WP4- Improving bio-based industry in the textiles sector

D4.2 “Report for Stakeholders: Textile sector-wide recommendations”

Lead: CENTEXBEL

Author(s): Gertrude Kignelman (CENTEXBEL), Jurjen Spekreijse (BTG), Jean-Luc Derycke (UTEXBEL), Rachel van der Sluis (BTG), Sofie Huysman (CENTEXBEL)

Published: 09/2025

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

PROJECTS DETAILS			
Project title		Aligning Life Cycle Assessment methods and bio-based sectors for improved environmental performance.	
Project acronym	ALIGNED	**Start / Duration**	01/10/2022 – 36 months
Type of Action	RIA	**Website**	www.alignedproject.eu

DELIVERABLE DETAILS			
Dissemination level	Public	**Nature**	Report
Due date (M)	M36	**Submission date**	09/2025

DELIVERABLE CONTRIBUTORS			
	Name	**Organisation**	**Job title**
Deliverable leader	Gertrude Kignelman	CENTEXBEL	Research scientist
Contributing Author(s)	Jurjen Spekreijse	BTG	Consultant
	Jean-Luc Derycke	UTEXBEL	Director Innovation
	Rachel van der Sluis	BTG	Consultant
	Sofie Huysman	CENTEXBEL	Research scientist
Reviewer(s)	Philippe Nimmegeers	ANTW	Tenure Track Assistant Professor
	Jade Vetters	ANTW	PhD researcher
	Massimo Pizzol	AAU	Professor
	Agneta Ghose	AAU	Assistant Professor

DOCUMENT HISTORY			
Date	**Version**	**Name**	**Changes**
08/09/2025	0.1	Gertrude Kignelman	First draft
22/09/2025	0.2	Gertrude Kignelman	Review comments incorporated
29/09/2025	0.3	Massimo Pizzol	Final review
30/09/2025	1.0	Dalia Stakenaite	Final version ready for submission

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Table of Contents

Table of Figures

Funded by the European Union
Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Executive summary

The textile industry faces significant sustainability challenges, including high water and energy consumption, chemical pollution, and social issues such as poor working conditions and lack of supply chain transparency. The fast fashion model exacerbates these problems through overproduction and waste, while recycling systems remain fragmented. To address these issues, Life Cycle Assessment (LCA) methodologies offer a structured approach to evaluate environmental impacts and support sustainable transitions.

This deliverable, developed under the ALIGNED project, presents sector-wide recommendations for improving sustainability assessments in the textile sector. It draws on consultations—including surveys and workshops—with textile professionals to identify current practices, challenges, and opportunities for implementing LCA.

Key Findings

- **Most used LCA methods**: ISO 14040:2006 and the Product Environmental Footprint (PEF).
- **Main barriers**: Lack of data, limited expertise, and incompatibility with existing standards, particularly for Consequential and Prospective LCA.
- **Stakeholder roles**: Effective sustainability assessment requires coordinated efforts from designers, producers, recyclers, LCA practitioners, software developers, federations, and policymakers.

Recommendations

- **Designers & Producers**: Integrate recycling considerations at the design stage to reduce non-recyclable components and improve economic viability of recycled textiles.
- **Recycled Textile Producers**: Implement quality control through top-down (application-driven) and bottom-up (material-driven) approaches to optimize recycling processes.
- **LCA Practitioners**: Focus on the use phase as a major environmental impact area and contribute anonymized data to open-access platforms.
- **Software Developers**: Improve interoperability and granularity of LCA databases to better reflect textile-specific parameters (dimension, origin, construction, etc.).
- **Sector Federations**: Provide targeted training and raise awareness to build internal capacity for sustainability assessments.
- **Policy Makers & Standardisation Bodies**: Support data generation for biobased materials and develop standardized formats for Life Cycle Inventory (LCI) data.

Conclusion & outlook

While the recommendations stem from a specific case study (Dr Green by UTEXBEL), the challenges and insights are broadly applicable across the textile sector. The ALIGNED project has made meaningful contributions to advancing LCA methodologies tailored to textile applications. However, critical questions remain around data availability, standardization, and integration with the upcoming Digital Product Passport for textile products. Continued multi-stakeholder collaboration is essential to overcome these hurdles and drive sector-wide sustainability.

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

1 Overview of the sector

The textile sector is evolving rapidly to address sustainability challenges, with a growing emphasis on biobased fibres, advanced recycling methods, and the use of Life Cycle Assessment (LCA) to guide environmental improvements.

Biobased fibres are derived from renewable biological sources and are gaining traction as alternatives to conventional petroleum-based synthetics. The main categories include:

- **Natural fibres**: Cotton (the most widely used), wool, silk, flax (linen), hemp, jute, and ramie. Cotton alone accounts for nearly a quarter of global textile fibre production.
- **Regenerated fibres**: These are made by chemically processing natural polymers. Examples include viscose, modal, and lyocell (all derived from cellulose), as well as chitosan fibres from crustacean shells and soybean protein fibres.
- **Biobased synthetics**: Polylactic acid (PLA) fibres, made from corn starch or sugarcane, and bio-based polyamides and polyesters, which are synthesized from plant-based feedstocks rather than petroleum. These fibres can offer biodegradability and a lower carbon footprint, though not all are biodegradable.

Textile recycling is critical for reducing waste and resource use. The main recycling methods are:

- **Mechanical recycling**: Physically breaks down textiles (usually cotton or wool) into fibres for reuse. This method is common for single-material textiles but often results in lower-quality fibres.
- **Chemical recycling**: Breaks down fibres at the molecular level, allowing for the recovery of high-quality raw materials. This is especially useful for polyester and blended fabrics. Companies like Eastman and Aquafil are leaders in this space, producing recycled polyester that meets performance standards.
- **Biological (enzymatic) recycling**: Uses enzymes to break down synthetic fibres like polyester and nylon. This method is emerging as a more energy-efficient and potentially less polluting alternative, with companies like Samsara Eco pioneering enzyme-driven processes.
- **Thermal recycling**: Involves incinerating textile waste to recover energy, but this is less favoured due to emissions and loss of material value.

Life Cycle Assessment (LCA) is increasingly used to evaluate the environmental impacts of textile products from raw material extraction through production, use, and end-of-life. LCA helps identify environmental “hotspots,” supports regulatory compliance, and guides companies in making more sustainable choices—such as selecting biobased fibres or investing in advanced recycling technologies.

The textile sector’s shift toward biobased fibres, innovative recycling methods, and robust LCA practices is essential for reducing its environmental footprint and moving toward a more circular and sustainable future. ALIGNED contributes to this shift by performing a case study focussing on Dr. Green, Utexbel’s pioneering circular textile that transforms used hospital garments into new, high-quality medical workwear through an industrial-scale recycling process. Worn-out uniforms are collected, mechanically shredded, and the recovered fibres are blended with cotton and recycled polyester to create new yarns. These yarns are used to create new workwear garments. This closed-loop system, managed entirely within a local supply chain in Belgium and surroundings ensures full traceability from waste garment to finished product. Dr Green demonstrates how textile circularity can be achieved in practice, significantly reducing waste and environmental impact while supporting local industry.

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

2 Identified sustainability assessment challenges

The textile sector is a major contributor to global environmental challenges, impacting ecosystems at every stage of its value chain. One of the most pressing issues is water consumption and pollution. Cotton cultivation, for example, requires vast amounts of water, often in regions already facing scarcity. Additionally, textile dyeing and finishing processes discharge large volumes of untreated wastewater containing toxic dyes, heavy metals, and other hazardous chemicals into rivers and lakes, threatening aquatic life and human health. Another significant challenge is the sector's reliance on chemicals. From pesticides used in cotton farming to the various agents applied during processing, many of these substances are persistent in the environment and can accumulate in the food chain. The industry is also energy-intensive, with manufacturing processes such as spinning, weaving, and dyeing consuming substantial amounts of fossil fuels, thereby contributing to greenhouse gas emissions and climate change. Waste generation is a growing concern, as both production and post-consumer phases generate large quantities of solid waste. The rise of synthetic fibres like polyester has introduced the problem of microplastic pollution, as tiny fibres are released during washing and eventually enter waterways and oceans. Furthermore, the extraction of raw materials for textiles leads to resource depletion, land use change, and loss of biodiversity. Addressing these environmental challenges requires a shift towards sustainable practices, including water and energy efficiency, safer chemical management, recycling, and the adoption of circular economy principles throughout the textile value chain.

In addition to these environmental challenges, there are several barriers to sustainability assessment in the textile. The main obstacles include:

- **Complex global supply chains:** textiles often pass through multiple countries and suppliers, making it difficult to trace materials and collect reliable, consistent data across all stages of production.
- **Data gaps and quality issues:** several actors on the textile value chain lack robust environmental reporting systems. This leads to incomplete or inconsistent data, which undermines the accuracy of sustainability assessments.
- **Diversity of materials and processes: t**he sector uses a wide range of fibres (natural, synthetic, biobased, blends) and processes (dyeing, finishing, coating), each with unique environmental profiles. Comparing impacts across such diversity is challenging.
- **Difficulties comparing LCA results:** LCA results can vary significantly depending on choices like system boundaries, allocation methods, and data sources. This makes it hard to compare results between studies or products.
- **Rapid technological change:** new materials, recycling methods, and production technologies are emerging faster than standardized assessment frameworks can adapt, making it hard to keep evaluations current and relevant.

Blended and composite materials: the increasing use of fibre blends and composites complicates recycling and makes it harder to assess the end-of-life impacts and circularity potential of textile products.

The textile industry faces major sustainability challenges including water use, chemical pollution, and energy consumption, especially in dyeing and finishing processes. Social issues such as unsafe working conditions and lack of supply chain transparency further complicate

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

efforts toward ethical production. Additionally, fast fashion drives overproduction and waste, while recycling systems remain fragmented and underdeveloped. For example, producing a single cotton shirt requires approximately 2,700 litres of water, and dyeing one ton of fabric can generate up to **200 tons of wastewater,** often containing hazardous substances like heavy metals and formaldehyde.[1] There is a need for more transparency in the textile supply chain and data backed-sustainability claims, using for example, LCA methodologies.

The main goal of LCA is to support companies in their transition to more sustainability. The environmental impact can be assessed following ISO 14040:2006 *Environmental management — Life cycle assessment — Requirements and guidelines,* the Product Environmental Footprint (PEF) method and more recently the Product Environmental Footprint Category Rules (PEFCR[2]). Despite its importance, several challenges hinder the adoption of LCA methodologies in the textile sector.

To have more insights into these challenges, over the course of the Aligned project, BTG conducted two rounds of stakeholder consultations and workshops through a survey and organized workshops targeted at professionals in the textile sector. On the 3rd of May 2023, the ALIGNED Textile Sector Workshop was held with 18 stakeholders from the textile sector. During this workshop the key results from the 16 responses from the consultation round were discussed and compared to the sector overview. On March 20 2025, the ALIGNED 2nd Textile Sector Workshop was held with 74 stakeholders from the textile sector. During this workshop the key results from the 25 responses from the consultation round were discussed. These sector consultations enabled to collect input from the textile sector professionals related to LCA practices in their companies, challenges their face for implementing LCA, and their feedback regarding the LCA methodologies developed within Aligned.
As for assessing the environmental impact in the textile sector, the consultations revealed that the **Product Environmental Footprint (PEF)** and **ISO 14040:2006** are the most used guidelines based on both survey results and responses from textile sector professionals during the workshop.

[1]https://www.openaccessgovernment.org/article/water-pollution-in-the-textile-industry-sustainable-innovation/195144/
[2] https://green-forum.ec.europa.eu/green-business/environmental-footprint-methods/pef-method_en

Funded by the European Union
Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

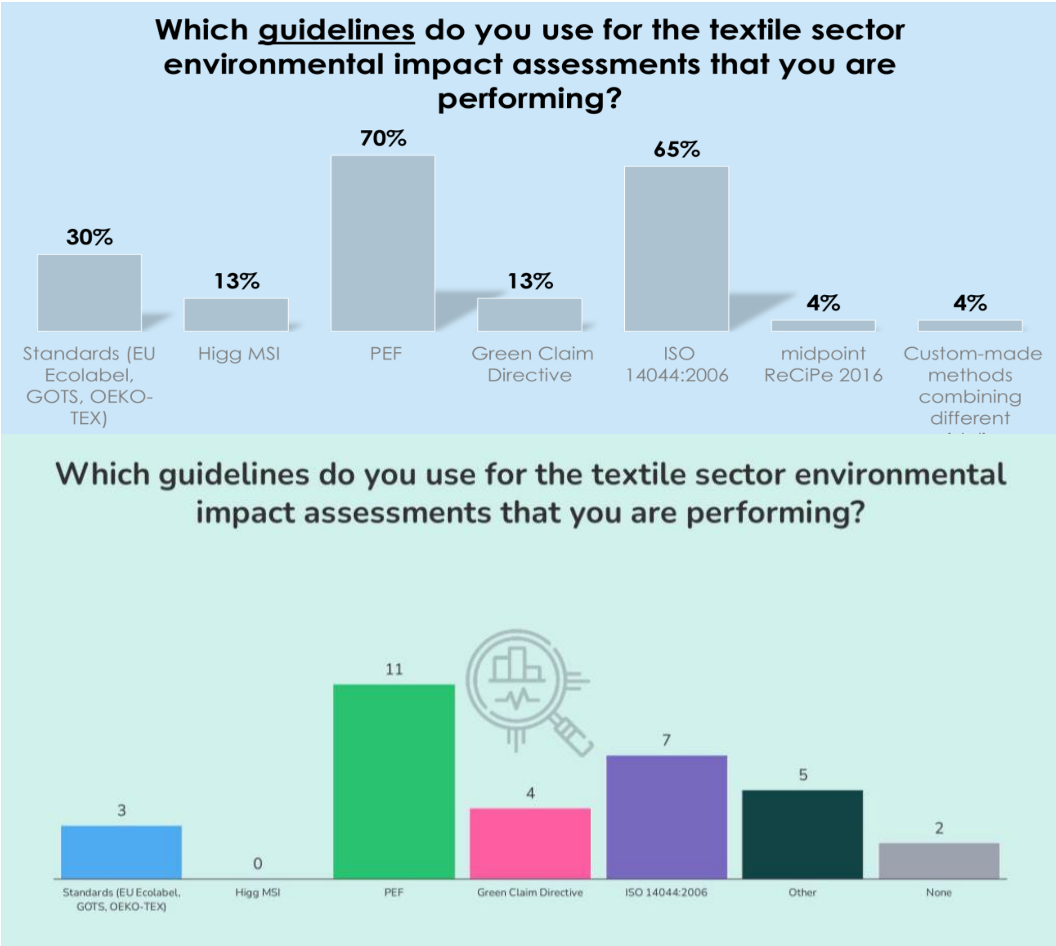

Figure 1. Methods used in textile sector for sustainability assessment (top) from survey and (bottom) from workshop participants responses

Challenges for implementing LCA in the textile sector

Data availability remains the main obstacle to the implementation of LCA in the textile sector, followed by lack of professional skills and high costs. The identification and ranking of these challenges from the survey remain consistent with responses collected from participants during the workshops as shown in **Figure 2**.

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

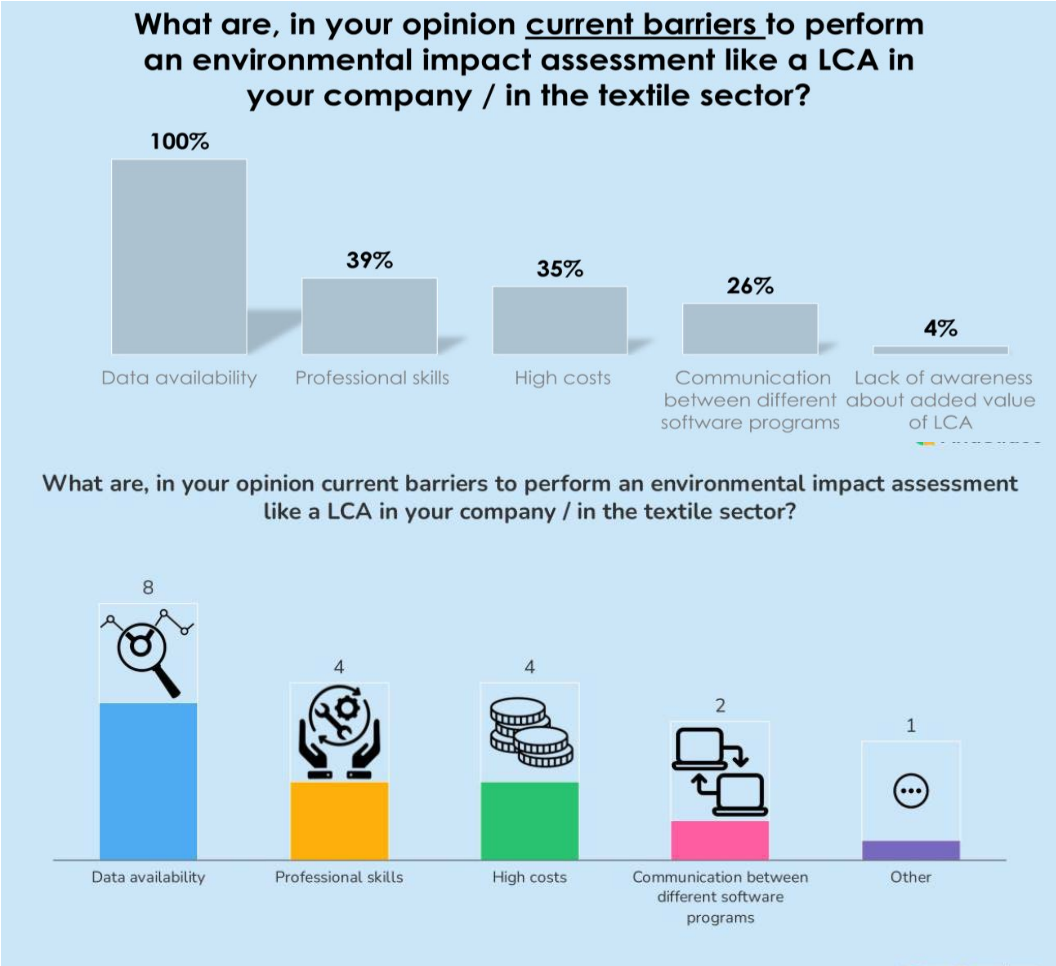

Figure 2. Challenges to implementing LCA in textile sector from survey (top) and input collected during the workshop (bottom)

Barriers for applying Aligned methodologies

In addition to **lack of data** and **inadequate expertise**, the textile sector consultations revealed that **incompatibility** with existing LCA methodologies and standards is a major barrier to implement Consequential LCA (Figure 3) and Prospective LCA (Figure 4). For instance, incompatibility of Prospective LCA with other LCA methodologies was mentioned as one of the main challenges to performing Prospective LCA next to lack of data and expertise of the personnel in the textile industry. The direct consequence of this incompatibility is the is that LCA results from prospective LCA cannot be directly compared to LCA results from other methods as evidenced by responses from workshop participants in Figure 4. The open methodologies provided by ALIGNED to facilitate the use of both consequential and prospective methods could help filling the expertise gap.

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

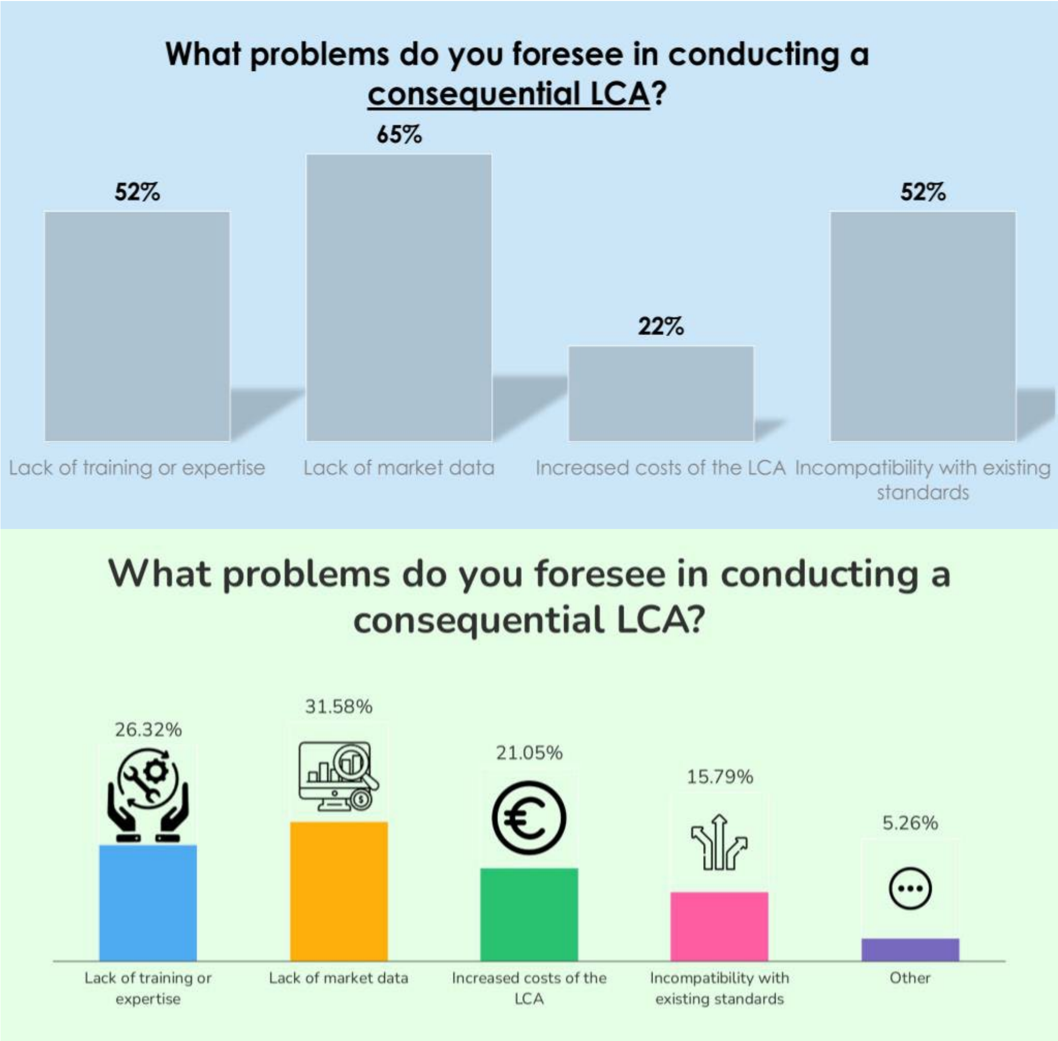

Figure 3. Foreseen obstacles for implementing Consequential LCA with (top) survey responses and (bottom) responses collected during the workshop

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

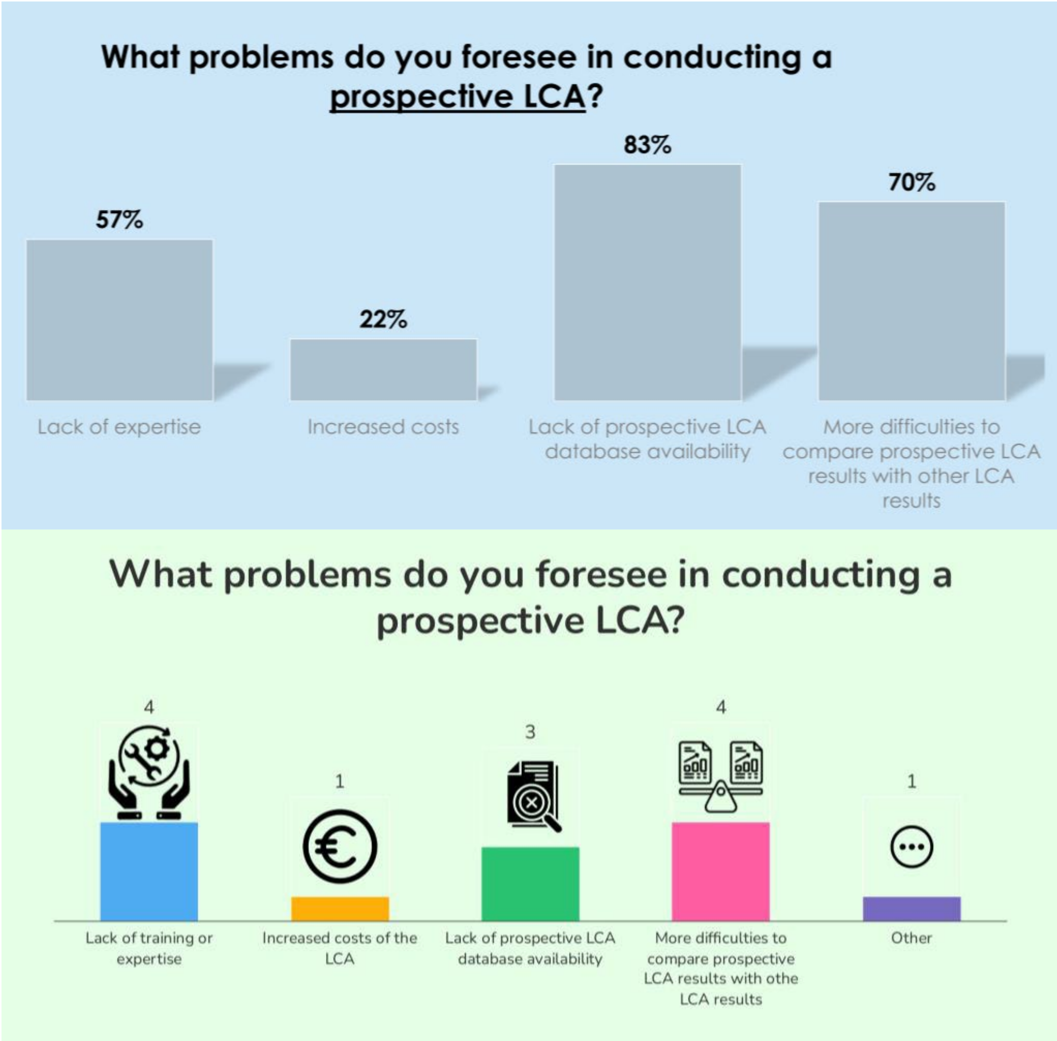

Figure 4. Predicted hurdles for implementation of Prospective LCA based on (top) questionnaire and (bottom) responses of workshop participants

Main stakeholders to solve LCA challenges in textile sector

To address the main challenges for sustainability assessment in the textile sector challenges identified from the textile sector consultations, several stakeholders, from policy makers to software providers and LCA practitioners, shall play their role. This need for multi-stakeholders' intervention to solve these challenges was highlighted in the results from both the survey and workshop participants from the textile sector. For instance, next to the textile sector, other parties such as suppliersLCA practitioners and policy makers are held accountable for providing both market data (Figure 0) and background data (Figure 6) for emerging new textile materials. The following recommendations are examples of actions which could be undertaken by each stakeholder to facilitate assessing sustainability in the textile section by means of LCA.

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

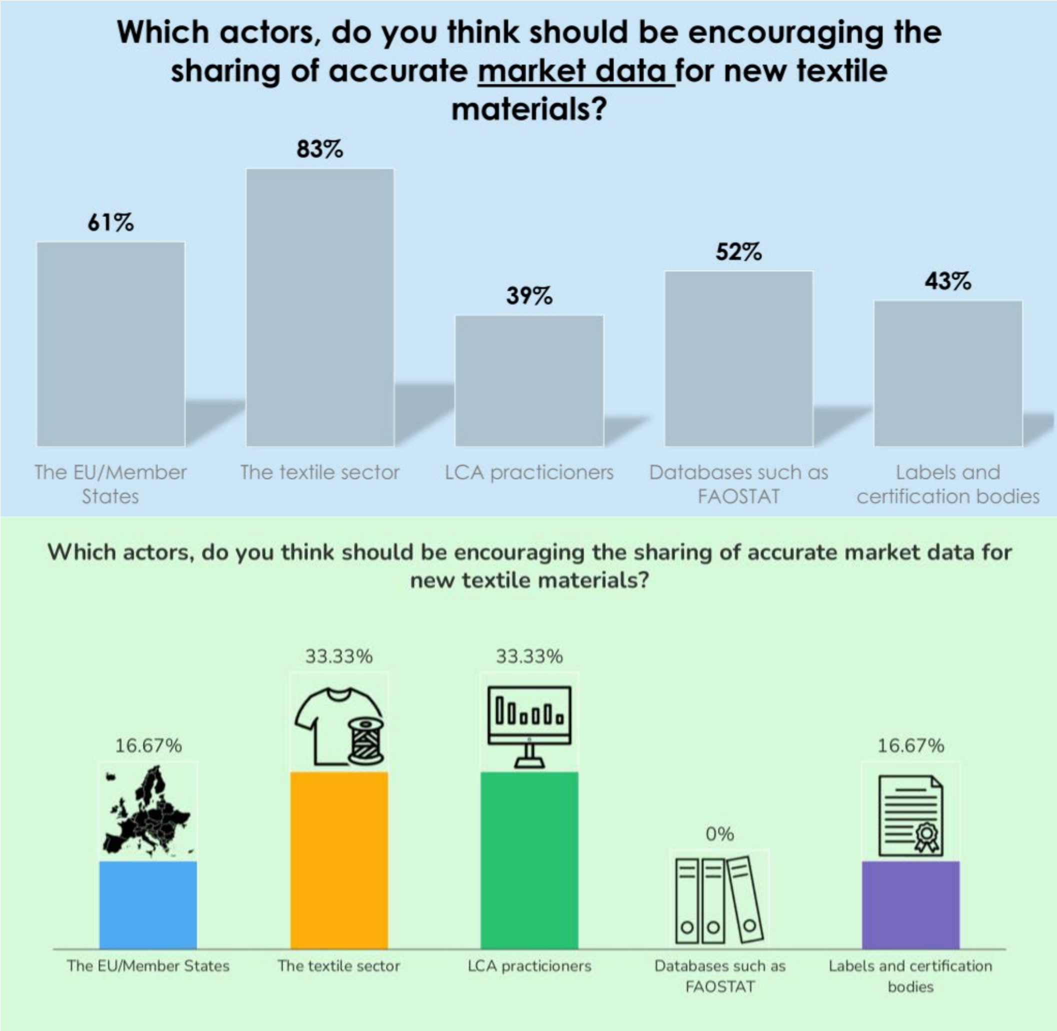

Figure 5. Stakeholders accountable for accurate market data (top) from survey and (bottom) from workshop participants responses

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

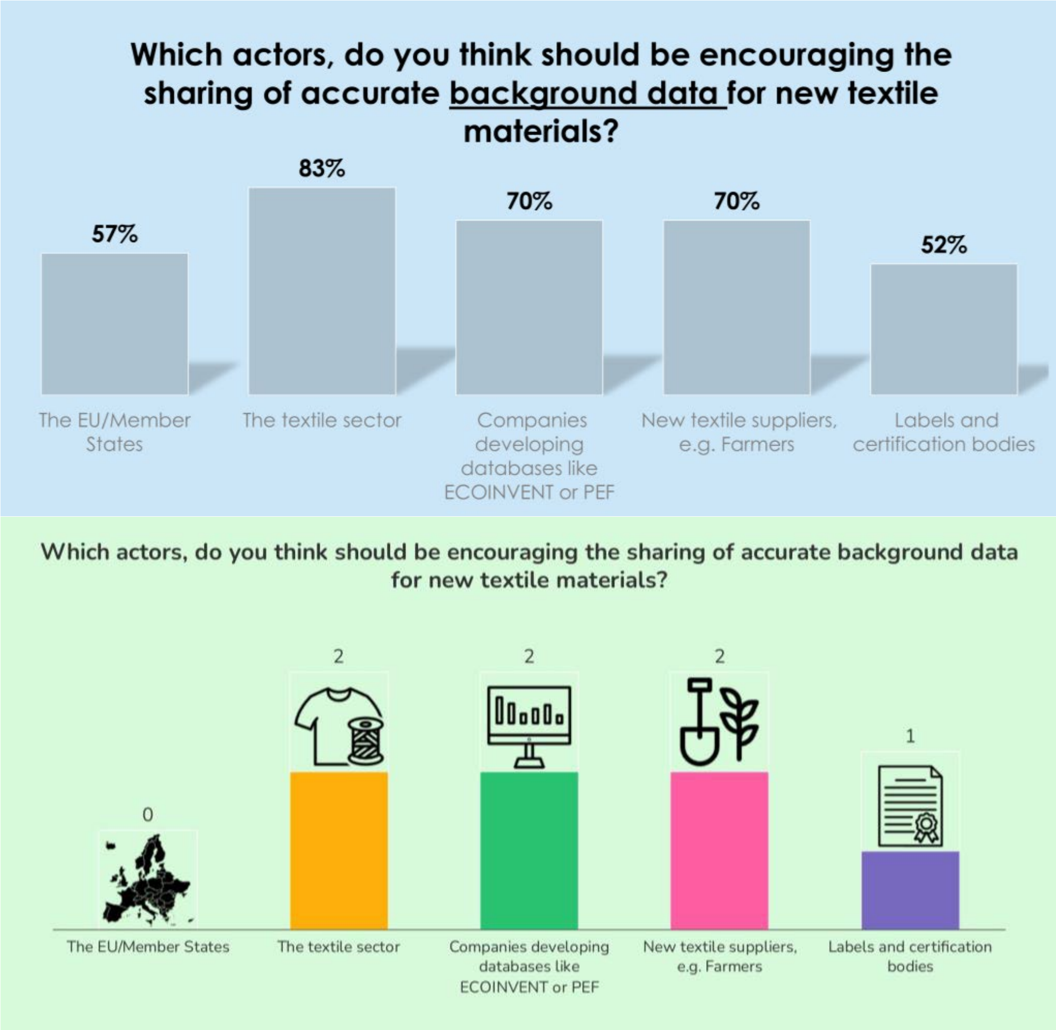

Figure 6. Stakeholders accountable for background data (top) from survey and (bottom) from workshop participants responses

3 Recommendations

3.1 LCA practitioners

Finding the stage that bears the most impact in (recycled) fabric life cycle

For performing LCA on recycled textiles, the work conducted by BTG showed that the step with the largest impact on the environment (climate change impact) is the use phase, particularly due to the substantial use of water and electricity during the washing and drying phases. Therefore, a conclusion was that this impact could be minimized by using non-fossil-based electricity mix.

Textile (garment) washing and drying are common operations during the use phase regardless of whether the textile is recycled or not. Therefore, the impact of washing and drying steps would be comparable for both recycled and non-recycled textiles. Therefore, suggestions for performing LCA on recycled textiles include comparing the fraction of energy used during the use phase compared to other steps in the LCA and determining the energy needed for producing a virgin fabric vs a recycled fabric of the same composition (for example, in the case of ALIGNED, Dr Green vs the benchmark fabric).

Contributing to LCA data availability and reproducibility

We recommend that stakeholders systematically contribute to LCA data availability and reproducibility by making anonymized input/output datasets and model documentation openly accessible—e.g., via open-access journals and repositories such as Zenodo—without breaching confidentiality. The ALIGNED standard Excel document can be used with clear metadata, version control, and persistent identifiers (e.g., DOIs) to enable verification, reuse, and consistent implementation across methods and partners.

3.2 LCA software developers and providers

Ensuring interoperability of LCA software

For example, in applying LCA methods to the textile case, it was necessary to combine LCA data from different software. However, due to incompatibility in data formats, it was not possible to share data across LCA software.

Making more granular datasets on textiles supply chains available in LCA databases

The data found in commonly used-databases such as ecoinvent is often generic. To realistically represent textile value chains, specific data need to be collected at different stages, such as the dimension of yarns and their origin.
For example, while the thickness of the yarns is relevant, the weight of fabric should be considered during the weaving to assess the impact of these steps in terms of energy consumption and CO_2 emissions. Current databases should include data depending on the dimensions of the textile filaments and distinguish between yarns of different constructions (single yarns, twisted yarns, ring-spun, open-end yarn, etc.) and include data for yarns of European origin. Cotton is represented by a single global figure in common data bases such as ecoinvent while there should be a distinction between European cotton, African cotton, Asian cotton, and cotton from the USA to account for the specificities on each of these geographies and agricultural practices. Also, one of the major impacts in energy consumption or CO_2 emission during production is due to the ambient conditions in the production location and this is variable depending on the geography. For example, the coefficient for carbon footprint referred to in kg CO_2 emissions per kg of textile (yarn or fabric) for textile production is 4-fold higher than the impact obtained by UTEXBEL on actual process data based on parameters including production (volume, fineness or number of picks), energy consumption linked to the process (electricity, steam, gas, water, etc.), energy consumption linked to the environment (climate, lighting, etc.), and Belgium's energy mix.

Supporting projects for creating background LCA data for non-conventional biobased materials

In ALIGNED, unavailability of data for organic cotton in LCA databases lead to using an estimate or a proxy to assess the sustainability of the third generation of Dr Green made of recycled polyester and organic cotton.

3.3 Textile sector federations: raising awareness and training

In addition to raising awareness about sustainability assessment methods, textile sector federations may organize training for their members from the textile industry which may not have the necessary expertise inhouse. More importantly, the training needs to be tailored

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

depending on the function of the professional involved in the whole textile life cycle. For instance, training the textile production process responsible to identify which types of information and process parameters to collect and training the procurement department regarding which type of LCA-relevant information to request from material suppliers. This training will facilitate the gathering of quality information from the textile producer to be ready to use as input for LCA. In this case, it would be simpler to perform LCA inhouse or provide the data to external LCA analysts, such as it was done in ALIGNED between UTEX and BTG, to assess the environmental impact the textile product or process. Ultimately, that data collected for LCA, may also use for other types of audits (e.g. from business customers) which are common in the textile sector.

3.4 Policy makers and standardisation bodies

Making standard document available for Life Cycle Inventory (LCI) data to facilitate the sharing of knowledge between LCA practitioners and industry.

4 Conclusion and perspectives

Extrapolating from the insights gained by applying the ALIGNED methodologies in the case study on Dr Green from UTEXBEL, as well as input from ALIGNED stakeholder interaction and sector insights, this document aims to provide recommendations relevant to the whole textiles sector. The challenges encountered by UTEXBEL, a fully integrated textile manufacturing company which has been operative for almost a century, are likely also faced by multiple textile producers. Based on the lessons learned from this ALIGNED textile case, combined with survey results and workshop participants responses from the textile sector, we are confident that the identified challenges are thus relevant for the broader textile sector. The proposed recommendations are not exhaustive. They indeed provide pathways to support the textile sector in its transition towards more sustainability based on efforts from multiple stakeholders.

There are still open questions how the major challenge of data availability may be solved in relation to the LCI file. The LCI format, the minimum information that it should contain, the type of channel or platform on which such quality market and/or background data can be made available, and the link with the upcoming digital product passport for textile products are yet to be defined. The LCI format developed in ALIGNED could provide a starting point for this LCI format. Nevertheless, these despite open questions and the foreseen challenges in applying Aligned methods, the textile sector professionals are favourable to applying Aligned methodologies as evidenced by the survey responses (Figure 7). Therefore, we believe that Aligned contributed to the progress for LCA methodologies applicable to the textile sector and may be a stepping stone in future developments.

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

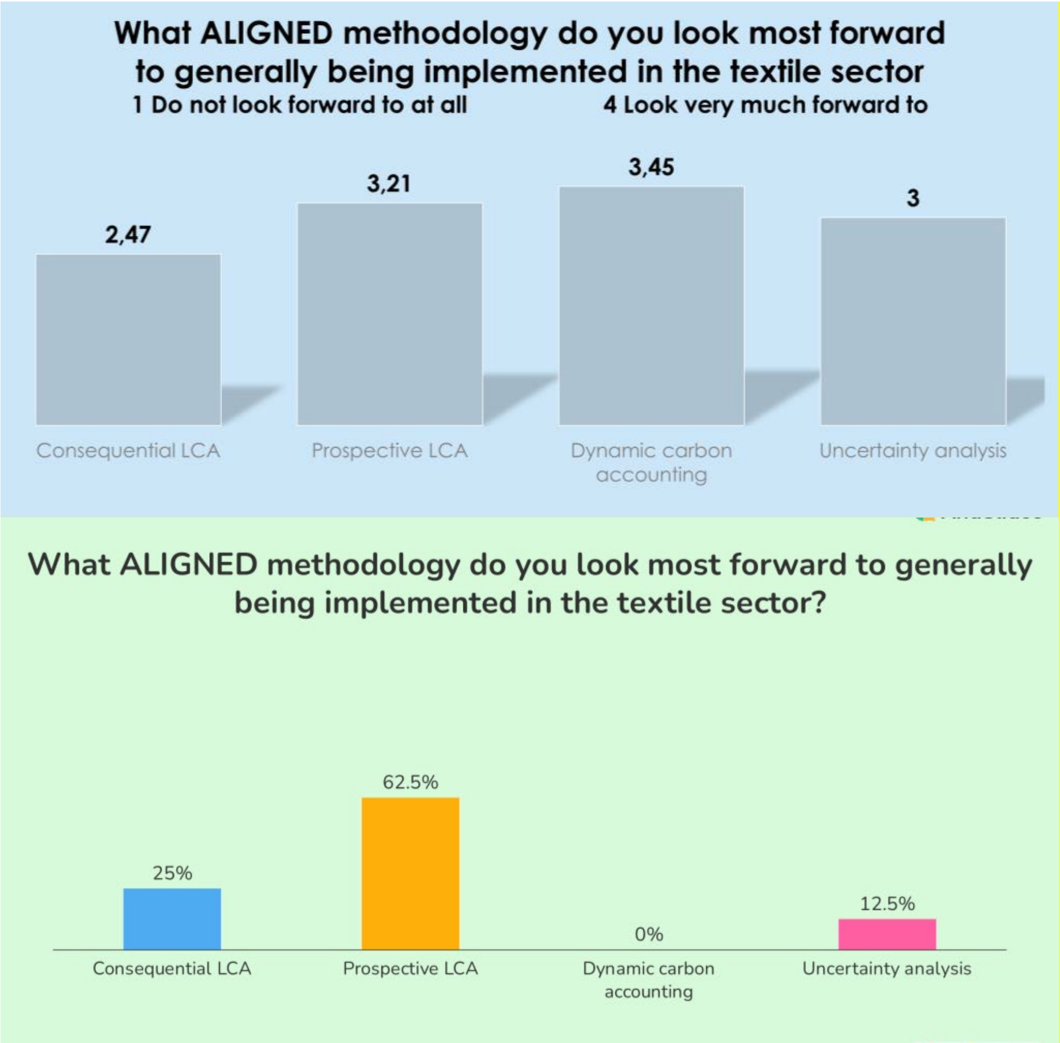

Figure 7. The textile sector looks forward to implementing Prospective LCA based on combined responses (top) from survey and (bottom) workshop participants

Funded by the European Union

Horizon Europe grant agreement N° 101059430. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.