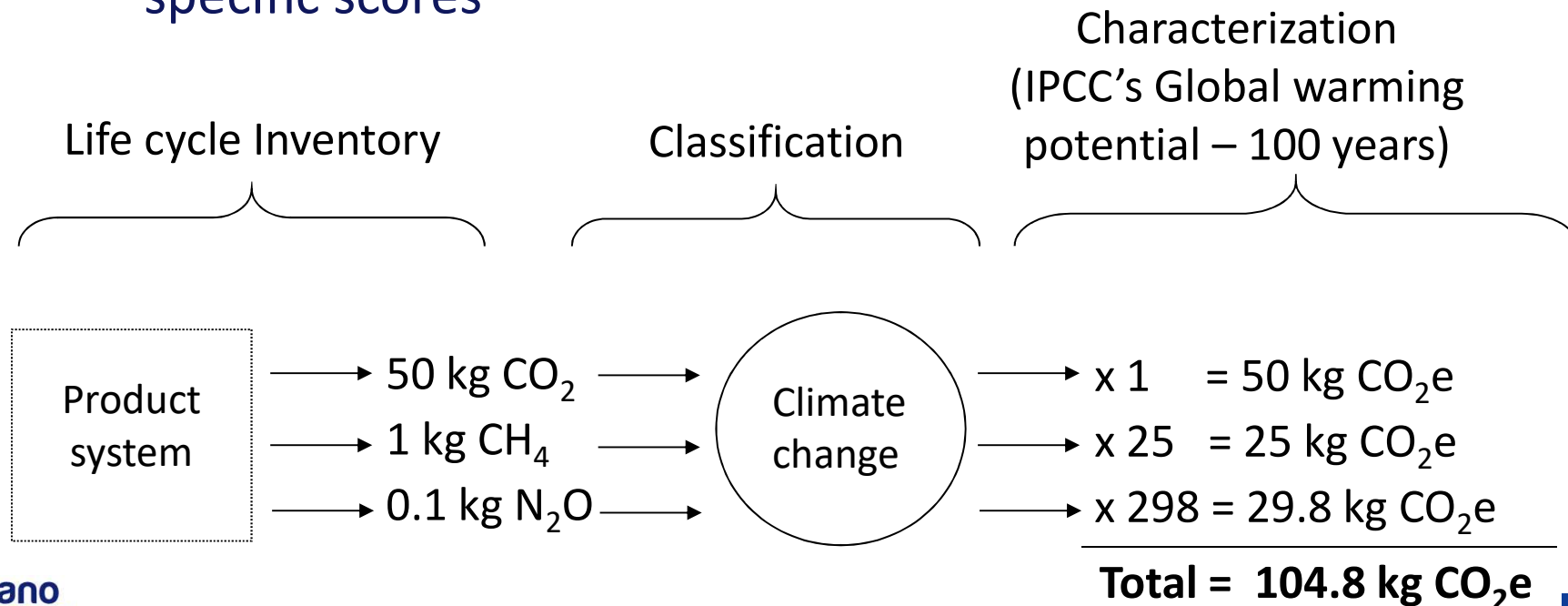
## Example of inventory data: mass balances for chitin and chitosan production in India

INPUTS		
Shrimp shells, fresh weight	33	kg
HCl, 32%	8	kg
NaOH, 98%	1.3	kg
Electricity, India	1.3	kwh
Water, fresh	167	L
Land occupation	0.045	m <sup>2</sup> y
OUTPUTS		
<b>Chitin</b>	1	kg
Protein sludge fertilizer	4	kg
Calcium waste	1.5	kg
CO <sub>2</sub> to air	0.7	kg
Wastewater	167	L

INPUTS		
Chitin	1	kg
NaOH, 98%	3.7	kg
Water, fresh	179	L
Electricity, India	0.8	kwh
Wood fuel	1.4	kg
Land occupation	0.031	m <sup>2</sup> y
OUTPUTS		
<b>Chitosan</b>	0.71	kg
Wastewater	179	L

# Impact assessment

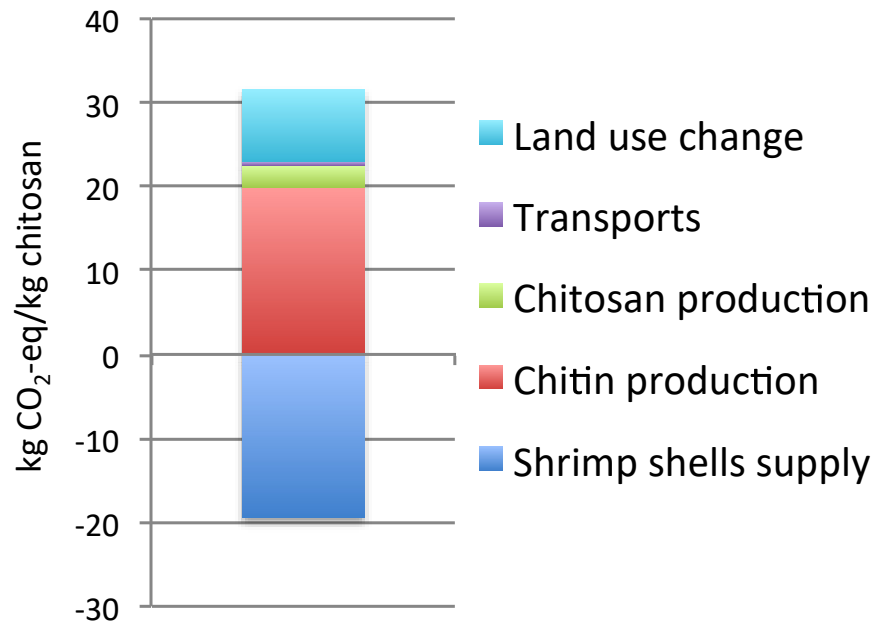
- ≡ The result of the LCI is a huge table with flow quantities (natural resources, pollution), not useful for interpretation
- ≡ Substances contributing to a given environmental impact are quantitatively aggregated into impact-specific scores



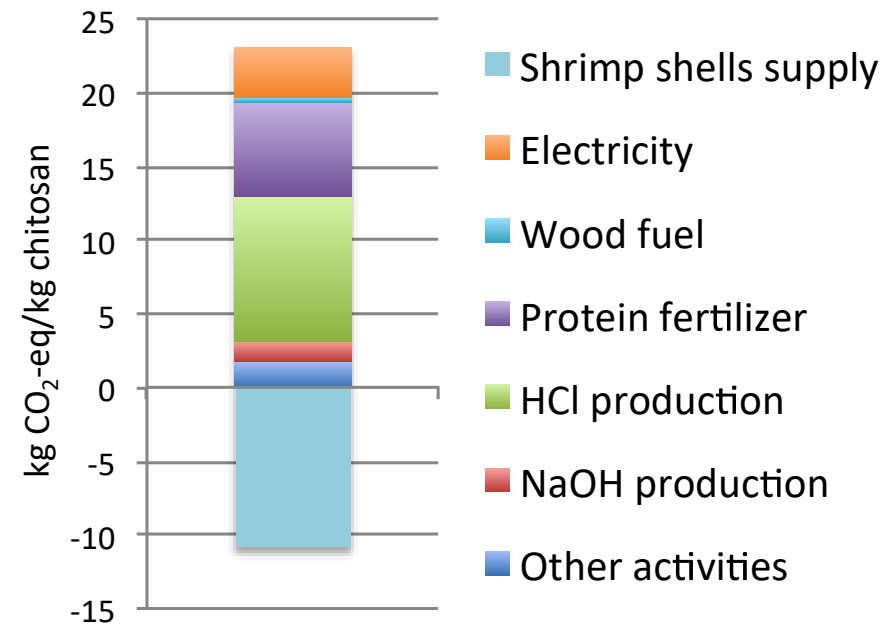
# Impact assessment

## Focus on Greenhouse-gas emissions: **Chitosan-India**

**GHG by life cycle stage**



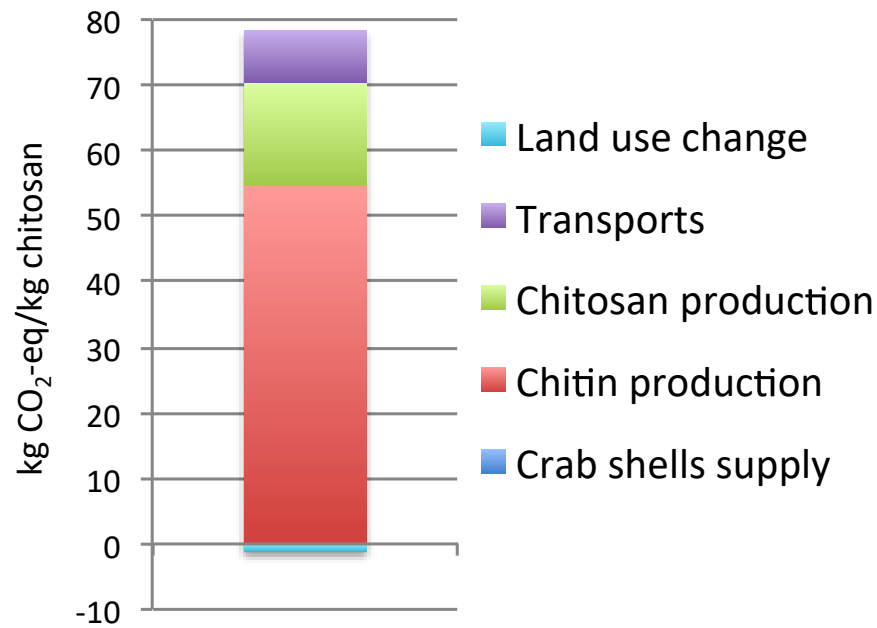
**GHG by activity**



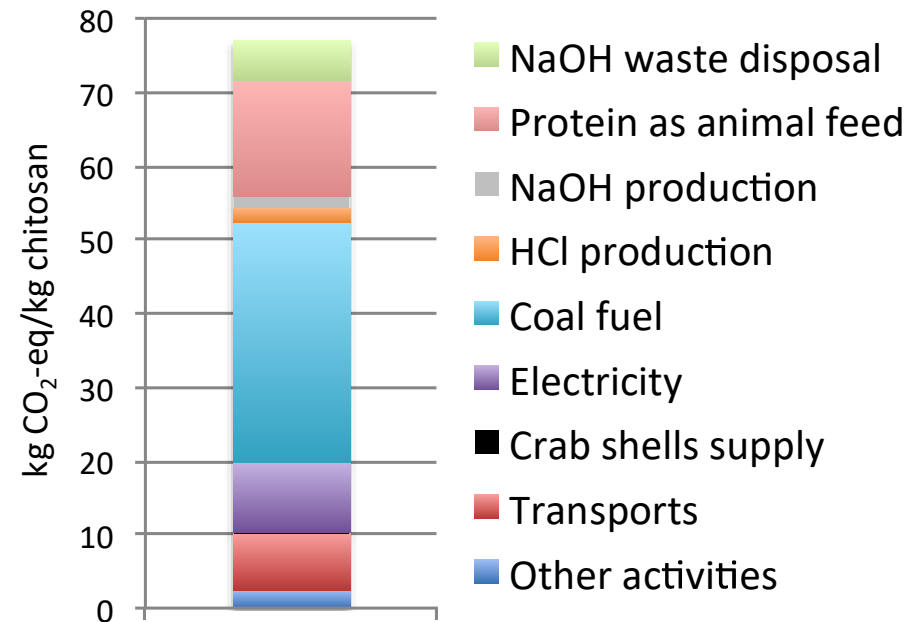
# Impact assessment

## Focus on Greenhouse-gas emissions: **Chitosan-Europe**

### GHG by life cycle stage



### GHG by activity

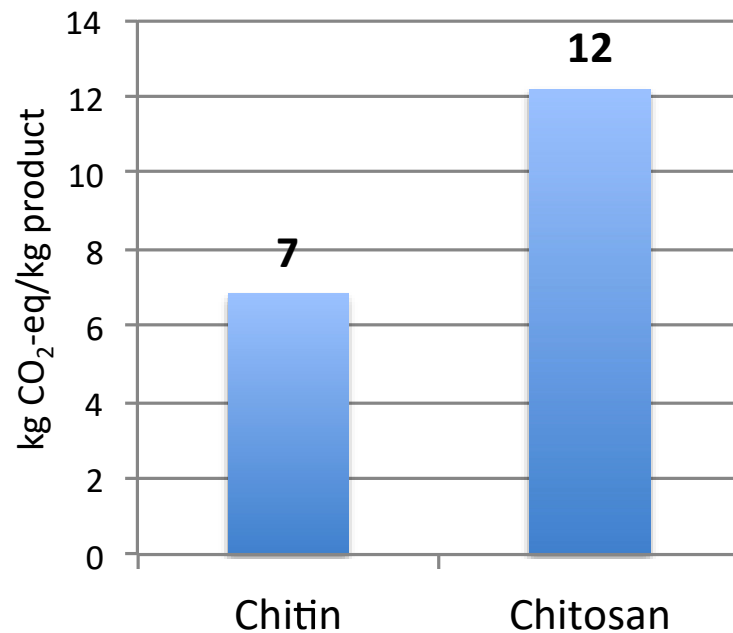




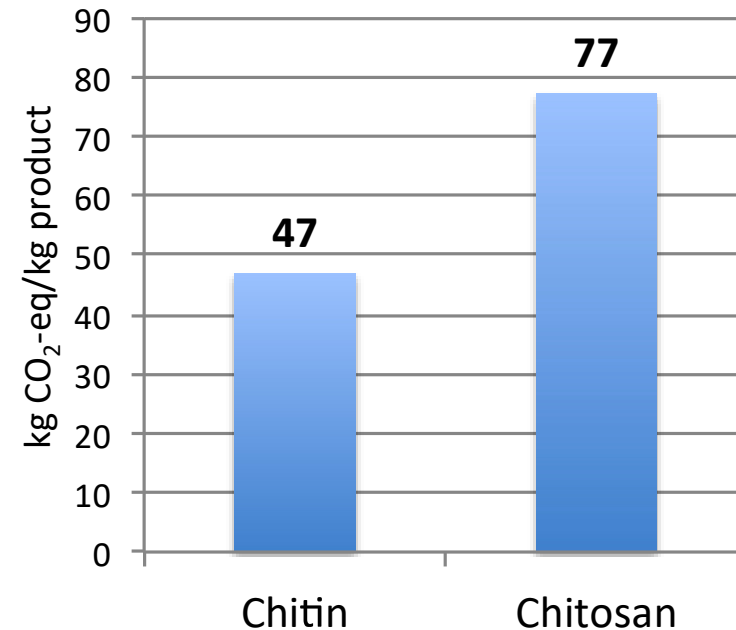
# Impact assessment

## Focus on Greenhouse-gas emissions: **Chitosan vs Chitin**

**Chitin and Chitosan-India**



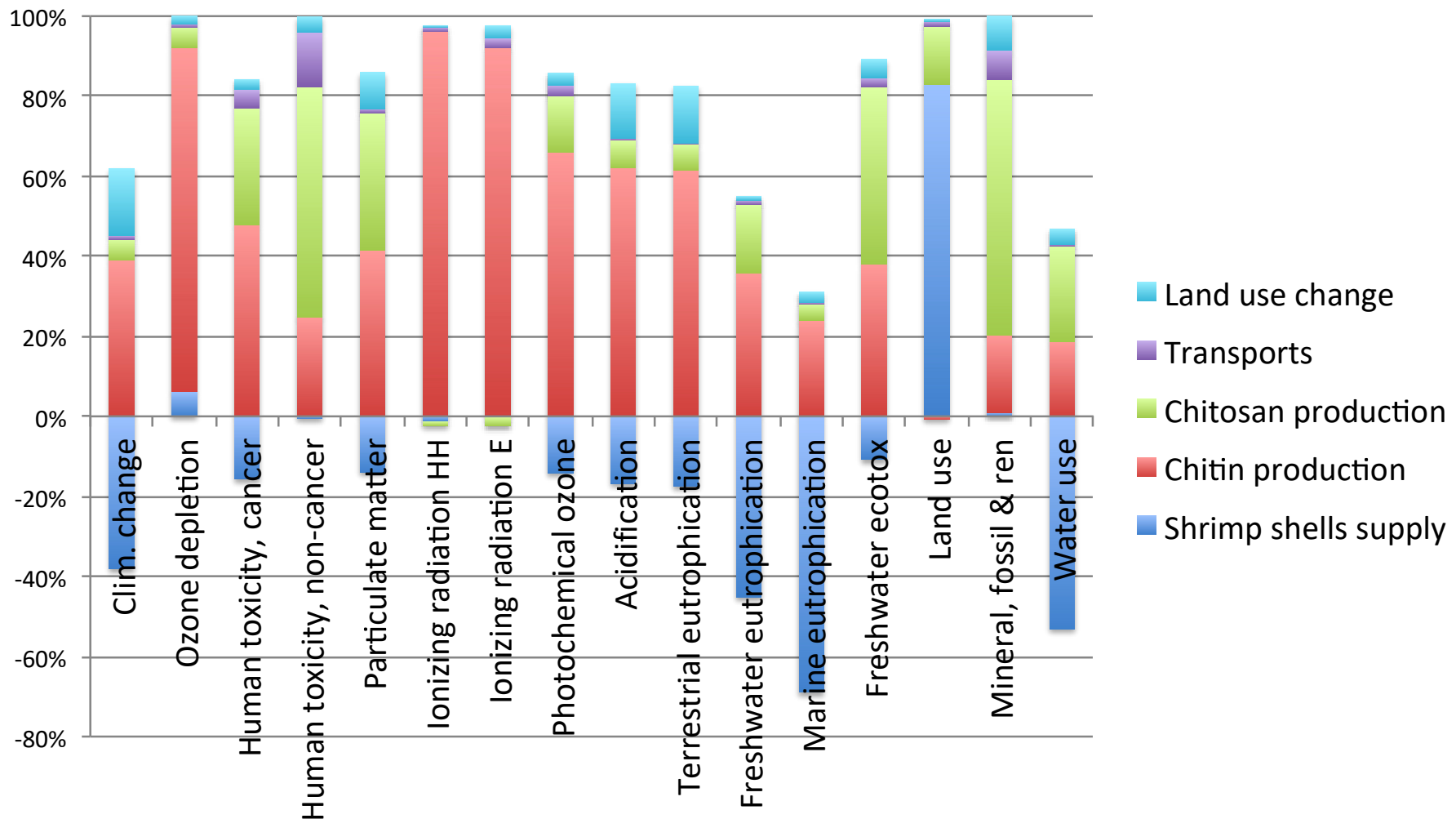
**Chitin and chitosan-Europe**



# Impact assessment

≡ LCA is not only about greenhouse-gas emissions...

**Chitosan-India: contribution analysis for 16 impact categories**



## Conclusions

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- ≡ Life cycle impact of chitosan production dominated by obtention of chitin
- ≡ India supply chain, in terms of GHG:
  - ≡ Production of HCl
  - ≡ Emissions from sludge application to soil
  - ≡ Benefit from using shrimp shells – avoided palm oil production
- ≡ Europe supply chain, in terms of GHG:
  - ≡ Clearly dominated by use of coal and electricity in China

## Conclusions

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- ≡ Chitosan production has higher life cycle impacts than chitin production (roughly twice as much GHG emissions)
- ≡ The EU supply chain involves substantially higher GHG emissions, as it is more complex and energy supply in China heavily relies on coal.
- ≡ However the goal was not to identify an “environmentally-friendly” chitosan, but to identify environmental impacts that can be subject to improvement

Muñoz I, Rodríguez C, Gillet D, Moerschbacher B M (2017) **Life cycle assessment of chitosan production in India and Europe.** *International Journal of Life Cycle Assessment*. DOI: 10.1007/s11367-017-1290-2

**Thank you for your  
attention!**

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