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# From ecodesign to eco-innovation towards sustainable food systems

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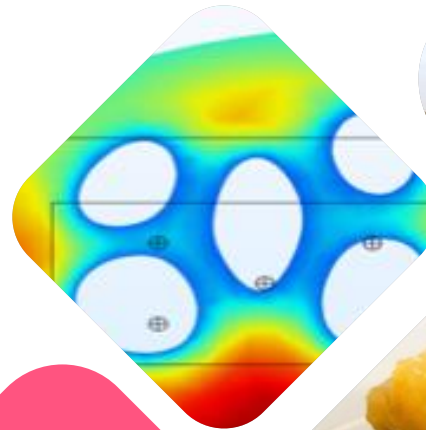
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# From Ecodesign to Ecoinnovation towards Sustainable Food Systems

FIPDes Day 2023  
2023 September 7

Caroline Pénicaud  
Research scientist INRAE, UMR SayFood

**SayFood**  
Food & Bioproduct Engineering



# Context & Challenges

## Production of food and bioproducts



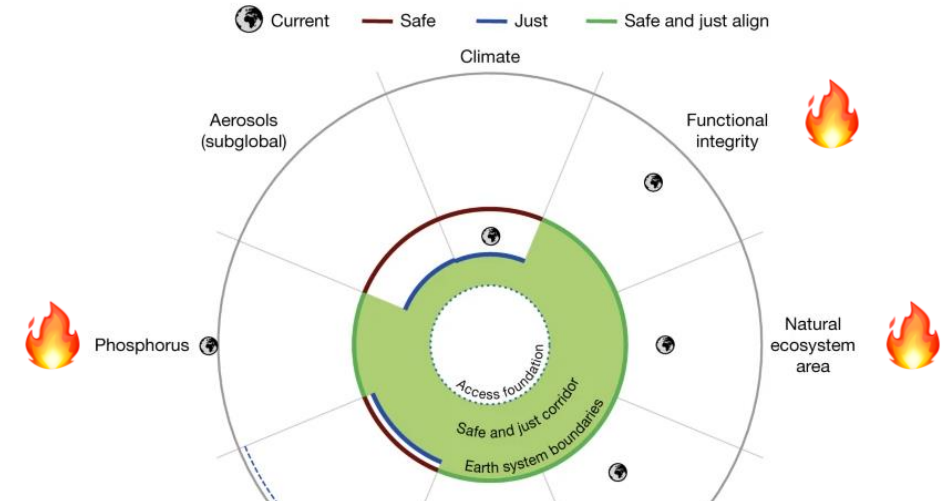
Sanitary quality

Nutritional quality

Sensory quality



## Environmental emergency



How can the environmental dimension be integrated into the design and management of food and bioproduct production systems?

23

Environmental quality



~1/3 of environmental impacts due to productions in food systems

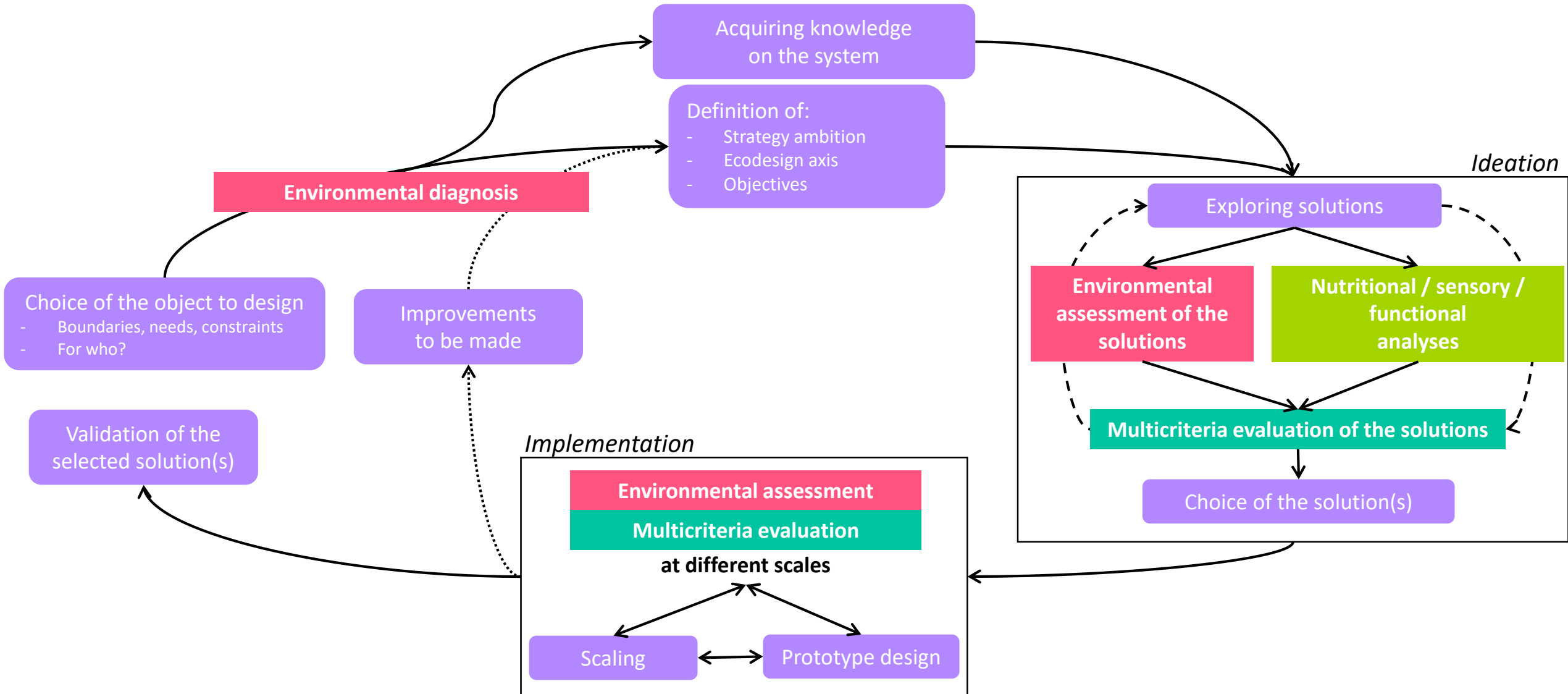
*Tukker et al. 2006, Xu et al. 2021*



# Which ecodesign approach?

Environmental assessment

Design



# Environmental assessment: Life Cycle Assessment

## Use of raw materials and energy

- Fertilizers
- Metals
- Pesticides
- Electricity
- Fuel
- Packaging
- Gas
- Water
- Refrigerant fluids
- Infrastructures



## Emissions into air, water and soils



- Greenhouse gases
- Nitrogen, Phosphorus
- Toxic molecules
- Polluted water
- ...



## Potential environmental impacts

- Climate change
- Ozone depletion
- Ecotoxicity
- Eutrophication
- Acidification
- Particulate emissions
- ...

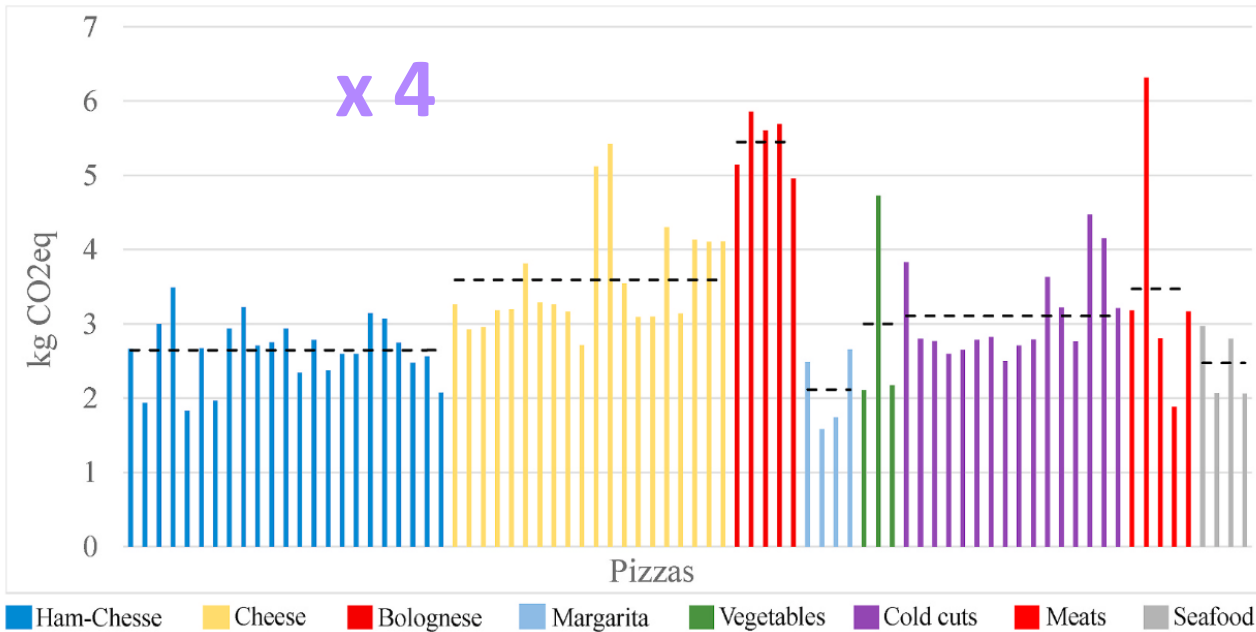
ISO 14040-14044, 2006

# Environmental diagnosis: Variability of food impacts

*Within the same food category, does product variability justify reasoning ecodesign at the product level?*

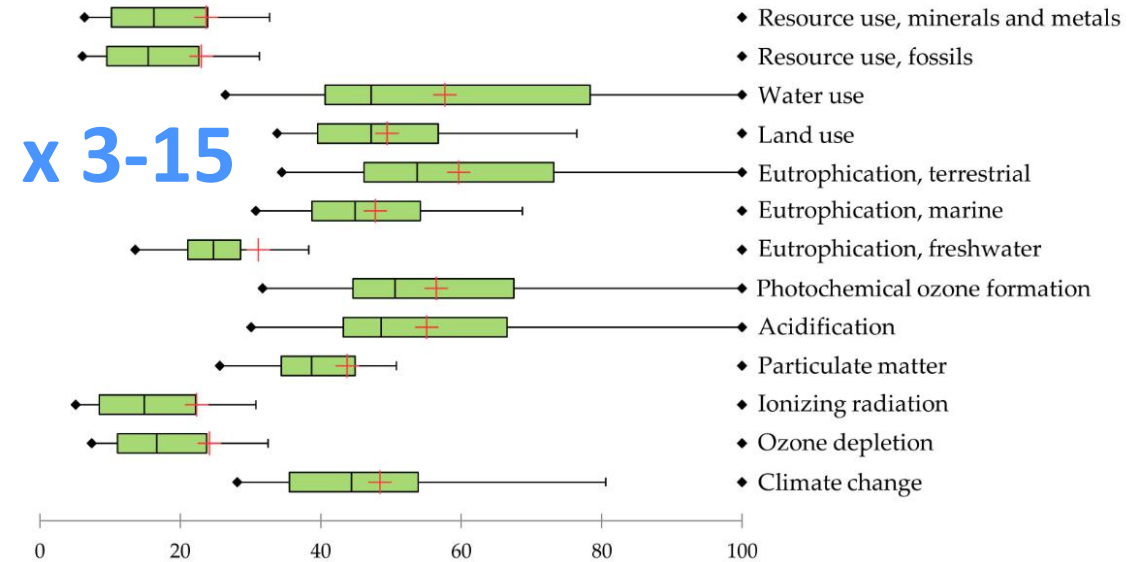
## 80 industrial pizzas

Cortesi et al. 2022, Journal of Cleaner Production



## 44 PDO cheeses

Cortesi et al. 2022, Sustainability



Cheese and beef contents

Ingredients

Milk type and quantity

Equipment

Performance of ripening room

Between two rooms: 90% difference in impact on indicators sensitive to electricity consumption

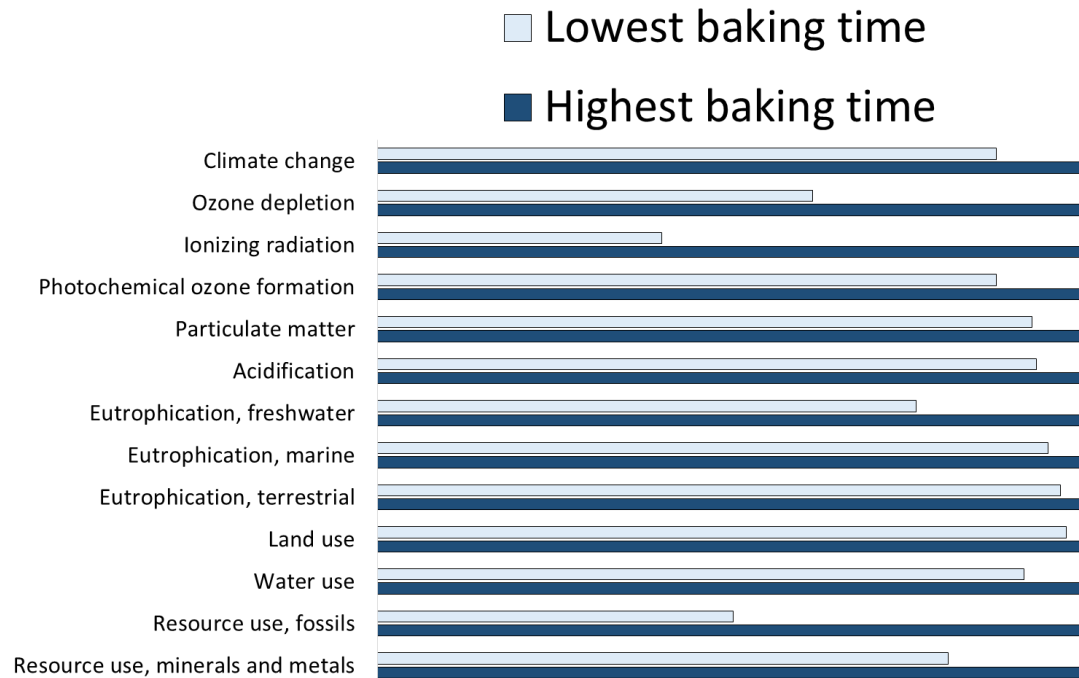


# Environmental diagnosis: Integrating consumer practices

*Do consumers' home practices significantly influence the environmental impact of products?*

## 6 pizzas consumed at home

*Cortesi et al. 2023*

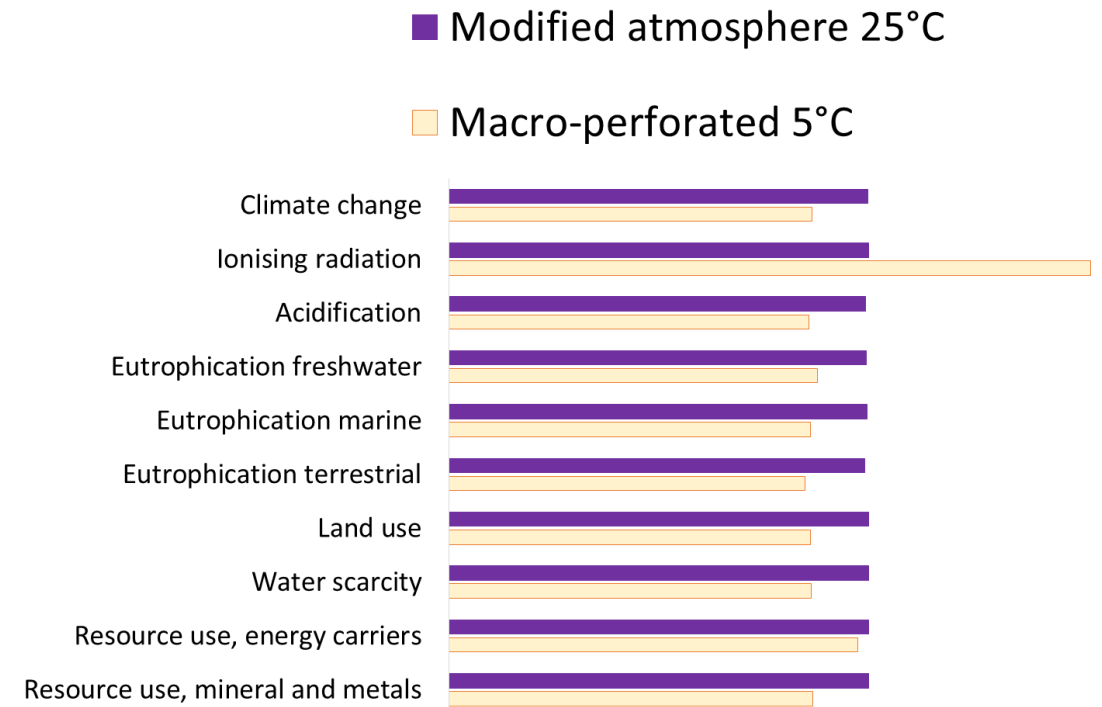


Oven use can double certain impacts

Home practices

## Packed strawberries

*Matar et al. 2021*



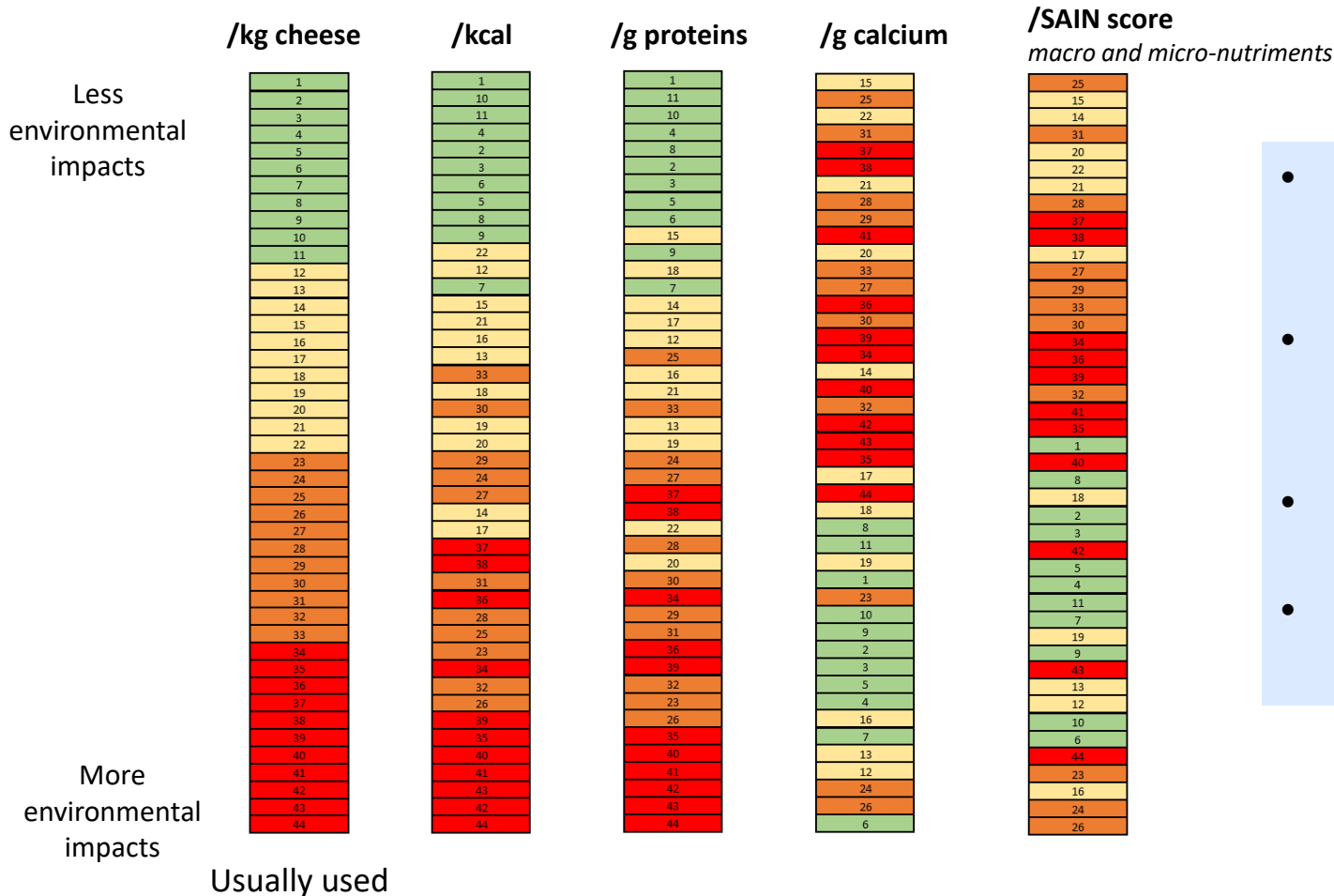
Behavior towards packaging affects impacts

# Environmental diagnosis: Joint diagnosis of environment and nutrition

## How can we combine environment and nutrition to assess food?

Nutrition: LCA functional unit

44 PDO cheeses

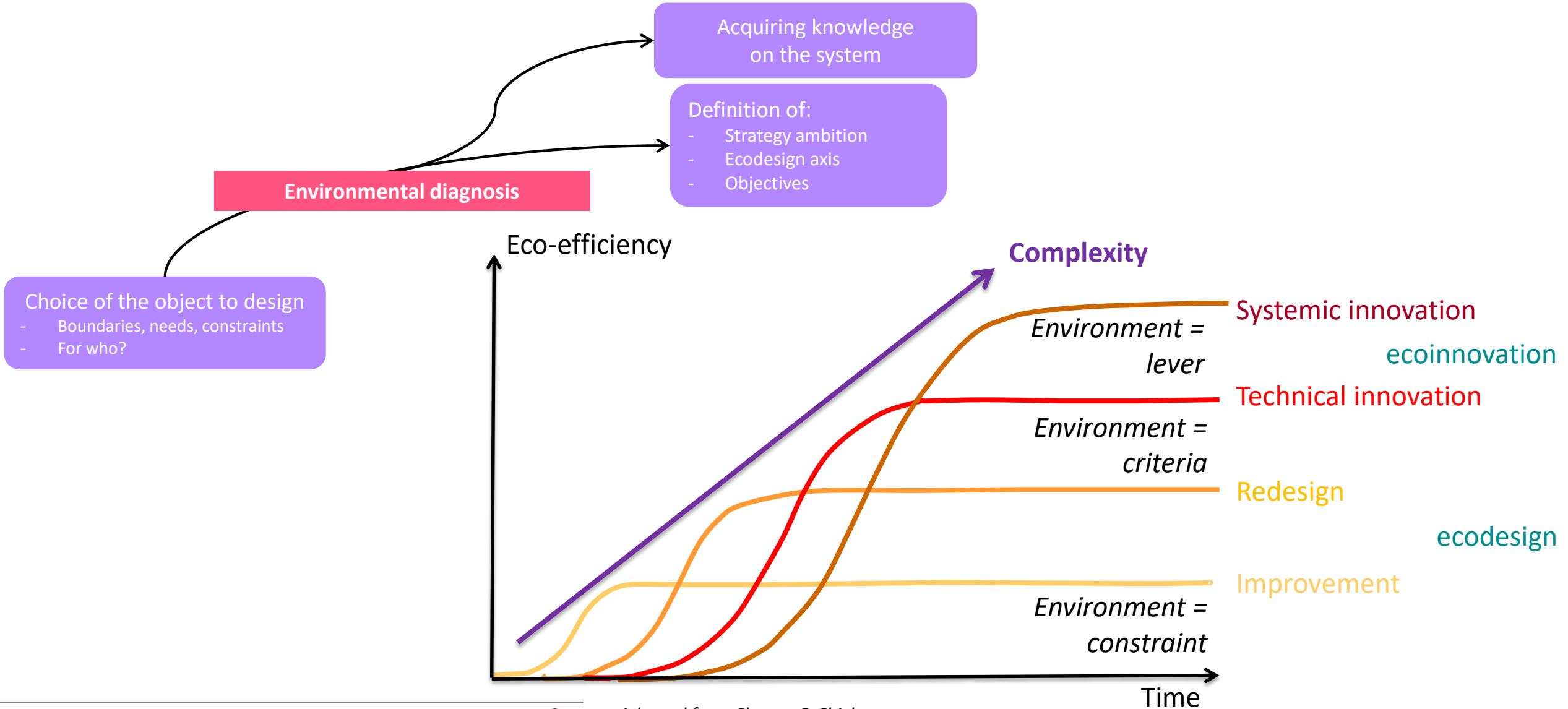


- Nutritional FU allows the nutritional dimension to be included in the environmental dimension
- Nutrient-based FU improves ranking of products rich in that nutrient
- Ideally, study several FUs
- How can we integrate other dimensions, such as the sensory dimension?

Cortesi et al. submitted



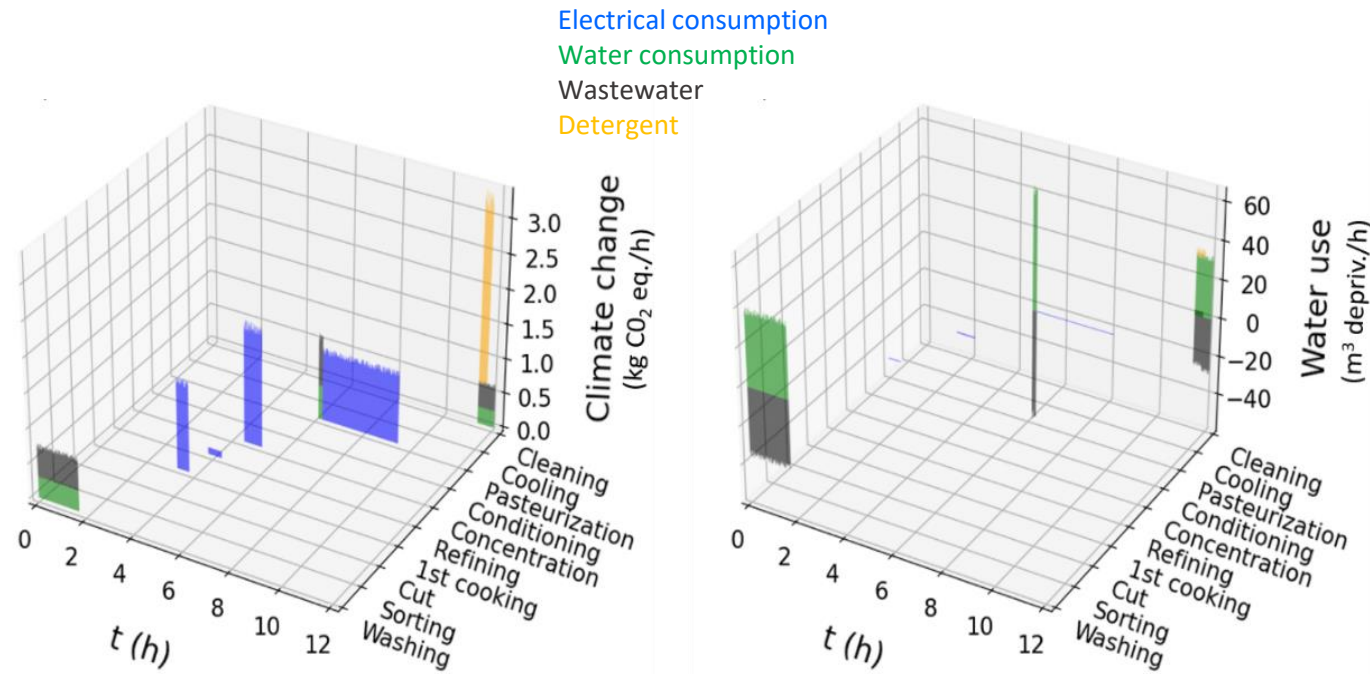
# Which ecodesign approaches?



# Improvement - Optimization: Dynamic LCA approach



- **Temporalized inventory**



## Visualize

- steps and unit operations and their associated impacts
- whether the impact is due to the intensity of the flow or the duration of the operation

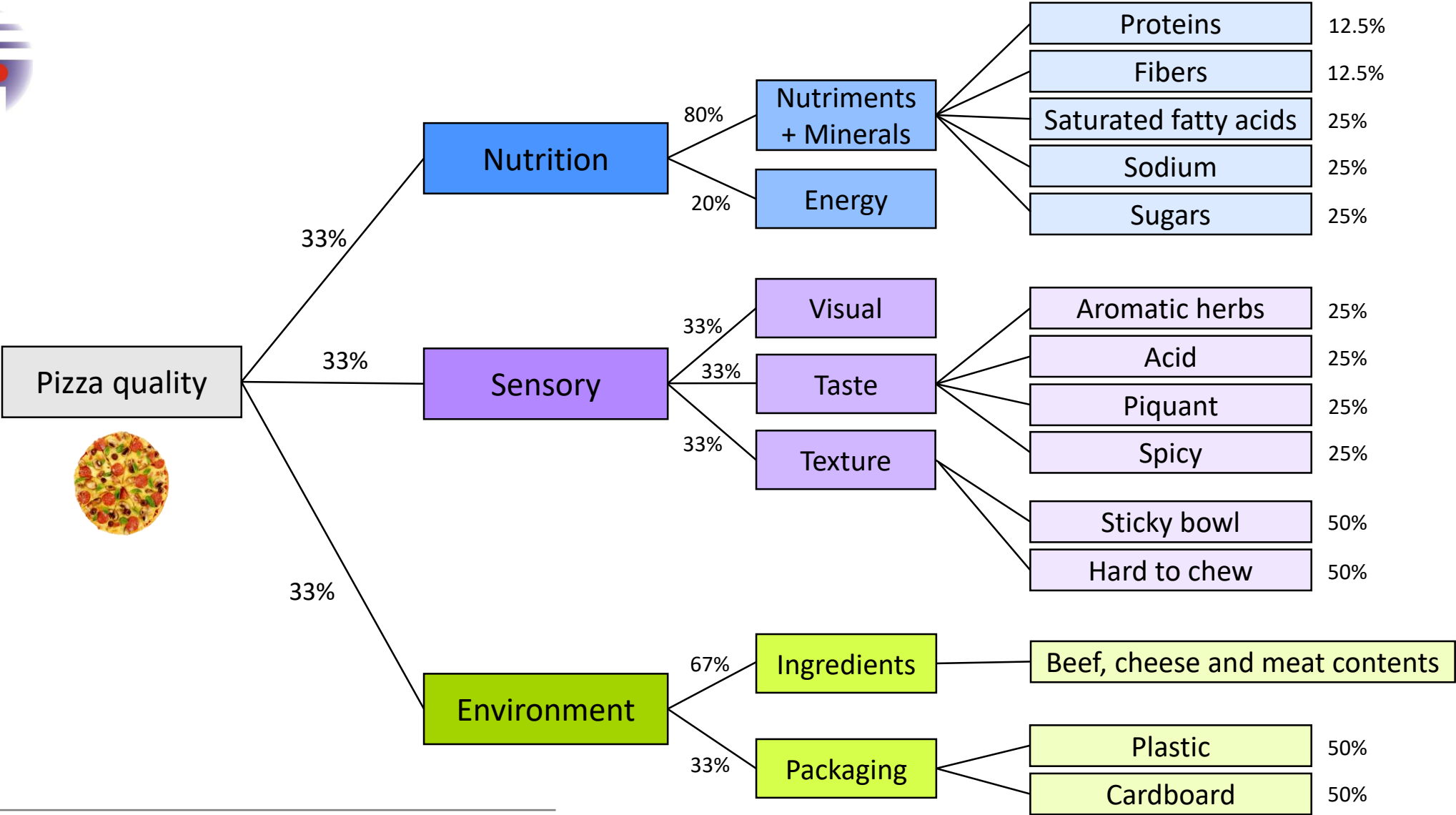
- **Temporalized energy mix**

- Importance of up-to-date, seasonally-adapted data
- Impacts can be reduced by different process planning

Better appropriation of LCA results by process engineering specialists

*Ly et al., in preparation*

# Redesign: example of pizza reformulation



# Redesign: example of pizza reformulation



Attribute	Pizza N
<b>Pizza quality</b>	Bad
<b>Environmental quality</b>	<b>Very bad</b>
Ingredients	<b>Bad</b>
<b>Packaging</b>	<b>Bad</b>
Plastic	<b>Bad</b>
Carboard	<b>Good</b>
<b>Nutritional quality</b>	Average
Energy	<b>Very bad</b>
<b>Nutrients &amp; minerals</b>	Average
Protein	<b>Good</b>
Fiber	<b>Bad</b>
Saturated fatty acids	<b>Bad</b>
Sodium	Average
Sugars	<b>Good</b>
<b>Sensory quality</b>	Good
Visual	Average
<b>Taste</b>	<b>Good</b>
Acidic	Average
Pungent	Average
Spicy	Average
Aromatic herbs taste	<b>Good</b>
<b>Texture</b>	Average
Sticky/Doughy bowl	Average
Chewability	Average



- Cheese
- Cream
- Lardoons
- Plastic packaging



- Tomato sauce
- Olive

Attribute	Pizza N bis
<b>Pizza quality</b>	Good
<b>Environmental quality</b>	Average
Ingredients	Average
<b>Packaging</b>	Average
Plastic	Average
Carboard	<b>Good</b>
<b>Nutritional quality</b>	Good
Energy	Average
<b>Nutrients &amp; minerals</b>	Good
Protein	Average
Fiber	<b>Good</b>
Saturated fatty acids	<b>Good</b>
Sodium	Average
Sugars	Average
<b>Sensory quality</b>	Good
Visual	Average
<b>Taste</b>	<b>Good</b>
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➔ To validate

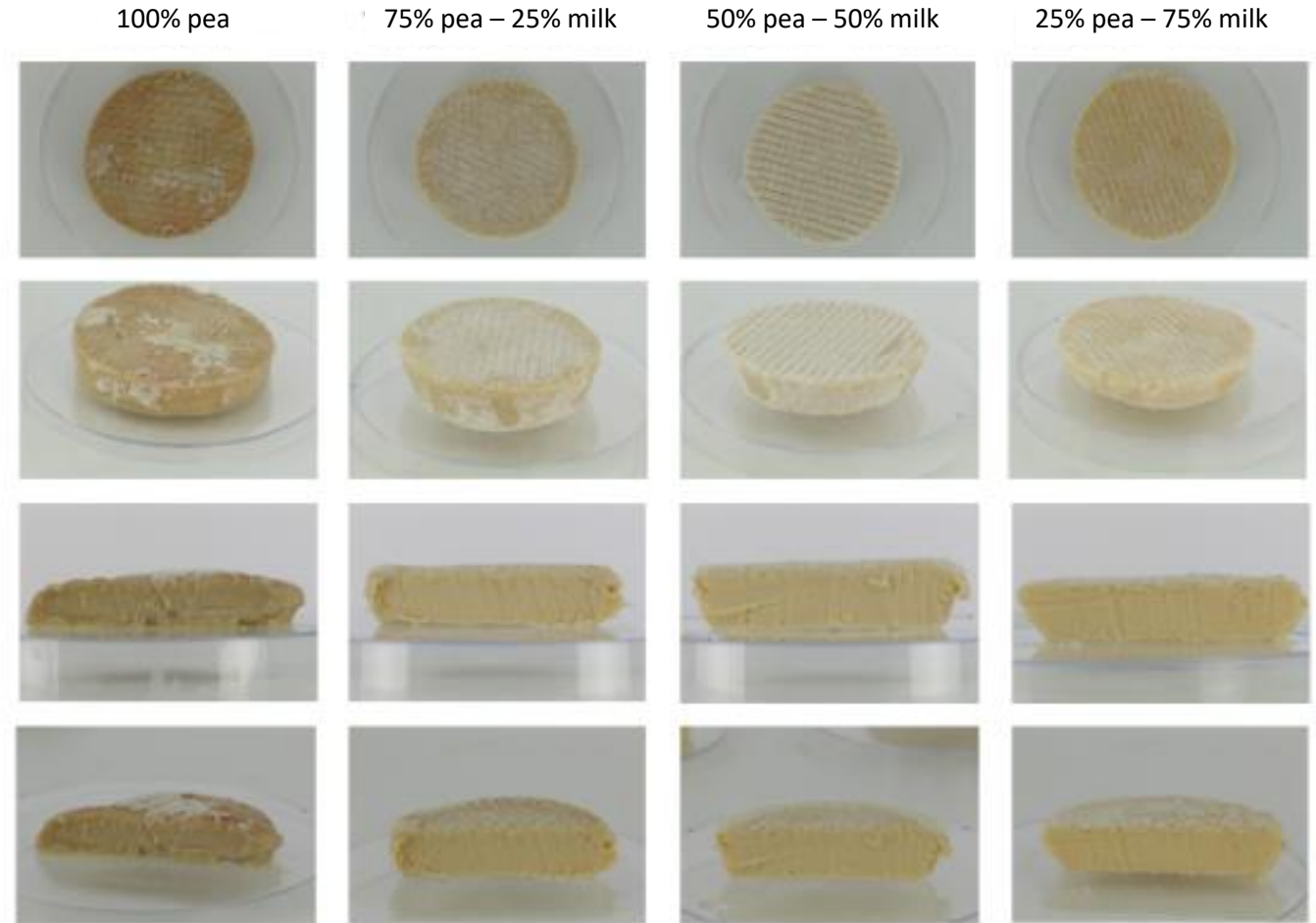
# Innovation: example of “frompois”

- 4 products like “camembert”

- 25% pea / 75% milk
- 50% pea / 50% milk
- 75% pea / 25% milk
- 100% pea

<b>Microbial consortium</b> (same for all products)
<i>Lactobacillus rhamnosus</i>
<i>Lactococcus lactis</i>
<i>Geotrichum candidum</i>
<i>Kluyveromyces lactis</i>

*INCUBATION 30°C / 18h –  
UNMOLDING – RIPENING 12°C  
until 13 days*

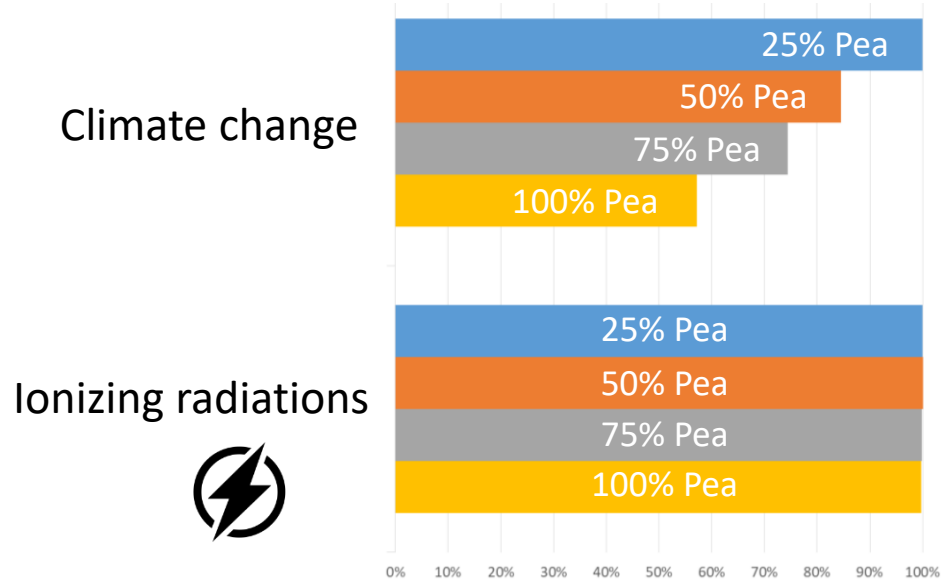


*Development / making:  
UMR SayFood – Aurillac UMR Cheeses platform*

*Saint-Eve et al. 2021  
Huguet et al. 2023*



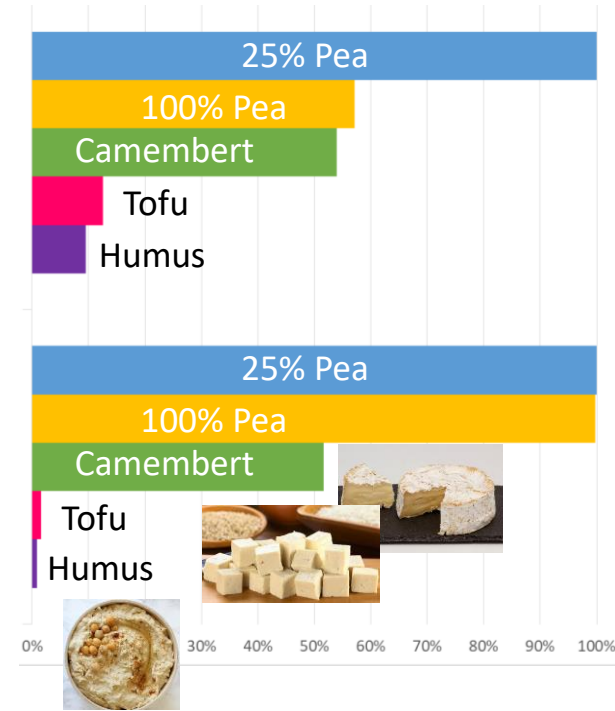
# Innovation: example of “frompois”



## Benefits of increasing pea content in frompois

Contradiction with the consumer study!

*Saint-Eve et al. 2021*



Impact of frompois > Impact of Camembert, humus and tofu

Simplify and eco-design the process!

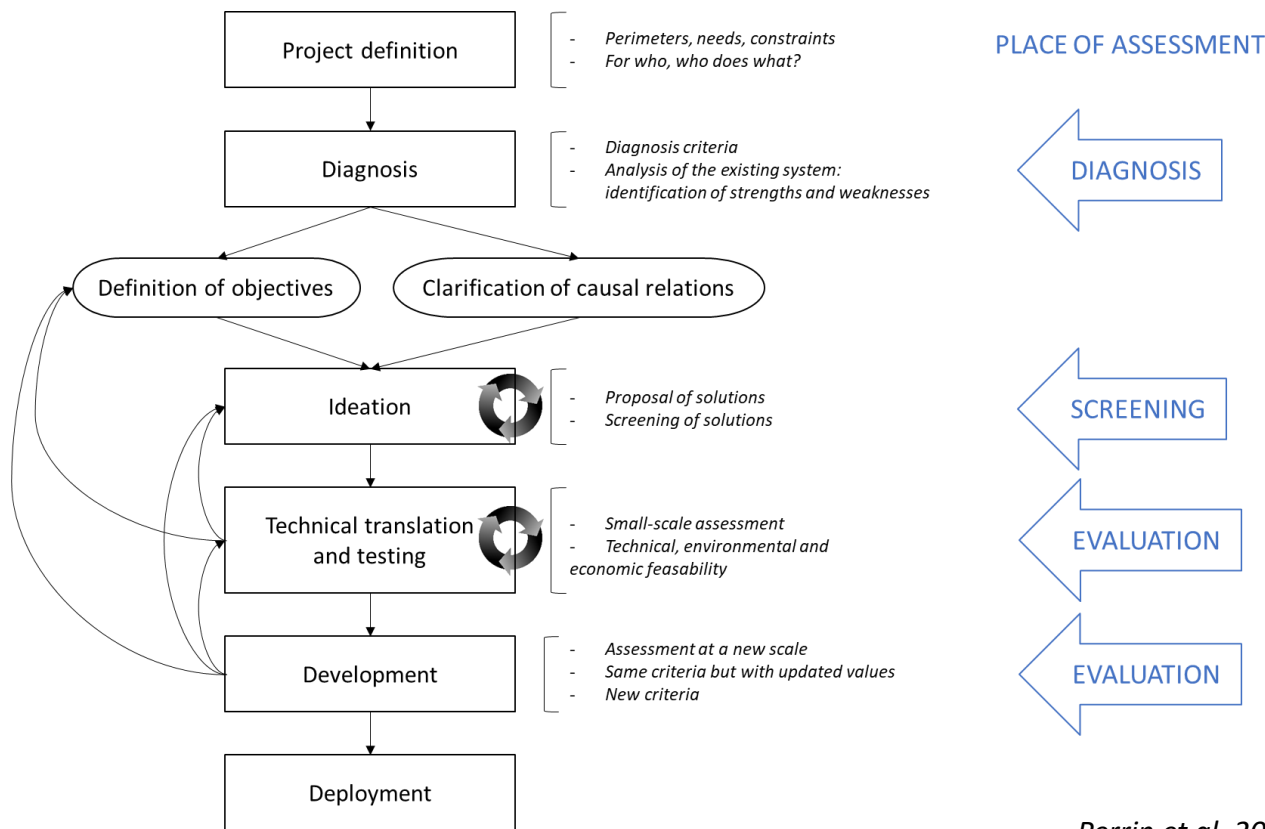
## Ecodesign paradox

Huguet et al. 2023

# How to tackle the eco-design paradox in innovation?

## Ecodesign paradox reinforced in the innovation process

- Choices made early in the design process yield the greatest environmental benefits
- The most effective environmental assessment methods can be used at an advanced stage of the design process

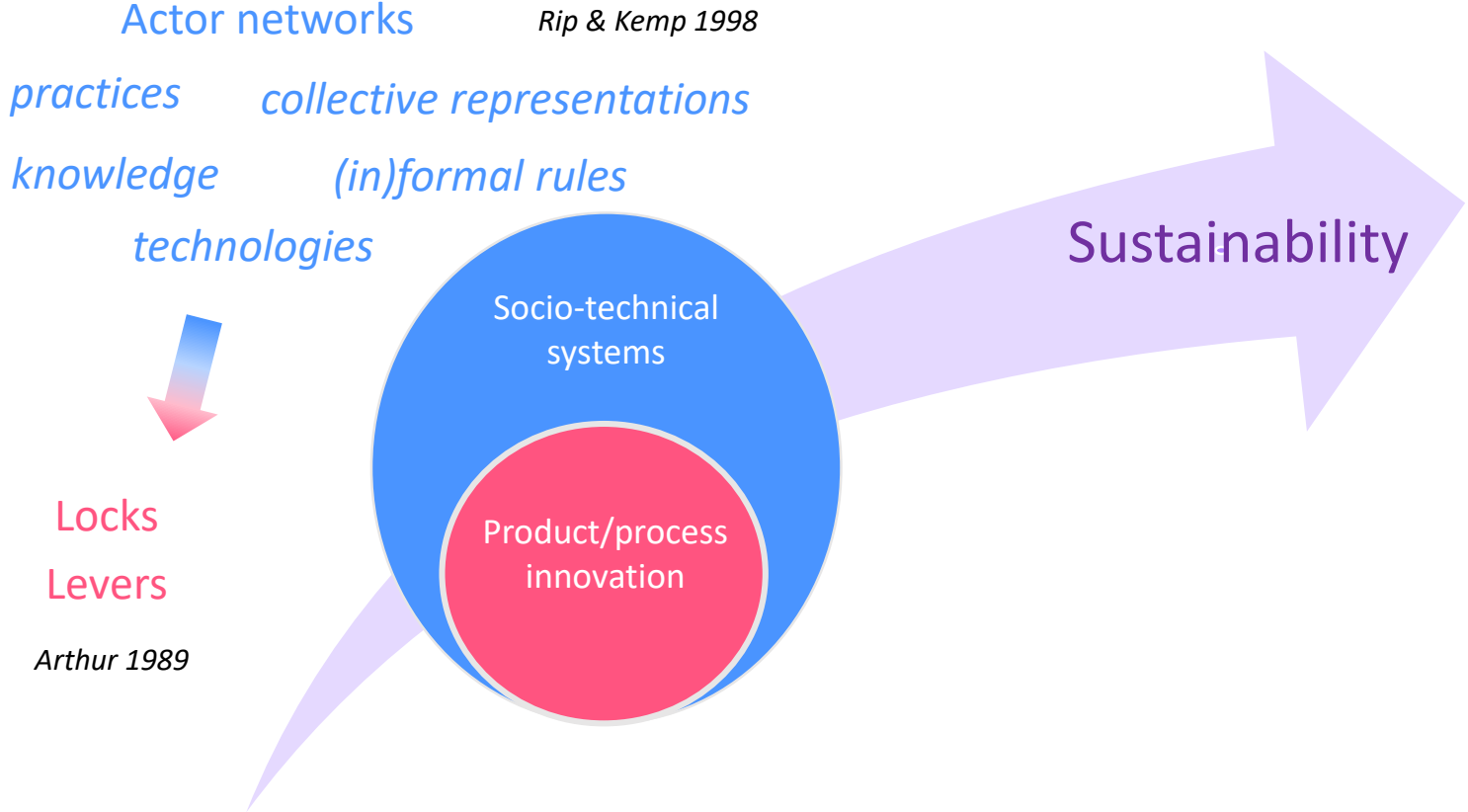


Perrin et al. 2023

- ### Key points
- Formalize the role and mode of evaluation
  - Use relevant sustainability criteria and indicators
  - Adapt evaluation to the context of the artifact designed
  - Reinforce participatory practices



# Towards sustainable food systems



## Importance of integrating innovation in systemic approaches