Life cycle instruments for sustainable textiles

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Samuele Abagnato – PhD student in Environmental Engineering

Let me introduce myself

1. Who am I?

- I am first-year-PhD student in Environmental Engineering at Politecnico di Milano
- My research group name is AWARE (Assessment on Waste and Resources)
- My research is focused on the management of textile waste in a life cycle perspective
- In my PhD research I collaborate with Regione Lombardia, so I am interested in the role that public policies can have in the circular economy framework

2. My perspective on environmental protection and resource efficiency

We have to find a plurality of solutions that must be integrated in order to approach to sustainability. Life-cycle-thinking can help us to have a holistic approach to problems.

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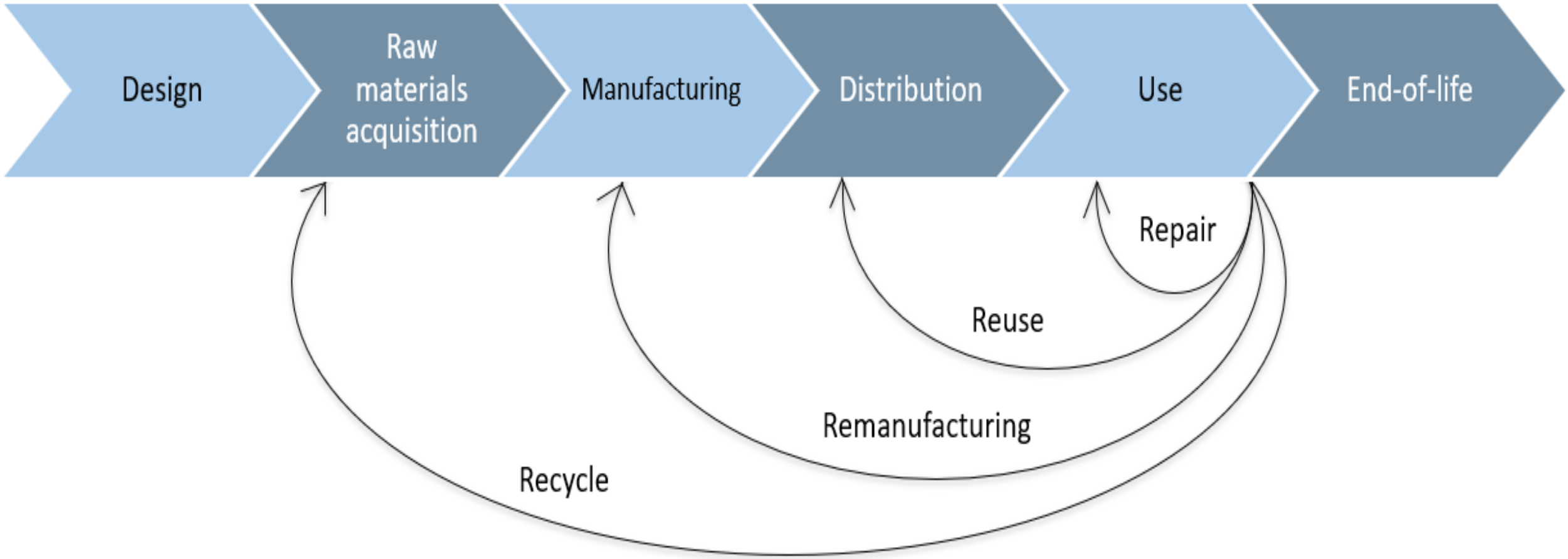
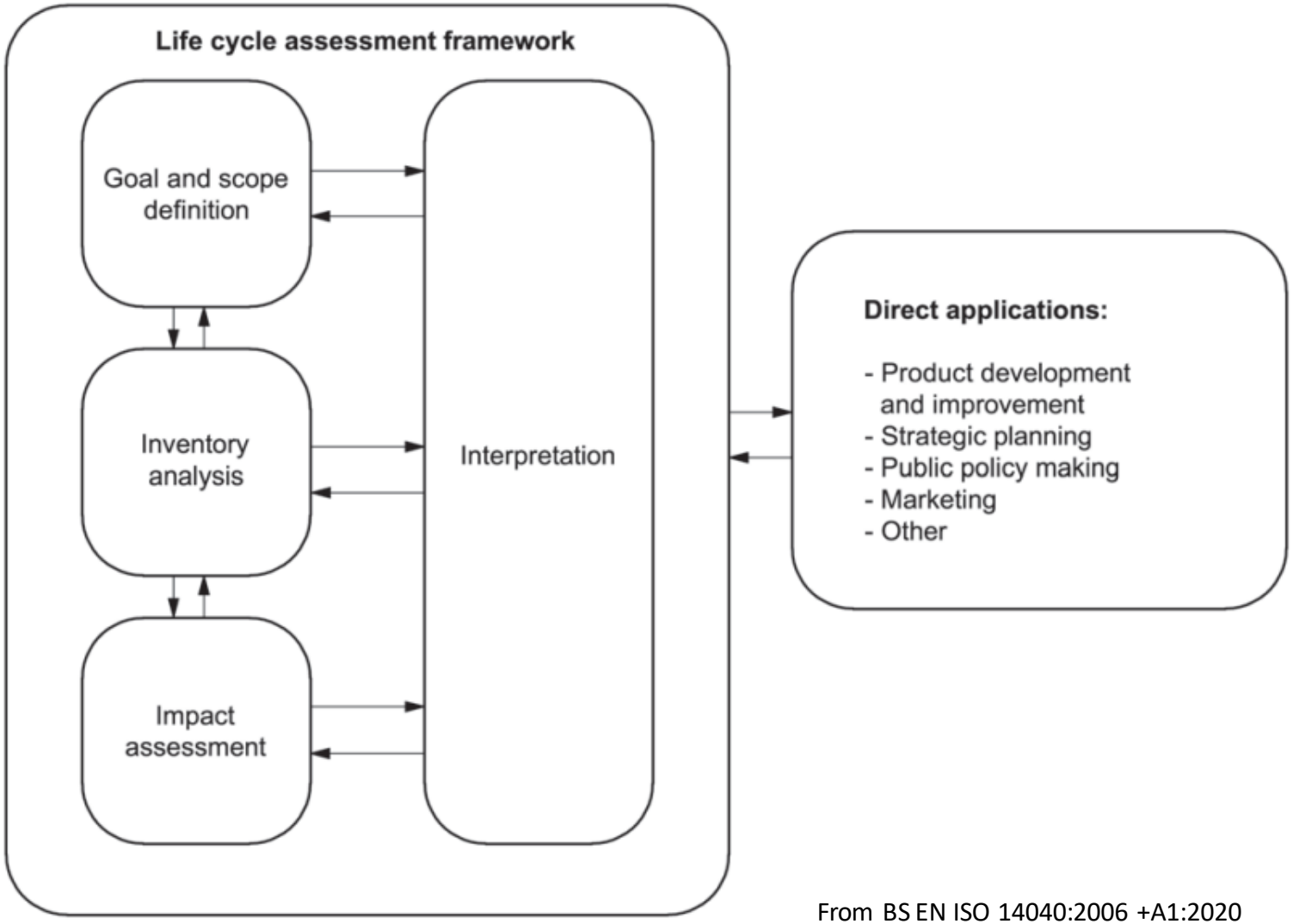
What is life cycle thinking (LCT)?



Sustainability: environmental, social and economic point of view

Life cycle assessment (LCA)



From BS EN ISO 14040:2006 +A1:2020

- **Standardised methodology**: ISO 14040, ISO 14044
- Systems of **indicators**: different impacts categories to **avoid burden shifting**
- Software and databases
- **Data** collection from different levels: primary data, data from literature studies, data from databases and estimated data

Textiles: challenges in a world of complexity

Global supply chain and difficulty in the traceability of the products

Environmental and social impacts of the textile industry

Fast fashion

Challenges for textile waste management: high variety of fibres and different qualities of discarded textiles

How can we apply LCT to textiles?

Review: 20 papers about LCA on textiles and textile waste management

Goal and scope of the publications	N° of papers found in the review
Comparative LCA of recycled textile products with products made from virgin materials	5
LCA of recycled fibres	1
Comparative LCA of reusable garments with disposable ones	2
Impact assessment of the use phase of textile products	2
Impact assessment of the whole textile sector of a country	1
Impacts assessment of reuse strategies for textiles	2
Impact assessment of a particular recycling process	2
LCA of the textile waste management system of a country	5

How can we apply LCT to textiles?

Article

Environmental Consequences of Closing the Textile Loop—Life Cycle Assessment of a Circular Polyester Jacket

Gregor Braun *, Claudia Som, Mélanie Schmutz and Roland Hischier

LCA on a product

LCA on a specific life cycle stage

Reducing environmental impacts from garments through best practice garment use and care, using the example of a Merino wool sweater

Stephen G. Wiedemann[1] · Leo Biggs[1] · Quan V. Nguyen[1] · Simon J. Clarke[1] · Kirsi Laitala[2] · Ingun G. Klepp[2]

LCA about different business models

Life cycle assessment of clothing libraries: can collaborative consumption reduce the environmental impact of fast fashion?

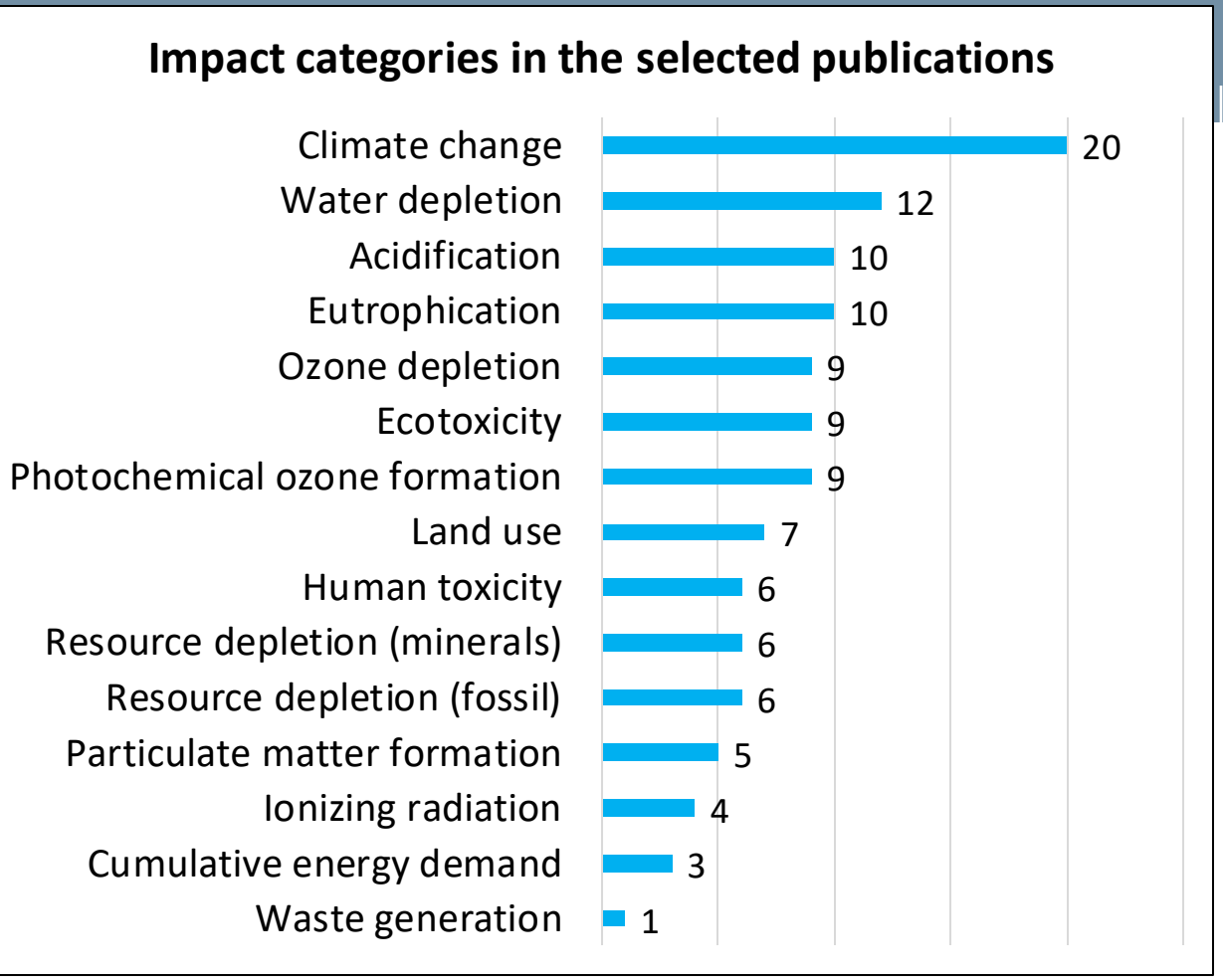
Bahareh Zamani [a], Gustav Sandin [b, *], Greg M. Peters [a, c]

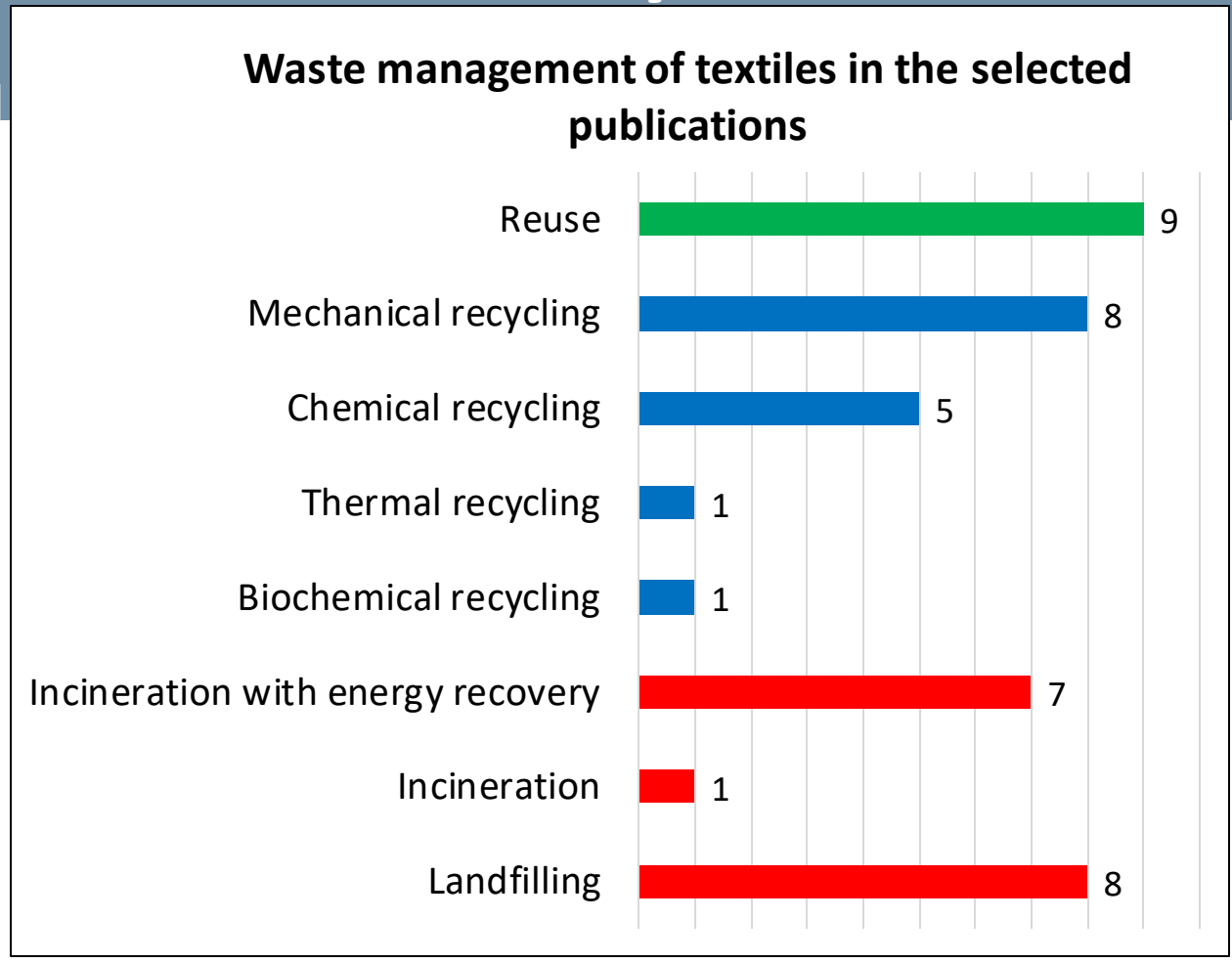
LCA about waste management system

Environmental assessment of end-of-life textiles in Denmark

Athina Koligkioni[a]*, Keshav Parajuly, Birgitte Liholt Sørensen, Ciprian Cimpan

Some results from the literature analysis





- LCA studies should cover an **high number of impact categories to avoid burden shifting**.
- In a **waste management integrated system** all the operations should be considered.
- The **composition of the textiles** highly affect their fate as a waste.

LCT applied to textiles waste management

Waste management operation	Effects on environmental impacts	Options	What to consider in LCA studies
Reuse	It is **usually the best way** to decrease environmental impacts of textiles	• Reuse between **multiusers** (sharing platforms) • Reuse **after waste collection and sorting**	• Transport, collection, sorting • Longer lifespan when reusable vs disposable products are compared • Avoided impacts
Recycling	Products with **recycled content** have **usually lower impacts** than virgin products (with some exceptions)	• **Fibre-to-fibre** recycling • **Open loop** recycling	• Chemicals, water, energy and other input to recycling processes • Avoided impacts from virgin production
Final disposal	Incineration and landfilling give a **little contribution** to the total impacts but they are the **worst than reuse and recycling**	• Incineration with energy recovery • Incineration without energy recovery • Landfilling	• Impacts related to the processes (ex: emissions) • Impacts avoided from energy and methane production

LCT applied to textiles waste management

1. Material flow analysis (MFA)
   - What
   - How much
   - From where
2. Analysis of the composition
   - Collected textiles quality
   - Fibre composition
3. Data collection from plants and companies
   - Waste management processes
   - Energy and material consumptions associated to the processes
4. Impact assessment and cost analysis
   - LCA model to calculate impacts
   - Indications about costs (EPR schemes)

Post-consumer textile waste in EU

Difference between **pre-consumer** and **post-consumer** textile waste

Consumption of textile products in EU

12.3 kg/capita in EU-27 in 2018 (*Circular economy perspectives in the EU Textile sector*, JRC, 2021)

Post-consumer textile waste

About **11 kg/capita** of textiles are discarded every year in the EU (*EU Strategy for Sustainable and Circular Textiles*, 2022). **1.7 - 2.1 million t of used textiles are collected annually** in EU. The majority of the remaining 3.3 - 3.7 million t are thought to be discarded in mixed household waste (JRC, 2021).

% of separated collection in EU

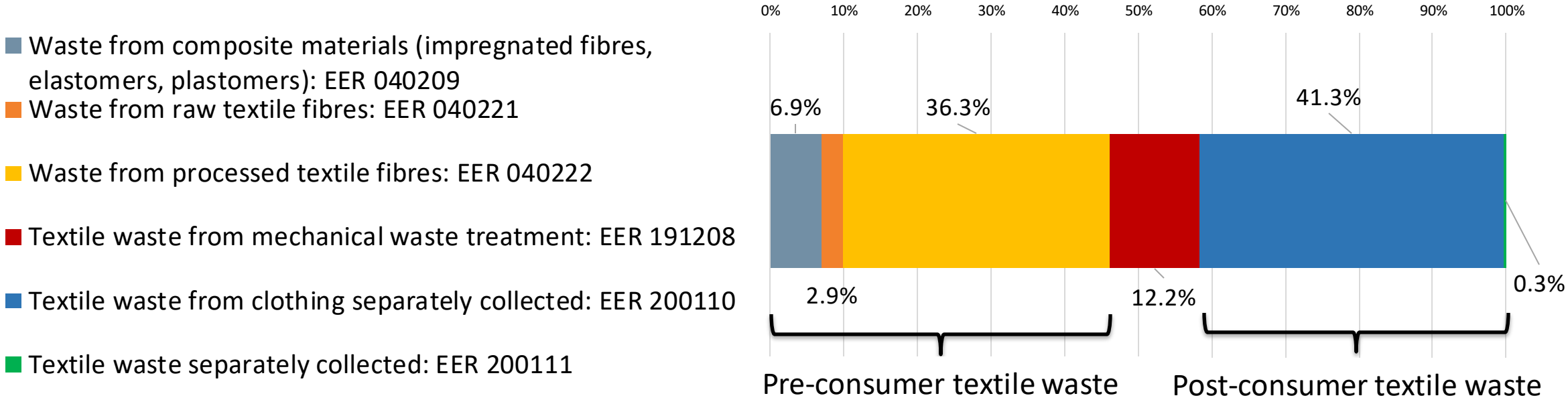
On **average 38% of textiles placed on the market** are separately collected. The collected % varies between different countries and there is a lack of harmonisation in the accounting methods used.

Textiles in mixed waste

Flanders (BE): 5.5 kg/capita in 1996, 4.0 kg/capita in 2001 and 7.09 kg/capita in 2014.
Netherlands: textiles (and footwear) were 1.8% of household residual waste in 1980 and 5.9% in 2018 (JRC, 2021).

What kind of textiles waste? How much? From where?

Textile waste in Lombardy in 2021



Analysis on post-consumer textile waste:

- **Source** of the waste: 86% is waste collected by municipalities
- **Extra-regional fluxes**: 14% of waste comes from other italian regions
- **Operators**: 7 operators/plants out of 71 declare to manage the 78% of the total waste
- **Type of operation** on the waste: 65% of the waste is stocked waiting other operations (R13), 30% is addressed to material recovery (R3)
- **How much**: 4.2 kg/inhabitant in 2021

Examples of MFA with economical evaluations

The goal of this project is to estimate the potential of circularity from the discarded textiles in 6 European countries.

Sorting for circularity Europe, 2022

Used textiles export

- **Used textiles export from EU**: from 0.55 million tonnes in 2000 to 1.7 million in 2019.
- In 2019, **46% of used textiles ended up in Africa and 41% in Asia** (European Environment Agency, *EU exports of used textiles in Europe's circular economy*, 2023).
- **Environmental impacts of reuse and final disposal in countries out of Europe** must be taken into account for a correct LCA of textile waste management.

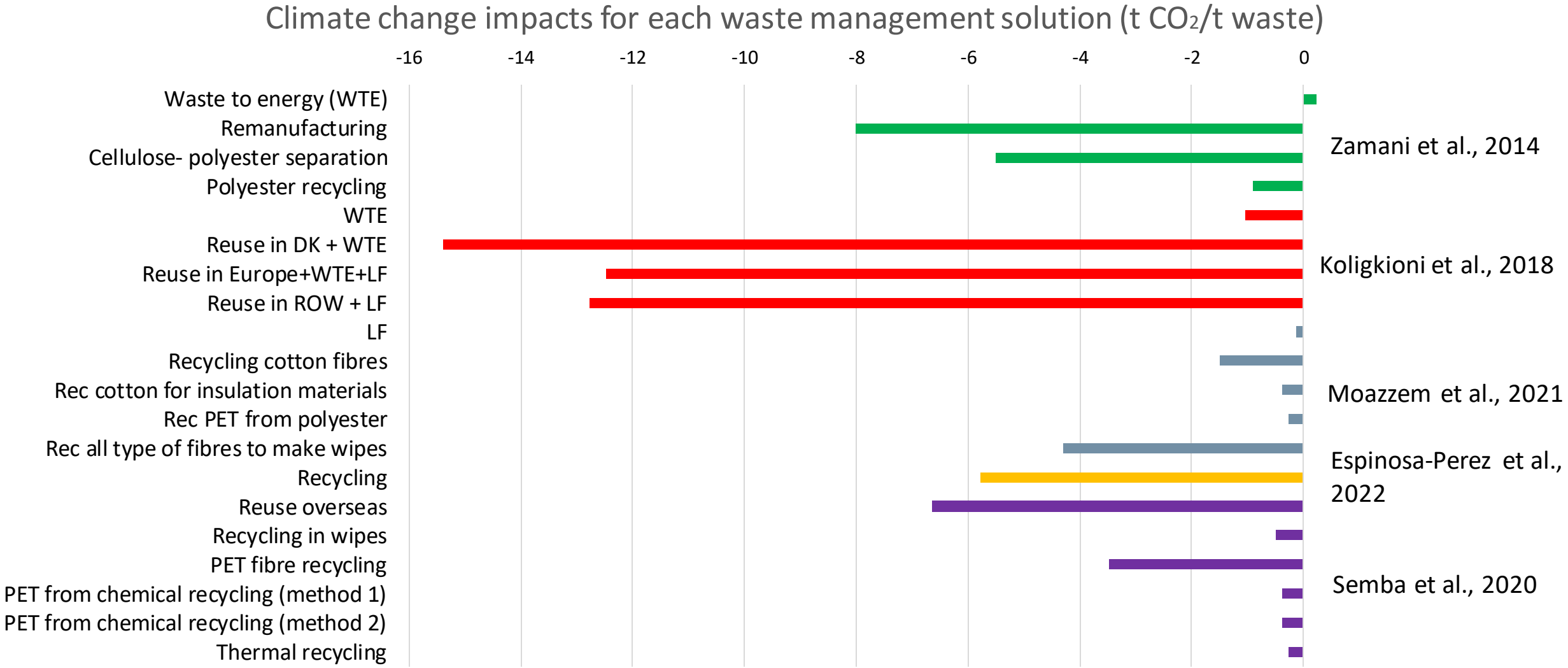
Return to Sender, The Nest

Some LCA results from textile waste management in scientific literature

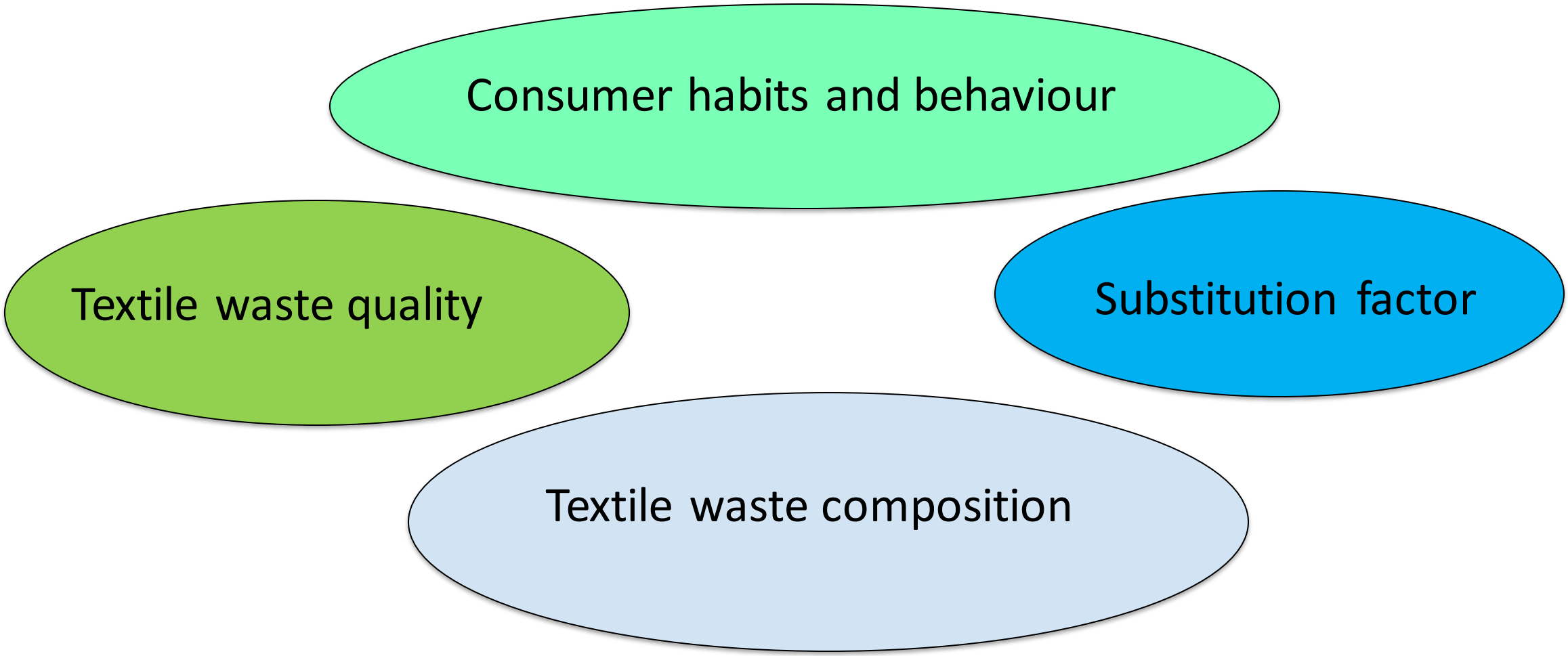
Same functional unit: the management of 1 t of post-consumer textile waste

Author, year, country	Waste management processes considered	Impact on climate change
Zamani et al., 2014, Sweden	Remanufacturing, cellulose-polyester separation, polyester recycling, incineration with energy recovery	- 10 t CO_2 eq./t waste
Koligkioni et al., 2018, Denmark	Reuse in DK and in Europe, incineration in DK and in Europe, landfill in Europe and in ROW	- 8,6 t CO_2 eq./t waste
Moazzem et al., 2021	Landfill, fibres recycling, recycling for insulation materials, recycling for wipes	There is not an integrated scenario
Espinosa-Perez et al., 2022, Chile	Recycling	- 5,8 t CO_2 eq./t waste
Semba et al., 2020, Japan	Reuse overseas, recycling in wipes, PES fibre recycling, PET chemical recycling, thermal recycling	- 11 t CO_2 eq./t waste

Some LCA results from textile waste management in scientific literature



What are the main variables that con influence LCA studies on textiles?



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AWARE
Assessment on WAste and REsources

Regione Lombardia

Tanks for your attention

samuele.abagnato@polimi.it