Textile Exchange

Life Cycle Assessment for Cotton

Summary

March 2026

Cotton LCA goal and scope

Textile Exchange, with the support of consultancy Sphera, has completed a comprehensive Life Cycle Assessment (LCA) study to develop robust and transparent environmental datasets for cotton production systems worldwide. The study aims to address critical data gaps and methodological variability found in existing cotton LCA studies by generating new datasets for country average (reference system), organic, regenerative, and recycled cotton across key producing countries.

Environmental impacts are assessed across several key categories, including climate change, water use, eutrophication, and ecotoxicity. Additionally, the Textile Exchange LCA+ approach is incorporated, addressing soil health and biodiversity as semi-quantitative metrics, as well as the inclusion of a social assessment.

The LCA study has been completed in accordance with ISO 14044:2006 Environmental Management—Life Cycle Assessment—Requirements and Guidelines. The study has undergone a critical review by an independent expert panel to ensure conformity with the ISO standard and the scientific robustness of the results. In addition, a Technical Advisory Group (TAG), comprising representatives from cotton initiatives, industry stakeholders, and LCA experts, provided ongoing guidance and input during the development of the study.

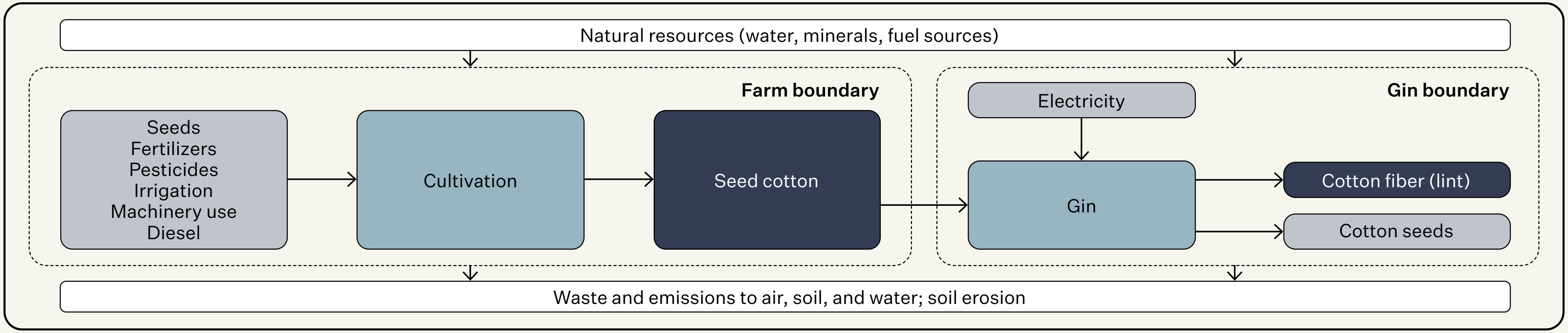
Cover photo: Abhishek Khedekar

Life Cycle Assessment scope

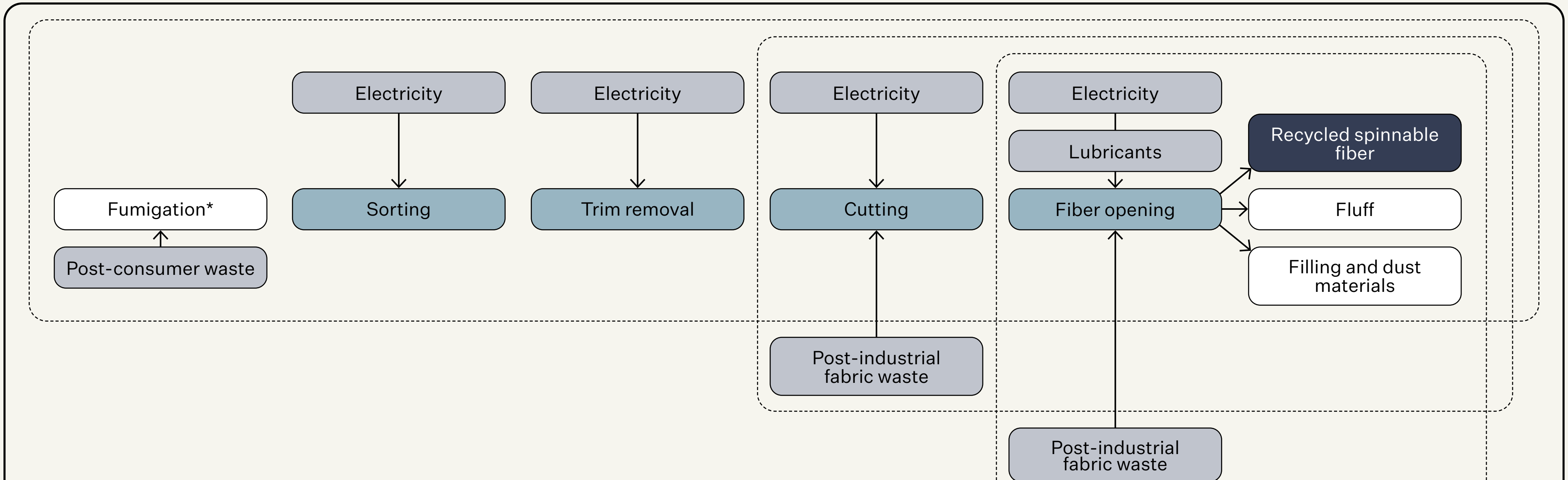
The study follows a non-comparative, attributional LCA approach and focuses on cradle-to-gin-gate boundaries. The cradle-to-gin-gate system for cotton cultivation covers raw material production from field to ginning. The functional unit is 1 kg of lint cotton at the gin gate. For recycled cotton, the scope includes three types of waste: post-industrial yarn waste, post-industrial fabric waste, and post-consumer waste. System boundaries include waste collection, transport, and mechanical recycling processes. The functional unit is 1 kg of recycled spinnable cotton fiber product for further processing at the factory gate. The geographical coverage is represented in the table below.

Photo: Lindokuhle Sobekwa

System boundaries – Cotton cultivation:



System boundaries – Recycled cotton:



Not included in the baseline, but in a scenario analysis.

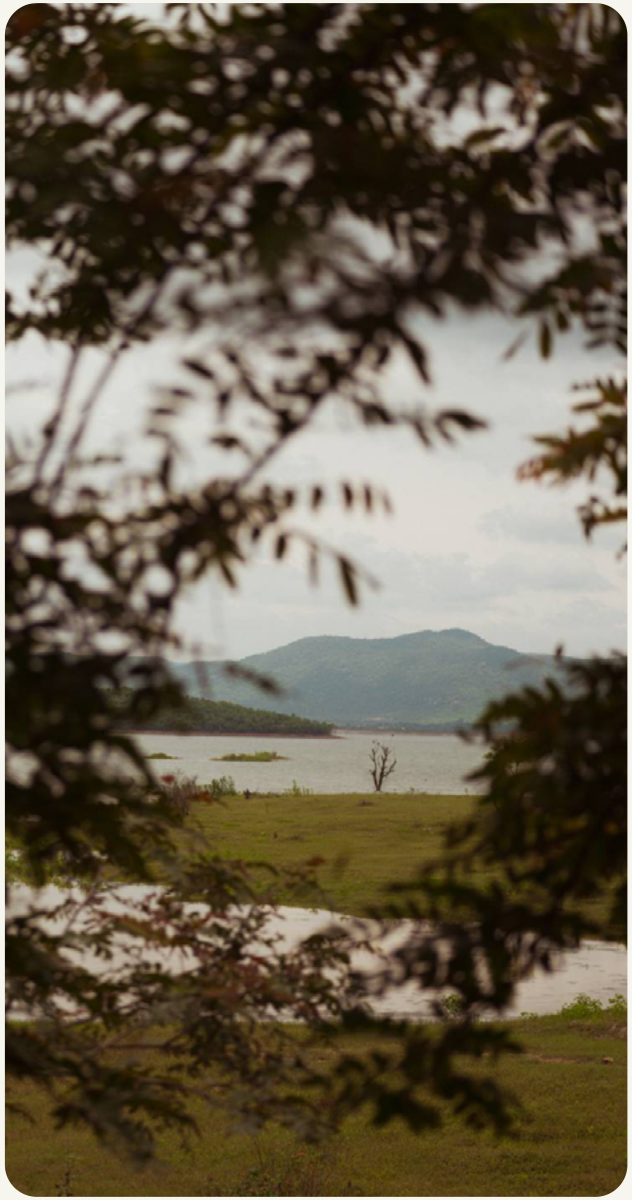


Photo: Priyadarshini Ravichandran

Geographical scope

In terms of allocation, for cotton cultivation, this study follows the default allocation approach recommended by the Cascale Cotton LCA methodology, namely, economic allocation based on the five-year average price data. For recycled cotton, which is a multi-output system, economic allocation is used to allocate impacts between the main product and by-products. However, the study takes a conservative assumption, assuming 100% allocation to the main product.

NOTE: Further information can be found in:
3.3 System boundary and 3.4 Allocation.

Within scope of assessment ●

Out of scope of assessment ○

Country	Country average	Organic	Regenerative	Post-industrial yarn waste	Post-industrial fabric waste	Post-consumer waste
Bangladesh	○	○	○	●	●	○
Brazil	●	●	○	○	○	○
China	●	○	○	●	●	●
India	●	●	●	○	○	●
Pakistan	○	○	○	●	●	●
Peru	○	●	●	○	○	○
Tanzania	○	●	○	○	○	○
Türkiye	●	●	●	●	●	●
U.S.	●	●	○	○	○	○

Table 1: Geographical scope

Key findings

For cotton cultivation

- Environmental impacts associated with cotton cultivation are shaped by a set of systemic drivers that cut across impact categories. Field emissions related to the nitrogen balance are central for climate change and eutrophication modeling; fertilizer provision impacts further condition results.
- Irrigation influences both blue-water consumption and energy-related emissions, and its relevance depends on climate, water use efficiency, technique, and local hydro-geological conditions.
- Pesticide inventories and characterization factors strongly affect ecotoxicity modeling.
- Yield levels act as a scaling parameter across categories because inventory flows are expressed per unit of output.
- Scenario analysis indicates that results remain sensitive to several methodological choices. These include the treatment of organic fertilizers, soil nutrient loss factors, assumptions about nutrient contents in organic materials, the use of a nitrogen balance for emission modeling, the level of detail used in pesticide modeling, and the electricity mix applied for ginning.

For recycled cotton

- Electricity consumption and transportation have been identified as key drivers of potential environmental impacts for all impact categories and inventories.
- For all cotton waste types, impacts are most significantly influenced by the intensity of the recycling process and the electricity consumed.
- For post-consumer waste, there are additional processing steps required prior to fiber opening and higher process waste losses, contributing to high electricity consumption.
- Scenario analysis highlighted that for post-consumer waste, international transportation, along with other potential upstream impacts, such as washing and drying or fumigation, were identified as a significant potential source of additional environmental impacts.
- A high level of uncertainty remains regarding the potential environmental impacts of individual suppliers of recycled cotton fibers, and it cannot be assumed that one waste type is inherently more impactful than another.

NOTE: Further information can be found in: 5. Results.

Photo: Abhishek Khedekar

LCA+ approach

Soil health

For soil health, the study used soil organic carbon (SOC) as a proxy, applying the Intergovernmental Panel on Climate Change (IPCC) Tier 1 methodology. Results suggest that reduced tillage and especially increased organic inputs, such as cover crops or manure, can enhance SOC stocks and strengthen long-term soil resilience. However, these estimates rely on default factors, assume linear trends, and do not capture site-specific variation. They should therefore be interpreted as indicative scenarios, not as robust or reportable removals.

NOTE: Further information can be found in: 7.1 Results of soil health assessment.

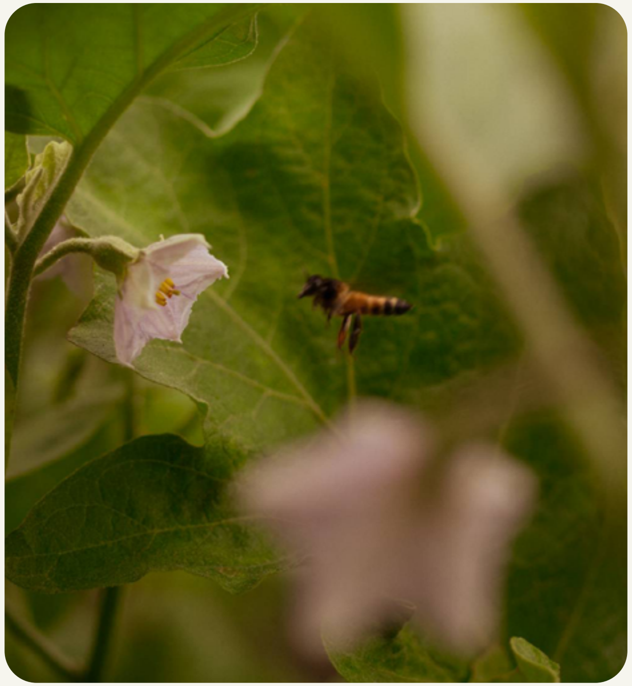


Photo: Priyadarshini Ravichandran

Biodiversity

For biodiversity, impacts were assessed indirectly by interpreting existing environmental impact categories such as land use change, eutrophication, pesticide use, and water consumption as proxy indicators. However, these indicators were not designed to measure biodiversity directly. While reductions in these pressures are generally expected to lower biodiversity risks, outcomes remain highly site-specific, and no direct one-to-one relationship can be assumed. Some potential benefits of specific farming practices develop gradually over time and may fall outside the resolution of this LCA. A meaningful evaluation of biodiversity impacts would require more detailed, spatially explicit, and locally grounded data, which goes beyond the screening level possible with the LCA+ approach.

NOTE: Further information can be found in: 7.2 Results of biodiversity assessment.

Social assessment

The human rights assessment part of this LCA study is intended to serve as a high-level human rights screening. The outcomes should not be used for any claims or external communication, but rather to support the identification of the most relevant areas for action.

The findings indicate that significant human rights impacts persist within the cotton supply chain, requiring continued attention and improvement. Social experts noted progress in several areas, including gender equality, awareness-building, child labor, and structural changes in rural areas. However, they also highlighted worsening conditions related to forced labor, geopolitical risks, rising costs, and gender-based disparities in task allocations and wages. Additionally, the growing impact of climate change on human rights throughout the cotton supply chain was a major concern raised during interviews with experts.

NOTE: Further information can be found in: 7.3 Results of human rights impact assessment.

Data challenges and limitations

For cotton cultivation:

- Data availability constraints, methodological assumptions, and the inherent complexity of agricultural systems and natural environments.
- Variability and uncertainty in primary data quality and challenges related to the representativeness of regional data.

For recycled cotton:

- Benchmark LCA data availability, data availability constraints, and validation of primary data collection.
- Variability and uncertainty in primary data quality and challenges related to quantifying the representativeness of supplier-specific data.
- Specific uncertainties affecting inventory data, including assumptions on packaging, auxiliaries, and transportation distances.

NOTE: Further information can be found in: Executive summary and 6.2 Assumptions and limitations.

Conclusions and recommendations

- This study represents a considerable advancement in the state of LCA data for cotton, providing comprehensive documentation, greater consistency of results, transparency, and robustness.
- LCA results remain sensitive to assumptions and contextual factors; the results should be interpreted within their limitations, and simplistic rankings or claims based on these results should not be undertaken.
- To improve data quality, the study emphasizes methodological harmonization, particularly for recycled cotton, where inconsistencies in system definitions and inventory parameters persist. For cotton cultivation, expanding datasets to better capture spatial and temporal variability is critical.
- To reduce environmental impacts from cotton cultivation, the study highlights the importance of using inputs efficiently. Key measures include nitrogen management, the use of low-carbon fertilizer, and promoting Integrated Pest Management to reduce chemical use while maintaining or increasing yields. Lowering energy and water use for irrigation, as well as adopting renewable energy sources at ginning facilities, can provide additional reduction potentials.
- For recycled cotton, the study emphasizes a switch to 100% renewable electricity generation for all waste types, as well as increasing the domestic treatment of post-consumer waste to avoid impacts associated with international transportation.

NOTE: Further information can be found in:
6.4 Conclusions and recommendations.

Photo: Abhishek Khedekar