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COTTON
MADE IN
AFRICA
Organic

Life Cycle Assessment of CmiA Organic Cotton from Tanzania

Supplier-specific Summary based on Textile Exchange's Life Cycle Assessment for Cotton - country averages, organic, regenerative, recycled

March 2026

AID BY TRADE
FOUNDATION

Client:	Aid by Trade Foundation
Title:	LCA of CmiA Organic Cotton from Tanzania Supplier-specific summary based on Textile Exchange Cotton LCA
Report version:	v1.1 (Final version)
Report date:	December 2025

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KEY TAKEAWAYS

- This study summarizes the life cycle assessment (LCA) of CmiA Organic cotton produced in Tanzania, prepared as a supplier-specific summary derived from a large LCA on cotton cultivation systems conducted by Textile Exchange. The parent study provides country-average LCA results for different cotton production systems (conventional, organic, regenerative, and recycled) across major producing regions and has undergone independent critical review. Within this framework, data submitted by the Aid by Trade Foundation (AbTF) were used to represent organic cotton cultivation in Tanzania. The present report highlights these results specifically for CmiA Organic cotton, quantifying cradle-to-ginnery-gate environmental impacts per kilogram of lint. The study aims to document and communicate the environmental profile of Tanzanian organic cotton under AbTF program conditions, supporting transparent reporting and continuous improvement, while remaining non-comparative in scope and purpose.

- The Tanzania CmiA Organic system represents a low-input, rainfed cotton production model characterized by the absence of mineral fertilizers and pesticides, limited mechanization, and the prohibition of genetically modified seeds. Field emissions from nitrogen turnover are the dominant contributors to climate change and eutrophication impacts, while energy use at the ginnery constitutes a secondary hotspot. The lack of mineral fertilizer inputs and irrigation results in negligible environmental impacts from fertilizer manufacturing and blue water consumption, meaning that several common hotspots observed in more intensive systems are not relevant for CmiA Organic cotton from Tanzania.

- The contribution analysis for climate change impacts indicates that, of the total 0.89 kg CO_2 eq per kilogram of fiber, approximately 0.59 kg CO_2 eq originate from field emissions, around 0.20 kg CO_2 eq result from ginning, and about 0.10 kg CO_2 eq arise from other life cycle stages (machinery use and transport). Ranges of total results reported in the TE Cotton LCA span from 0.44 to 4.17 kg CO_2 eq per kilogram of fiber. The Tanzania CmiA Organic system falls toward the lower end of this range, although no comparative assertions should be derived from this observation. The reported range reflects global variability across systems with different methodological uncertainties, data qualities, and farming intensities, and is therefore provided solely as background information rather than as a basis for comparison.

- Overall data quality is good, with high geographical and temporal representativeness. However, uncertainty in the nutrient content of farmyard manure (FYM) remains a key source of variability in the results.

- Scenario analyses confirm that assumptions about nitrogen content and related upstream impacts of organic fertilizers strongly influence nitrogen-driven categories such as climate change and eutrophication. Alternative IPCC factor settings demonstrate how climatic classification affects modeled N_2O and nitrate losses. The soil carbon screening suggests a potential for increasing soil organic carbon under current management practices, although these values represent indicative potentials rather than verifiable removals.

- Key recommendations to enhance data quality and reduce uncertainties focus on strengthening primary data collection. Direct measurement of FYM application rates and nutrient content should replace proxy assumptions to better capture nitrogen-related emissions.

- The system may offer potential for greenhouse gas removals through soil carbon sequestration, yet quantification remains uncertain due to methodological and baseline limitations. Additional removal pathways, such as on-farm biomass accumulation and biochar application, are more directly measurable and should be further explored in future assessments.

- For interpretation and communication, results should be communicated as ranges rather than single values, highlighting sensitivity to nitrogen assumptions, and any broader contextualization should reference the *Textile Exchange Cotton LCA Study* as the parent framework.

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1. INTRODUCTION

1.1 INTRODUCTION TO THE AID BY TRADE FOUNDATION AND THE CMIA STANDARDS

The Aid by Trade Foundation (AbTF) is a non-profit organization established in 2005 with the mission to use trade as a lever for sustainable development. Its founding principle is to empower smallholder cotton farmers and cashmere herders through market incentives rather than direct financial aid. By creating demand for sustainably produced cotton and cashmere, AbTF aims to improve living conditions for farming and herding communities, promote environmentally responsible cultivation practices, improve the welfare of animals and strengthen local economies.

AbTF functions as the standard-setting and quality assurance body behind its four sustainability standards –Cotton made in Africa (CmiA) and CmiA Organic, Regenerative Cotton Standard (RCS) and The Good Cashmere Standard (GCS). It defines sustainability criteria, oversees independent verification, and facilitates partnerships across the global textile supply chain, including e.g. cotton companies, ginners, traders, brands, and retailers. Revenues from licensing fees are reinvested in standard implementation, such as farmer and herder training, community development, verification and impact evaluation.

Through these mechanisms, AbTF connects international textile markets with raw material producers, integrating social, ecological, and economic dimensions of sustainability into a trade-based model.

Cotton made in Africa (CmiA) and CmiA Organic Standards

The Cotton made in Africa (CmiA) standard is one of the largest sustainability standards for smallholder cotton production globally, covering about 800,000 of farmers across ten African countries. The CmiA initiative promotes sustainable agricultural practices, social welfare, and economic resilience while ensuring full traceability of cotton fiber throughout the supply chain from ginnery to final product .

Compliance is verified through independent third-party verification conducted according to the CmiA Assurance Manual. The program's architecture emphasizes continuous improvement, whereby producers progressively adopt better practices in, amongst others, soil management, input efficiency, and occupational safety.

CmiA Organic is a dedicated program under the CmiA standards system that combines the social and economic principles of CmiA with the production requirements of organic agriculture as defined by recognized international standards (e.g., EU Organic Regulation and others of the IFOAM family of standards). CmiA verified Managing Entities must hold a valid organic certificate by an accredited control body in order to qualify for a CmiA Organic Certificate.

The implementation of CmiA Organic in Tanzania is coordinated by local cotton companies and farmer business groups operating under AbTF-licensed partnerships. Farmer training and monitoring are conducted with financial and technical support from AbTF, which includes support on organic cultivation, soil improvement techniques, record keeping, post-harvest handling and more. Ginning is not only verified against a set of sustainability criteria but also includes requirements on segregation and traceability to maintain physical integrity of certified cotton throughout the supply chain.

1.2 BACKGROUND AND PURPOSE OF THE CURRENT LCA STUDY

The AbTF is committed to providing regular and transparent impact assessments for cotton produced under its programs, including CmiA and CmiA Organic. In line with this mission, AbTF contributed farm-level activity data to a comprehensive LCA study conducted by Textile Exchange. The study provides LCA data for different cotton cultivation systems across global regions and was critically reviewed. As its scope focuses on generating country averages for different cultivation systems rather than program-specific datasets, the data submitted by AbTF were used to represent the country-average organic cotton system in Tanzania. The present summary report highlights these results in a program-specific context for CmiA Organic cotton.

Within the scope of the Textile Exchange LCA study, contributing data providers receive supplier-specific results. These results are not intended for publication without additional context and review to ensure accurate interpretation and responsible communication. Against this background, the current study aims to prepare a concise, standalone LCA summary focused on cotton produced under the CmiA Organic standard in Tanzania. The report builds directly on the methodology, data, and results of the critically reviewed *Textile Exchange Cotton LCA Study* to ensure methodological consistency and avoid duplication. A single-expert review process is conducted to confirm the transparent and appropriate use of these results in accordance with ISO 14044. The following Table explains how the two studies are referenced throughout the document.

Table 1-1: References to parent and standalone summary study

Full Name	Short Form	Reference to production system	Context
Life Cycle Assessment for Cotton - country averages, organic, regenerative, recycled, on behalf of Textile Exchange	"TE Cotton LCA"	TZ Organic	Used for all references to the global, critically reviewed parent study.
Life Cycle Assessment of CmiA Organic Cotton from Tanzania Supplier-specific Summary based on Textile Exchange's Life Cycle Assessment for Cotton - country averages, organic, regenerative, recycled	"Tanzania Summary LCA"	Tanzania CmiA Organic	Used for this standalone, country-specific summary report prepared for AbTF.

2. Goal and scope

2.1 GOAL

As outlined above, this report builds upon the comprehensive TE Cotton LCA study, which assesses environmental impacts of cotton production across major global production systems and regions. The overarching goal of the TE Cotton LCA is to provide scientifically robust, transparent, and representative environmental data on cotton production systems globally. The specific objectives of the parent study are to:

- Generate country-level reference data for key cotton production systems, based on the most recent and representative primary data available.
- Improve the transparency, comparability, and methodological consistency of cotton-related LCA data across the industry.
- Align modeling and reporting practices with recognized methodological frameworks such as ISO 14040/14044, the Product Environmental Footprint (PEF) method, the GHG Protocol Land Sector and Removals Guidance, and the Cascale Cotton LCA Methodology.
- Provide reliable input data for Scope 3 greenhouse gas reporting, material impact benchmarking (e.g. Cascale's Material Sustainability Index, the Higg MSI), and sectoral tracking of environmental performance improvements over time.

Within this broader framework, this standalone report focuses exclusively on cotton produced under the CmiA Organic standard in Tanzania. Its goal is to present the relevant country and system specific results from the TE Cotton LCA in a concise, accessible format for the AbTF and its stakeholders. The report applies the same methodological setup, functional unit, and modeling assumptions as the parent study to ensure full consistency. No new modeling or data collection is conducted. All results are directly derived from the critically reviewed Textile Exchange LCA model. The purpose of this report is therefore to:

- Compile a concise, standalone LCA summary report focused specifically on cotton produced under the CmiA Organic standard in Tanzania.
- Refer to and summarize the methodology, modeling approach, and results presented in the critically reviewed Textile Exchange LCA study to maintain consistency and avoid duplication.
- Facilitate a lightweight review process (e.g., single expert reviewer rather than a full review panel) to ensure credibility and alignment with reporting standards.

2.2 INTENDED USE

The TE Cotton LCA study places strong emphasis on defining the intended use of its datasets to ensure responsible application and interpretation. Textile Exchange has recently published a position paper titled *"Ensuring Integrity in the Use of Life Cycle Assessment – Data-Responsible Impact Measurement for the Fashion, Textile, and Apparel Industry"* (Textile Exchange, 2025), which provides important context for interpreting and applying LCA data. Users of the data generated in this study are strongly encouraged to consult this publication to gain a comprehensive understanding of the possibilities and limitations associated with the use of LCA data from Textile Exchange's studies. The intended use is defined as follows in the TE Cotton LCA (TE Cotton LCA, section 2.3):

Intended use:

- Analyzing the environmental impact reduction potentials of alternative management practices in cotton cultivation.
- Scope 3 reporting and target setting.
- As a source of default inventory data for internal or supply chain-specific assessments.
- As a source of validation and benchmarking data for internal or supply chain-specific assessments.
- Submission to LCA databases, such as Higg MSI (Cascale), WALDB (Quantis), Ecoinvent and other databases.
- Scenario analysis.
- To promote holistic considerations of impact including human rights impacts.

Data shall not be used for:

- Public claims, marketing claims (including for use on product labels), or any form of comparison:
  - based on the comparison of the LCI or LCIA results of this LCA study.
  - based on comparing the results of this LCA study to other studies.
  - about differences between countries and production systems (including comparisons between virgin and recycled cotton)
- Production or sourcing decision-making based solely on country average LCA results. Implementing reduction measures in high-impact regions is more environmentally beneficial than shifting sourcing, and human rights impacts deriving from changing sourcing strategy requires careful evaluation[1].

The Tanzania Summary LCA provides program specific inventory data for CmiA Organic cotton cultivated in Tanzania and supports users of Tanzania CmiA Organic fiber in Scope 3 reporting and related impact assessment applications, including the use of program specific data where available. In the data preference hierarchy outlined in the TE Cotton LCA, such program specific data have higher priority compared to global or regional default datasets. The study also facilitates an improved understanding of the environmental impact profile of Tanzania organic cotton systems.

1 Shifting sourcing to low-carbon geographies is discouraged as well by SBTi FLAG guidance (p. 48), which emphasizes engagement and improvement in existing supply regions to avoid leakage and promote long-term sustainability outcomes (Anderson et al.,2022).

2.3 PRODUCT SYSTEM

Organic cotton cultivation in Tanzania under the CmiA Organic standard is characterized by small-holder rain-fed systems that prohibit all synthetic inputs and genetically modified seeds. Farmers are required to adhere to international organic standards in addition to CmiA's sustainability principles. Crop rotation is mandatory, with cotton alternating with legumes or cereals to maintain soil fertility and break pest cycles. Residue burning is discouraged; instead, crop residues shall be returned to the soil through mulching, composting or as biochar. Fertility is managed using organic inputs such as farmyard manure, compost, and in some cases, bokashi. Soil conservation is supported through low-tillage practices, erosion control structures, and organic amendments, contributing to improved soil structure and moisture retention. Water use is limited to rainfall only; irrigation from surface or groundwater is not permitted. Farmers manage water through timely planting, mulching, and in some cases, basic rainwater harvesting methods to optimize soil moisture. Biodiversity conservation is embedded in the system through habitat protection, crop diversification, and avoidance of synthetic pesticides, fertilizer and genetically modified seeds. Pest control relies on integrated production and pest management techniques including botanical extracts (e.g. neem), traps, and enhancement of beneficial insects.

2.4 PRODUCT FUNCTION AND FUNCTIONAL UNIT

In cotton production, seed cotton, sometimes also referred to as raw cotton, or unginned cotton, describes the material harvested directly from the cotton plant. It consists of cotton fibers still attached to the seeds, along with small amounts of leaf, stem, and field debris. Seed cotton must undergo mechanical processing (ginning) to separate its components before further use. Through the ginning process, seed cotton is separated into:

- Lint cotton: The cleaned and separated fibers, which are spun into yarn and serve as the main input for textile manufacturing.
- Cottonseed: The separated seeds, which may be further processed for oil extraction, animal feed, or replanting.

In LCA studies, lint cotton is typically treated as the main product of ginning, while cottonseed is considered a co-product requiring appropriate allocation of environmental burdens (see section 2.5 for system boundaries and 2.6 for allocation). In this study, in accordance to the TE parent study, the functional unit refers to:

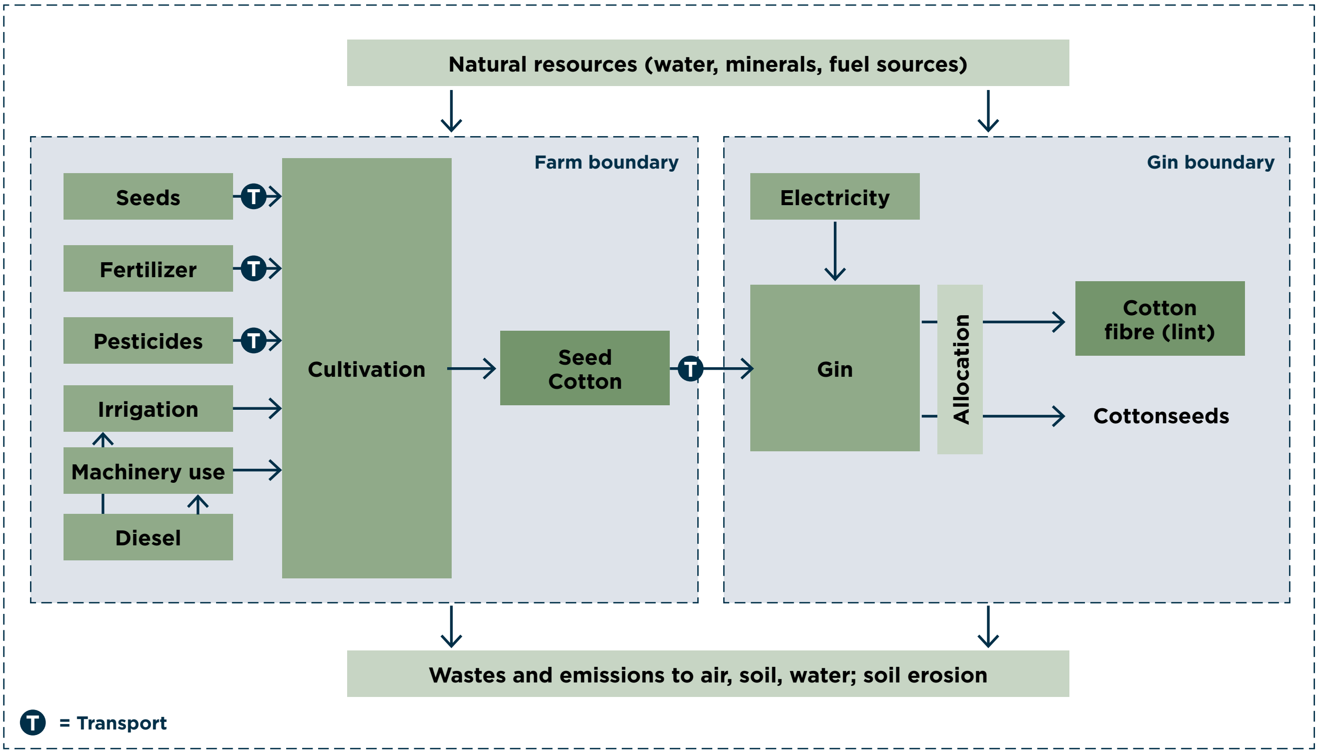
The cradle-to-ginnery gate system for cotton cultivation covers raw material production from field to ginning. The functional unit is 1 kilogram of lint cotton at the ginnery gate (excl. packaging).

The function of the product is lint cotton for further processing in the textile industry. Fiber quality is not considered in the study.

2.5 SYSTEM BOUNDARY

The TE parent study is conducted as a cradle to gate assessment from farm to ginnery, covering the system boundaries shown below (Figure 1). These boundaries also apply to the present Tanzania Summary LCA.

Figure 1: System boundaries – Cotton cultivation (Source: TE Cotton LCA)



No explicit cut-off criteria were established a priori for the study. All material and energy flows required for the two phases of production (cultivation and ginning), as well as all associated waste and emissions are included in the study. This includes fertilizer and pesticide production as well as field emissions (e.g., N_2O), emissions related to fire clearing (i.e., the combustion of biomass remaining on the field from previous cultivation period) (e.g. CH_4, SO_2), electricity for ginning and all transport (agricultural inputs to the field, seed cotton to ginnery). An assessment of Land Use Change (LUC) is included in the scope of the TE Cotton LCA study (statistical LUC used as proxy for direct LUC); however, it is assumed to be not applicable for the Tanzania CmiA Organic cultivation system (see section 3.4).

Table 2-1 provides a summary of inclusions and exclusions from the system boundaries. Please refer to the full TE Cotton LCA study for a detailed discussion of exclusions, rationale for exclusion and expected impacts on the results (TE Cotton LCA, section 3.3).

Table 2-1: Summary of inclusions and exclusions

Included	Excluded
✓ Fertilizer and pesticide production	× Draught animals
✓ Irrigation and water consumption	× End of life of ginnery waste
✓ Energy consumption for irrigation	× Capital equipment
✓ Transport	× Human labor
✓ Seed and planting material inputs	× Provision impacts of organic fertilizer (included in scenario)
✓ Field emissions	× Packaging at ginnery
✓ Emissions from fertilizer and pesticide application	× Indirect LUC
✓ Field clearing, biomass burning	
✓ Plastic mulching (only applicable to cultivation systems in China)	
✓ Direct LUC	

2.6 ALLOCATION

When a system yields more than one valuable output, as is the case with cotton production (seed and lint following ginning), a decision must be made regarding the allocation of impacts. Allocation is defined as “partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems” (ISO 14040:2006). The topic is thoroughly discussed in the Cascale Cotton LCA methodology (Cascale, 2024), including different allocation options, and therefore, will not be repeated in detail here.

The TE parent study follows the default allocation approach recommended by the Cascale Cotton LCA methodology (Cascale, 2024), namely, economic allocation based on the five-year global average price data. This approach also applies to the present Tanzania Summary LCA. The resulting allocation split is presented in Table 2-2.

Table 2-2: Allocation at ginnery (Cascale, 2024)

Process	Main product and co-products	Allocation factor
Ginning	Cotton lint (main product)	82.7%
	Cottonseed*	17.3%
	Gin by-products**	0%

* The LCIA results of Cottonseed are not provided in the study
** Gin by-products are excluded from the model (see section 2.3).

2.7 SELECTION OF LCIA METHODOLOGY AND IMPACT CATEGORIES

Various impact assessment methodologies are commonly applied in LCA studies, e.g. Environmental Footprint v3.1 (EF 3.1), CML (Centre of Environmental Science at Leiden), or ReCiPe. In alignment with the full TE Cotton LCA study, the scope of this study includes the full set of EF 3.1 impact categories as well as the additional categories recommended by Cascale for use in the Higg Material Sustainability Index (Higg MSI) (Cascale, 2024a). This means that in total, 18 impact categories need to be assessed. However, not all of these are equally relevant to the system studied. For instance, some impact categories may have limited applicability to agricultural processes, be largely influenced by background data, or show high correlation with other categories.

To support transparent communication and focused interpretation, three priority levels have been defined for the impact categories, as presented in Table 2-3 below.

Table 2-3: Classification of Impact Categories in this LCA Study

Priority Level	Purpose	Presentation Format
Key Impact Categories	Core environmental indicators; central to the interpretation and conclusions.	Full LCIA results in main body of the report, contribution analysis included, detailed interpretation
Supplementary Impact Categories	Provide additional context and transparency; to complete HIGG MSI indicator dataset	Detailed LCIA results in annex incl. contribution analysis, brief interpretation summary
Complete EF 3.1 Impact Set	Ensure methodological compliance and transparency.	Summary table in annex, no contribution analysis or interpretation

Table 2-4 lists the key impact categories that are included in the main body of the report. These categories are considered most relevant for interpreting the environmental performance of cotton cultivation. It should be noted that blue water consumption (included in key impact categories) and nitrogen balance (supplementary impact category), are in a strict sense inventory-level indicators. However, they are included under results because they are generated during the impact assessment phase rather than being directly collected as input data, and these indicators provide valuable interpretive context for the impact assessment categories that directly depend on them, namely climate change, eutrophication, and acidification in the case of nitrogen balance, and water scarcity in the case of blue water consumption.

Table 2-4: Key impact categories (included in main body of the report)

Impact Category	Description	Unit	Method
Climate change (global warming potential)	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare.	kg CO_2 equivalent	IPCC AR6 (EF 3.1)
Eutrophication (terrestrial, fresh-water, marine)	Eutrophication covers all potential impacts of excessive levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.	kg phosphate equivalent	CML 2016 (HIGG MSI)
Blue Water Consumption	A measure of water withdrawn from a watershed that is not returned (e.g. evaporation, or incorporation into the product). This is not an indicator of environmental impact without the addition of information about regional water availability (i.e., water use, see Table 2-5)[2].	kg of water	Inventory
Ecotoxicity	A measure of toxic emissions which are directly harmful to the health of the environment.	Comparative toxic units (CTUe)	EF 3.1 (ecotoxicity)

2 Note: This impact category typically reflects irrigation water consumption. Since Tanzania CmiA Organic production is fully rainfed, only contributions from background processes are captured in this impact category (seed provision, fuel provision, energy provision at ginnery).

Table 2-5 lists the Supplementary Impact Categories, which are included in the Annex B to provide additional context and transparency, and to ensure completeness of the Higg MSI indicator dataset.

Table 2-5: Supplementary impact categories (detailed assessment in the Annex)

Impact Category	Description	Unit	Method
N Balance	Calculated as the difference between total nitrogen applied (via fertilizers) and the nitrogen taken up by the crop. The result may be a surplus or a deficit.	kg N per ha	Inventory
Acidification Potential	A measure of emissions that cause acidifying effects to the environment. The acidification potential (AP) is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.	moles H^+ equivalent	EF 3.1
Abiotic Resource Depletion (fossil)	Abiotic Depletion Potential (ADP) is a measure for the use of non-renewable energy carriers, comparable to the Cumulative Energy Demand (CED) of fossil fuels	MJ	CML 2016 (HIGG MSI)
Green water consumption	Green water refers to the precipitation on land that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. Green water consumption refers to the actual evaporation from green water resources.	m^3	Inventory[3]
Water resources depletion/scarcity	An assessment of the potential to deprive other users of water, calculated as blue water consumption multiplied with regional characterization factors (AWARE). It accounts for the net intake and release of freshwater across the product system, while considering differences in water availability between regions. It should be noted that AWARE is not a direct scarcity metric, but a measure of potential user deprivation.	m^3 world equivalent	EF 3.1 (water use), based on AWARE characterization factors
Land occupation	The amount of land occupied for a certain time period to produce a product.	ha*year	Inventory

It should be noted that the above impact categories represent impact potentials, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) actually follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the functional unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks. No grouping or further quantitative cross-category weighting is applied.

Textile Exchange's "LCA+" approach

In its Climate+ strategy, Textile Exchange identifies climate change as a priority impact area to be

3 Green water consumption is usually not measured. These values are therefore always modelled, with a lot of uncertainty. University of Twente has published updated dataset on water use for important crops with global coverage (Mialyk et al., 2023). Their crop and country-specific green water consumption values are multiplied with the respective crop yields in this study, not differentiating crop systems.

addressed by the organization while recognizing other interdependent areas such as biodiversity, soil health, and social aspects. The term LCA+ refers to Textile Exchange's broader approach to using life cycle impact data within the framework of the Climate+ strategy. As part of the full TE Cotton LCA study, three additional assessment dimensions are included beyond the core life cycle impact categories: soil health, biodiversity, and social aspects (human rights). These are designed as high-level screening assessments that complement the standardized LCA results.

The biodiversity and social assessments were not differentiated in detail by country or cultivation system in the TE Cotton LCA and are therefore excluded from this summary report. It should also be noted that AbTF conducts its own extensive social impact assessments, which go far beyond the screening-level evaluation provided in the TE Cotton LCA. However, results from the soil health assessment (using soil organic carbon as a proxy indicator) as conducted in the TE Cotton LCA for Tanzania are included in the scenario analysis presented in this summary report (see section 4.2.10).

2.8 TYPE AND FORMAT OF THE REPORT

In accordance with requirements of ISO 14044 (ISO, 2006) this document aims to report the results and conclusions of the LCA completely, accurately, and without bias to the intended audience. The results, data, methods, assumptions and limitations are presented in a transparent manner and in sufficient detail to convey the complexities, limitations, and trade-offs inherent in the LCA to the reader. This allows the results to be interpreted and used in a manner consistent with the goals of the study.

2.9 SOFTWARE AND DATABASE

The LCA models of the TE Cotton LCA were created using Sphera's LCA FE Software system for life cycle engineering, developed by Sphera Solutions Inc. Sphera's MLC LCI database (Version 2025.1) provides the life cycle inventory data for several of the raw and process materials relevant for the background system.

2.10 CRITICAL REVIEW

The TE Cotton LCA was critically reviewed by a panel of four reviewers. In addition, an expert group was installed to guide and supervise the project, named the technical working group. The goal of the technical working group was to provide additional expertise, especially regarding regional specific aspects, to review data and methodological approaches. Please refer to the TE Cotton LCA report for further details (TE Cotton LCA, section 3.9).

The scope of the TE Cotton LCA includes the provision of supplier-specific results to data contributors such as AbTF. However, the supplier-specific datasets are not covered by the critical review of the overall TE Cotton LCA and therefore require an additional review if published independently. For this reason, the Tanzania Summary LCA undergoes a separate, independent review to ensure compliance with ISO 14044. Given the limited scope of this report, which focuses on a single country dataset, makes no comparative assertions, and relies entirely on the data and results from the TE Cotton LCA, a streamlined review procedure is applied. In accordance with ISO 14044, this review is conducted by an individual expert rather than a multi-member panel. The objective of this review is to confirm the correct interpretation and presentation of Tanzania-specific results in line with the scope and intent of the parent study, rather than to re-evaluate the underlying modeling or methodology. The review is conducted by Dr. Ulrike Eberle, the formal review statement is provided in the Annex A of this report.

3. LIFE CYCLE INVENTORY ANALYSIS

3.1 DATA COLLECTION PROCEDURE

Farm-level inventory data for the Tanzania CmiA Organic system were collected from two cotton companies participating as data providers in the Textile Exchange Cotton LCA: Alliance Ginneries and Biosustain. The Alliance Ginneries data represent the Bariadi region, while Biosustain covers the Singida region, located in central and northwestern Tanzania. For each company, data was collected across three consecutive cultivation years (2021, 2022, and 2023), to minimize the influence of interannual variability, reported values were averaged across the three years for each company. The Tanzania country average dataset was subsequently calculated as a weighted average of the two company datasets. Weighting was based on the respective production volumes, derived from the product of yield and cultivated area per company. The collected data represents the full production volume, since information was obtained from all farmers participating in the program and no sampling was applied. Across the three reporting years, the average cultivated area was approximately 19,400 hectares, and the average annual production volume was about 13,900 tonnes.

3.2 COTTON CULTIVATION INVENTORY DATA

Table 3-1 provides the inventory data for the Tanzania CmiA Organic cotton cultivation system.

Table 3-1: Inventory data cotton cultivation Tanzania CmiA organic

Inventory data	Unit	Tanzania CmiA Organic
Yield (seed cotton)	[kg/ha]	716
Mineral fertilizer		
Not applicable		
Organic fertilizer		
FYM (as total N)	[kg/ha]	28.3 [1)]
Other (at total N)	[kg/ha]	0.0
Total amount of nutrients applied		
N	[kg/ha]	28.3
P2O5	[kg/ha]	14.1
K2O	[kg/ha]	n.a. [5)]
Pesticide use		
Total amount (full list of ai applied provided in Annex L)	[kg ai/ha]	Biopesticides (see section 3.4)
Irrigation		
Irrigation applied	[m³/ha]	0.0 [2)]
Diesel use irrigation	[kg/ha]	0.0
Electricity use irrigation	[MJ/ha]	0.0

Machinery		
Diesel use tractor (excl. irrigation)	[l/ha]	7.3 3)
Gin		
Distance to ginnery	[km]	61.8
Energy use	[MJ/1000 kg raw cotton input]	293.7 4)
Lint output	[kg/1000 kg raw cotton input]	391.6
Seed output	[kg/1000 kg raw cotton input]	572.9

1) Organic fertilizer input estimated based on N uptake of crop (see section 3.3 below)
2) Rainfed
3) Secondary data (see section 3.3 below)
4) Secondary data (Cascale Cotton LCA methodology, see section 3.3 below)
5) n.a. = not applicable; K_2O content of organic fertilizer is not inventoried as it is not considered in any of the environmental impact assessment pathways used in this study.

3.3 DATA GAPS AND USE OF SECONDARY DATA

For the following inventory parameters, proxy values and secondary data were used either to fill data gaps, to account for uncertainty (by applying conservative estimates where values were uncertain), and to ensure methodological consistency across different cultivation systems and geographies within the TE Cotton LCA study.

3.3.1 Organic fertilizer use and nitrogen inputs

Accurate N input estimates require two parameters, the application rate of organic fertilizer and its N content. For smallholder systems in Tanzania these data are difficult to obtain and not consistently recorded for CmiA Organic producers. To approximate N inputs, crop N uptake was estimated from harvested seed cotton, then adjusted for typical losses:

- Assumed mean N content of seed cotton: 3.3%
- Calculated crop N uptake: seed cotton yield × 3.3%
- Adjustment for losses and inefficiencies: plus 20%.

This proxy can be considered conservative. It assumes that the full crop N uptake, plus an additional 20%, is supplied by applied organic fertilizers. In practice, part of plant N demand may be met by soil organic matter mineralization, biological N inputs, atmospheric deposition, and residual N from previous crops within the rotation. As a high level sense check, data from the International Cotton Advisory Committee (ICAC) for conventional cotton in Tanzania indicate only about 7 kg N per hectare of applied fertilizer (ICAC, 2024). While systems are not directly comparable, this benchmark supports the view that attributing the full N uptake to applied organic inputs (28.3 kg N per ha) likely overstates direct fertilizer N additions. The uncertainty of organic nitrogen inputs is explicitly tested in a sensitivity scenario (see section 4.2.8).

3.3.2 Fuel use

Organic cotton production systems in Tanzania are characterized by low levels of mechanization, consistent with small-scale and labor-intensive farming practices. Fuel use in these systems is therefore expected to be low to negligible. However, increasing levels of mechanization have been reported for Tanzanian agriculture in general (based on FAO STAT energy use in agriculture data (FAOSTAT, 2025)), and the TE Cotton LCA aimed to apply conservative assumptions where primary data were uncertain.

Fuel consumption was therefore estimated using fuel use reference values and country specific FAO data on agricultural energy intensity, as described in Sphera's Agricultural Model documentation (Sphera Solutions Inc., 2024). The resulting estimate of approximately 7 liters of fuel per hectare is low and consistent with the expectation of minimal mechanization, yet it represents a conservative assumption to ensure that potential fuel-related impacts are not underestimated.

3.3.3 Biopesticides

In the TE Cotton LCA study, biopesticide use was covered in the primary data collection; however, farmer responses were predominantly qualitative (i.e., descriptions of what products were used) rather than quantitative, which made it difficult to derive robust application rates. To avoid a complete cut-off, biopesticide use was included using proxy data. For cases where plant extracts such as neem were explicitly mentioned, where generic plant extracts were referenced (as in the case of Tanzania), or where pesticide use details were otherwise unspecified, a proxy seasonal application rate of 0.032 kg active ingredient per hectare of azadirachtin (active ingredient from neem extract) was applied. This value represents a medium-use assumption within label-consistent ranges for soluble neem formulations (US EPA, 2020). For Tanzania, the proxy rate was reduced by 50% to reflect the low-yield, low-input characteristics of the system.

3.3.4 Land use change (LUC)

Assessment of land use change (LUC) is included in the study. Ideally, this involves the collection of primary data on historical land use at farm level to identify any direct land use change (dLUC) that may have occurred within the past 20 years. No data provider explicitly reported LUC associated with their cotton production systems. However, verification of actual LUC impacts was not possible, and some uncertainty remains in this regard. A screening of statistical LUC (sLUC) was conducted as part of the TE Cotton LCA study based on the approach compiled for Sphera's Agricultural LCA Model (Sphera Solutions Inc., 2024). The screening showed that country-average cotton production in Tanzania could involve potential LUC risks (sLUC >0). However, this study specifically assesses only organic cotton in Tanzania. Since the CmiA organic standard explicitly includes criteria to prevent deforestation[4], the exclusion of LUC for organic cotton from Tanzania was justified.

3.3.5 Energy use at Ginnery

While transport distance to ginnery and lint yield are based on primary data, secondary data was used for ginnery energy use based on the default energy use values provided in the Casale Cotton LCA methodology document (Cascale, 2024).

4 The CmiA Standard, Volume 4, sets land-use safeguards that restrict cotton to legally classified agricultural land and require identification and respect of protected and High Conservation Value areas, explicitly listing primary forest and intact forest landscapes. See Principle 7, indicators 7.2.1 to 7.3.2.

3.4 AGRICULTURAL LCA MODEL

Section 4.3 of the TE Cotton LCA describes the agricultural LCA model used for cotton cultivation systems and its treatment of key modeling aspects such as fertilizer emissions, organic fertilizer handling, and biogenic carbon accounting. The study applies Sphera's Agricultural LCA Model (Sphera Solutions Inc., 2024), which is based on IPCC (2019) guidelines for agricultural emissions and aligned with the Cascale Cotton LCA methodology. The following table provides a summary, please refer to the full TE Cotton LCA and Sphera's Agricultural LCA Model documentation for details.

Table 3-2: Agricultural LCA Model: approach and documentation

Module	Approach	Documentation (Sphera Solutions Inc., 2024).
Fertilizer and pesticide production	Based on fertilizer and pesticide production datasets from LCA FE database (nearest available country proxy is used)	Part 1, Annex 4 (datasets) Part 2 Annex A (country proxies)
Provision of diesel and electricity	Based on energy provision datasets from LCA FE database	Part 1, Annex 4
Emissions from combustion of biomass[5]	Not applicable for Tanzania CmiA Organic	Part 1, 3.3
Gaseous emissions from fertilizer application	Based on emission factors provided in 2019 IPCC guidelines (Aggregated for N_2O, disaggregated for NH3).	Part 1, 3.1.1, see also section 4.3.2 of TE Cotton LCA
Nitrate emissions	Based on emission factors provided in 2019 IPCC guidelines	Part 1, 3.1.1; see also section 4.3.2 of TE Cotton LCA
Emissions from crop residues	Based on approach provided in 2019 IPCC guidelines	Part 1, 3.1.2
Emissions from soil erosion	Based on data from Global Soil Erosion Modeling platform (GloSEM) and default nutrient content in soil, reduced erosion rates considered based on management practices (see Annex H of TE Cotton LCA).	Part 1, 3.1.3 (approach) Part 3.3.3 (data)
Emission from tractor use and transport	Based on tractor and truck model in Sphera's LCA database	Part 1, 3.6
Pesticide emissions	Default emission factors from the PEF method have been applied (European Commission, 2017), i.e. 90% to soil, 9% to air, 1% to fresh water.	Part 1, 3.2
Emissions from LUC	Excluded for Tanzania CmiA Organic (see section 3.3.4 of this report).	
Irrigation	Not applicable for Tanzania CmiA Organic	Not applicable

5 Based on the data collected, this module was only used in the TE Cotton LCA for India country average based on ICAC data on the fraction of farmers that burn cotton stalks in the field (ICAC, 2024)- use of cotton stalk residues

Ginning	Additional module added to the Agricultural LCA model. Based on data collected on energy consumption, seed-to-lint ratios, typical transport distances and prices for allocation[6].	See section 3.1 of this report

Provision impacts of organic fertilizer

Organic fertilizers, mainly farmyard manure (FYM) and compost, are included in the inventory wherever applied. Following FAO LEAP guidance (FAO, 2016) and the Cascale Cotton LCA methodology, they are treated as residual products, meaning they enter the crop system without upstream burdens from livestock or waste management. Only emissions from their application (N_2O, NH_3, and nitrate leaching) are included in the baseline scenario. A scenario analysis (section 4.2.6) tests the sensitivity of results to the inclusion of provision burdens.

Biogenic carbon in the product

Biogenic carbon flows are modeled according to the Textile Exchange Biogenic Carbon Guideline (Textile Exchange, 2024a). The carbon content of cotton fiber is inventoried but the temporary uptake of CO_2 during growth is not credited in the results, since cotton is a short-lived product and its carbon is re-emitted at end-of-life. This static 0/0 accounting approach, consistent with PEF methodology, avoids assigning negative emissions in cradle-to-gate boundaries. Supplementary results including biogenic carbon uptake are provided separately to support transparency and allow compatibility with cradle-to-grave studies. Dynamic LCA methods that account for temporary storage were acknowledged as conceptually relevant but not applied, as they are not yet permitted under current ISO and PEF frameworks.

3.5 BACKGROUND DATA

Since no mineral fertilizers are used in the Tanzania CmiA Organic Cotton cultivation system, only a limited set of background data is applicable to the product model. The most relevant is energy use at ginnery, where for Tanzania, a grid mix specific for Africa (Regions of Africa, RAF) was used. Additional background datasets refer to a pesticide production (used as a proxy to estimate production impacts from biopesticide) and a diesel provision dataset (India used as proxy for RAF). Background datasets are used from Sphera's MLC LCI database (Version 2025.1), documentation for all datasets can be found online (Sphera Solutions Inc., 2025). All background datasets used for Tanzania CmiA Organic can be found in Table 3-3 below.

Table 3-3: Background datasets used

Region	Dataset name	Object group	Dataset - ID
RAF	Electricity, medium voltage, consumption mix	Electricity grid mix 1kV-60kV	{224fc9a9-6595-4aaa-b644-93e912055195}
GLO	Pesticide (average)	Pesticides	{e2ae08d0-05cf-4b2a-a334-e8b42b796b3d}
IN	Diesel mix at filling station	Filling station	{6c2c293e-ee47-4383-a385-c80f7f7d8bde}

6 See section 2.6 on allocation at the ginnery.

4 RESULTS

4.1 LCIA RESULTS FOR KEY IMPACT CATEGORIES

This chapter contains the life cycle impact assessment (LCIA) results for the key impact categories defined in section 2.7. Please refer to this section for an overview of the key impact categories selected for inclusion in the main report, along with the rationale for their selection. In addition, supplementary impact categories are presented in Annex B. Table 4-1 provides the definitions used for the contribution analyses in cotton cultivation results.

Table 4-1: Contribution analyses used in cotton cultivation results.

Contribution	Definition
Biomass combustion*	Emissions related to the combustion of biomass after cultivation to clear the field
Crop protection	Emissions related to production and application of crop protection agents
Field	Emissions from agricultural soil related to fertilizer application, crop residues and soil erosion
Ginning	Impacts associated with ginning cotton
Irrigation*	Water used in irrigation, Energy consumption from pumps, includes impacts of provision of energy and combustion emissions (in case of diesel pumps)
LUC*	Carbon emissions related to the conversion of forest (or other land use type) to agricultural land – if applicable; refers to direct LUC, see section 3.4 for details
Machinery	Emissions from tractor use and provision of fuel
Provision of fertilizer*	Emissions related to mineral fertilizer production (for provision impacts of organic fertilizer see section 4.2.6)
Transport to ginnery	Transport of raw cotton to the ginnery
Transport	Transport of agricultural inputs (fertilizer and pesticides) to the farm

* Fields in grey: not applicable for Tanzania CmiA Organic, but listed here for consistency with impact assessment from TE Cotton LCA

Table 4-2 presents the LCIA results for key impact categories. Context is provided in the following sections, both in reference to the parent study and specific to Tanzania.

Table 4-2: LCIA Results for Key Impact Categories for Tanzania CmiA Organic, all results per kg fiber after ginning

Impact category	**Climate change**	**Eutrophication**	**Blue water consumption**	**Ecotoxicity**
Method	**IPCC AR6 (EF 3.1)**	**CML 2016**	**Inventory**	**EF 3.1 (ecotoxicity)**
Unit	**kg CO_2 eq.**	**kg phosphate eq.**	**kg**	**CTUe**
Biomass combustion	0.00	0.00	0.00	0.00
Crop protection	0.001	0.00	0.01	11.32
Field	0.59	0.03	1.00 [1)]	9.27
Ginning	0.20	0.00	0.96	0.58
Irrigation	0.00	0.00	0.00	0.00
LUC	0.00	0.00	0.00	0.00
Machinery	0.08	0.00	0.04	1.36
Provision of fertilizer	0.00	0.00	0.00	0.02
Transport to ginnery	0.02	0.00	0.01	0.28
Transport	0.00	0.00	0.00	0.02
Total	0.89	0.03	2.02	22.85

1) Contribution from field caused by seed provision process which is included in this category

First, some generic context from the TE Cotton LCA is provided to better understand the results. The primary hotspot in impacts across all cultivation systems in all countries assessed in the TE Cotton LCA (except Brazil country average) is field emissions[7], which are influenced by the nitrogen balance (see Annex B) resulting from fertilizer application in each system. The impacts are also strongly influenced by fertilizer provision. For mineral fertilizers, the upstream provision processes contribute substantially to overall impacts. Organic fertilizers are considered residues or by-products of other systems, and their provision is typically not allocated to the cultivation system under study, i.e. their upstream burdens are excluded (inclusion of these burdens is assessed in a scenario, section 4.2.6). In consequence, both differences in nitrogen application rates, and fertilizer types (mineral or organic), lead to distinct profiles of climate change impacts. An additional hotspot observed for other cultivation systems in the TE Cotton LCA is irrigation energy use, which depends on several factors including the intensity of irrigation water application, the irrigation technique applied, and local conditions such as groundwater table depth. For orientation, the TE Cotton LCA reported values span from 0.44 to 4.17 kg CO_2 eq per kilogram of fiber for climate change, from 0.010 to 0.054 kg phosphate eq for eutrophication, from 2.0 to 4453.4 kg for blue water consumption, and from 3.4 to 2826.8 CTUe for ecotoxicity. The Tanzania CmiA Organic results within these respective global ranges are 0.89 kg CO_2 eq, 0.029 kg phosphate eq, 2.0 kg of blue water consumption,

7 Field emissions comprise releases to air and water that originate directly from agricultural soils due to nutrient inputs and soil dynamics. They include direct and indirect emissions from fertilizer application, such as nitrous oxide from microbial nitrogen turnover, ammonia volatilization, nitrate leaching and carbon dioxide from urea or lime (the latter not applicable for Tanzania CmiA Organic). Additional nitrogenous emissions arise from the mineralization of crop residues. Soil erosion mobilizes nutrient containing particles that can enter surface water bodies and contribute to off field nutrient loads. In the context of climate change impacts field emissions mainly refer to the release of nitrous oxide (N_2O). Nitrous oxide is a potent greenhouse gas (GHG), approximately 273 times more powerful than carbon dioxide (CO_2) over a 100-year time horizon (IPCC AR6, 2021), and agricultural soils represent one of the largest sources of anthropogenic N_2O emissions globally.

and 22.9 CTUe of ecotoxicity. These global ranges are provided solely as background information to illustrate the variability represented in the TE Cotton LCA and are not intended as a basis for comparison (see section 2.2).

In line with these findings, Tanzania is characterized by low intensity, with a relatively low yield, but also minimal fertilizer application (no mineral fertilizer), and no irrigation. Therefore, many of the hotspots identified for other cultivation systems do not apply for Tanzania CmiA Organic, leading to a relatively low overall carbon footprint. Field emissions (see footnote 7) are the most relevant hotspot for Tanzania CmiA Organic as well, followed by energy use at the ginnery (see also scenario on renewable energy use at ginnery in section 4.2.9).

Field emissions are the dominant source of **eutrophication impacts** as well. Eutrophication impacts are primarily driven by the nitrogen balance (see Annex B), which reflects the relationship between fertilizer inputs and crop yield. A higher nitrogen surplus leads to greater emissions of nitrogen compounds to soil, air, and water, resulting in increased eutrophication impacts. While nitrogen emissions, particularly nitrate leaching and ammonia volatilization, are the primary drivers of eutrophication in most systems analyzed, phosphorus emissions are also included in the assessment. Phosphorus contributions to eutrophication potential are modeled via two main pathways: leaching of soluble phosphate compounds, and surface run-off and soil erosion, which can transport particulate-bound phosphorus into adjacent water bodies. Yield also plays a key role in scaling the impacts: higher yields reduce the eutrophication impact per kilogram of fiber by distributing fixed field emissions over a greater amount of product. Similarly, lower land use per unit of product can reduce soil erosion-related eutrophication impacts, which are primarily area-dependent. While more intensive farming could theoretically increase soil disturbance and erosion risks locally, the baseline assumption is that agricultural activity always leads to some degree of soil erosion compared to undisturbed land. In the TE Cotton LCA study, erosion mitigation measures were included where applicable, as detailed in Annex H of the TE Cotton LCA. Erosion-related impacts are modeled per unit of cultivated area and are then expressed per functional unit. Systems with lower yields require more land area to produce one kilogram of fiber. As a result, systems of this type, including Tanzania CmiA Organic, show higher erosion-related impacts when expressed per kilogram of fiber.

It should be noted that nitrate leaching is influenced by many factors (e.g., soil type, precipitation, and timing of application). A detailed assessment is highly complex and lies beyond the scope of the TE Cotton LCA study. In the baseline setting, a fixed emission factor of 24% of all nitrogen applied is used, in accordance with the IPCC guidelines (IPCC, 2019) (see also scenario on emission modelling in section 4.2.7). However, this assumption does not necessarily hold under all conditions, particularly in arid regions (ibid). Moreover, nitrate leaching is also influenced by the total nitrogen surplus, which is not captured when using the fixed IPCC emission factor. For systems with a small surplus close to a closed nitrogen balance, the fixed factor may therefore overestimate emissions.

Even though the organic cotton cultivation system in Tanzania has low nutrient input (the organic fertilizer input was estimated based on the crop N uptake), there will always be some baseline emissions associated with these systems which are scaled by the area use and yield values per kilogram of fiber production. Since cotton yields in Tanzania are relatively low, the land area required per kilogram of fiber (land use) is high. As discussed above, larger cultivated areas can lead to greater soil erosion-related impacts, which can contribute to eutrophication through the runoff of soil particles and associated nutrients. This mechanism is consistent with the findings from the CmiA Cotton LCA study, where erosion-driven eutrophication impacts were similarly assessed under conditions of low yields and high area use (Aid by Trade Foundation, 2021).

The organic cotton cultivation system is rainfed in Tanzania (with only marginal contribution from background processes), resulting in negligible **blue water consumption impacts**.

Pesticide use is typically the dominant contributor to freshwater ecotoxicity in systems where synthetic pesticides are applied, as outlined in the previous section. In the case of Tanzania CmiA Organic, overall ecotoxicity results are low. Impacts reported under "crop protection" for Tanzania CmiA Organic refer to the use of biopesticides, please refer to section 3.3.3 on the use of proxy data to consider the potential impact of biopesticides. Biopesticide use accounts for slightly more than half of the modeled toxicity impact. The remaining contribution originates primarily from field emissions, which include heavy metal releases associated with soil erosion[8]. It should be emphasized that toxicity-related results carry substantial uncertainty (both on inventory level and impact assessment level, see section 5.2.5 of the TE Cotton LCA study).

4.2 SCENARIO ANALYSIS

The TE Cotton LCA includes an extensive scenario analysis to assess the influence of various modeling choices and data uncertainties on the results. In line with the scope of this summary report, the scenarios are not described in full detail here; readers should refer to the original TE Cotton LCA study for detailed descriptions of the underlying assumptions and scenario setups. This section provides only a brief overview and highlights findings specific to Tanzania CmiA Organic. It should also be noted that only the scenarios with highest relevance to the Tanzania Organic cultivation system are summarized, i.e. a scenario assessing potential impacts of organic fertilizer provision, a scenario reviewing different emission factors used in field emission modelling, a scenario investigating the N input with organic fertilizer, and a scenario assessing the reduction potential of renewable energy at ginnery. An assessment of soil carbon sequestration is included here as well though in the TE Cotton LCA study, it is provided in a separate section as part of the LCA+ assessments. Scenarios discuss both main impact categories and additional impact categories as defined in Table 2-3, the baseline results for the additional impact categories are provided in Annex B.

The discuss the ranges of the scenarios in this study, the following definitions are used, based on the divergane from the baseline[9]:

- Moderate: up to +/- 15% divergence
- Medium: between +/- 15% and +/-30% divergence
- Large: between +/- 30% and +/-50% divergence
- Very large: larger than +/- 50% divergence

4.2.6 Organic fertilizer provision impacts

Scope and rationale:

In the baseline of the TE Cotton LCA, organic fertilizers, farmyard manure (FYM) and compost, are modeled as residuals without upstream provision burdens, consistent with Cascale Cotton LCA guidance (Cascale, 2024). Because this assumption is influential, the study explores scenarios that attributes upstream impacts to organic fertilizer provision. FYM burdens are linked to animal liveweight using a simplified allocation of 10% of the animal system to manure, while compost burdens apply IPCC default methane and nitrous oxide factors to the input mass with full allocation to the

8 These emissions are linked to default heavy metal concentrations in agricultural soils as represented in the Sphera agricultural LCA model (Sphera Solutions Inc., 2024) .

9 There are no universally established thresholds for defining what constitutes a small, moderate, or large difference in LCA results. A robust assessment would require statistical testing based on the variability of the input data, which is often not available in LCA studies and was beyond the scope of this study that relies on illustrative data. The indicative ranges applied here are based on expert judgment and prior experience from comparing datasets across different LCI databases. They should not be considered definitive or authoritative but rather serve to support consistent interpretation of relative differences within this study.

compost output. The intent is to estimate a plausible magnitude, not to provide location specific exact values.

Findings for Tanzania CmiA Organic:

- Tanzania CmiA Organic applies only animal derived organic fertilizer. FYM as total N averages 28.3 kg N per hectare. No compost use is reported in the cultivation inventory.
- Results attributing upstream impacts to FYM (compost not applicable for Tanzania as stated above):
- Climate change increases from 0.89 to 1.07 kg CO_2 eq per kg fiber, approximately +20%.
- All other impact categories show moderate increases (Acidification +2%; Eutrophication +1%; Abiotic depletion, fossil, +12%, Freshwater ecotoxicity + 2%; blue water consumption and water use remain unchanged).
- The magnitude of change is medium in climate change and moderate elsewhere because total organic N input is low to medium and entirely FYM (allocating impacts to compost showed larger increases for other cultivation systems assessed in the TE Cotton LCA study).
- The scenario employs conservative attributions, notably a 10% allocation of animal system burdens to manure, however, actual farm level outcomes could be lower or higher, depending on FYM characteristics, animal system intensity, and site-specific storage and management practices.

4.2.7 N_2O and NO_3 emission factors, wet and dry climate

Scope and rationale:

- Baseline modeling used the IPCC Tier 1 aggregated direct N_2O emission factor of 1% of applied N (EF1), with a fixed nitrate leaching factor of 24% of applied N used for indirect emissions (FracLEACH).
  - Two sensitivity cases were tested for all cultivation systems to bound the effect of climate conditions on N emissions:
  - N2O_DRY, EF1 set to 0.5% for all N inputs, nitrate leaching factor set to 0%.
  - N2O_WET, EF1 set to 1.6% for synthetic fertilizer and 0.6% for other N inputs, nitrate leaching factor kept at 24%.
- Rationale for using the aggregated factor in the baseline is consistency with country average modeling and to avoid abrupt discontinuities at wet or dry thresholds (Tanzania CmiA Organic cotton, although rainfed, is a typical example of the complexities inherent in climate classification for the emission modelling as the regions considered in this study both boarder around the wet and dry classification). [10]

10 According to the IPCC classification, both regions fall within tropical climate zones. For tropical systems, “wet” climates are defined as having annual precipitation greater than 1000 mm, while “dry” climates fall below this threshold. Bariadi receives approximately 882 mm of rainfall annually, though localized values can slightly exceed 1000 mm, placing most of the region in the “dry” category, while some specific regions or years could bordering on “wet.” Singida receives between 645 mm and 950 mm rainfall annually, placing it in the “dry” category for tropical climates, but also bordering “wet” in some cases. This situation is a good illustration of how difficult it can be to strictly classify systems into “wet” or “dry.” Precipitation can vary significantly within a region due to local topography and climate variability, resulting in borderline or ambiguous classifications.

Findings for Tanzania CmiA Organic:

N2O_DRY scenario

- Climate change decreases from 0.89 to 0.62 kg CO_2 eq per kg fiber. This corresponds to an approximate 30% reduction relative to baseline, driven by the lower EF1 in dry conditions and the elimination of nitrate-related indirect N_2O.

- Eutrophication drops clearly as well (-32%), because the nitrate leaching factor is set to zero in dry conditions. This mechanism explains the large average reductions reported across systems, for Tanzania CmiA Organic any remaining eutrophication reflects non-nitrate sources (erosion based and phosphate leaching).

N2O_WET scenario

- Climate change decreases from 0.89 to to 0.75 kg CO_2 eq per kg fiber. This is consistent with wet-climate EF1 disaggregation that sets other N inputs to 0.6% (in contrast to mineral/synthetic fertilizer inputs), which benefits organic systems such as Tanzania CmiA Organic.

- Eutrophication remains essentially unchanged for Tanzania CmiA Organic at 0.029 kg phosphate eq per kg fiber, in line with the wet scenario retaining the 24% nitrate leaching factor used in the baseline.

- The direction and magnitude of changes for Tanzania CmiA Organic align with the fertilizer source logic embedded in the IPCC factors. Under dry conditions, setting nitrate emissions to zero leads to a pronounced eutrophication decrease and, together with the lower EF1, a notable climate change reduction. Under wet conditions, the lower EF1 applied to organic N reduces climate change relative to the aggregated baseline, while eutrophication is stable because the nitrate leaching factor does not change. These patterns are consistent across different cultivation systems assessed in the TE Cotton LCA and reinforce that the baseline aggregated factors represent a pragmatic average approach for reporting country averages.

4.2.8 Nutrient content in organic fertilizer

Scope and rationale:

Given the uncertainty of the amount of nitrogen applied with organic fertilizer (see also section 3.3 of this report), the TE Cotton LCA explores uncertainty in the nitrogen and phosphorus content of organic fertilizers through two scenarios that affect systems relying primarily on organic nutrient inputs, including organic cultivation. The cases scale the nutrient content, and therefore field-applied nutrient amounts, relative to baseline data.

- ORGFERT_200% assumes organic fertilizers contain twice the reported nutrient content, which doubles applied N and P.

- ORGFERT_50% assumes one half of the reported nutrient content, which halves applied N and P.

Findings for Tanzania CmiA Organic:

- ORGFERT_200%, relative change vs baseline:
  – Climate change: +59%
  – Acidification: +93%
  – Eutrophication: +58%

- ORGFERT_50%, relative change vs baseline:
  – Climate change: -29%
  – Acidification: -47%
  – Eutrophication: -71%

- ADP, blue water consumption and water use are not influenced

- The direction of change is consistent with emission drivers. Raising organic nutrient content raises modeled direct and indirect N emissions, which increases climate, acidification, and eutrophication impacts. Halving nutrient content has the opposite effect.

- The Tanzania CmiA Organic cultivation system is sensitive to assumptions regarding the nutrient content of organic fertilizers. The nitrogen balance (see Annex B) provides important interpretive context. At baseline, the system shows a small N surplus of about 5 kg N per hectare, indicating that it neither assumes a significant surplus nor a deficit. Under the 200% nutrient content scenario, the surplus would increase to approximately 33 kg N per hectare, which remains within a realistic range when compared to the surpluses observed for other cultivation systems in the TE Cotton LCA study. In contrast, the 50% nutrient content scenario would result in a moderate deficit of about −9.5 kg N per hectare. This value is also plausible, as such a small shortfall could reasonably be offset by other nitrogen sources, including soil organic matter mineralization, biological nitrogen fixation, atmospheric deposition, and residual nitrogen from previous crops in the rotation.

- In conclusion, given that nitrogen input values had to be estimated rather than derived directly from primary data (see section 3.3), the uncertainty in the results associated with this parameter alone should be considered to be at least ±30% for the climate change impact category, and even larger for other impact categories such as eutrophication and acidification.

4.2.9 Renewable energy at ginnery

Scope and rationale:

The scenario evaluates a full switch of ginning electricity to renewable sources. In the baseline, country specific grid mixes are applied for ginneries. In the scenario, electricity at the ginnery is modeled as 100% renewable to quantify the decarbonization potential of the post harvest step relative to the total fiber footprint.

Findings for Tanzania CmiA Organic:

- Climate change impacts decrease from a baseline of 0.89 kg CO_2 eq to 0.71 kg CO_2 eq in the scenario, corresponding to a reduction of about 0.18 kg CO_2 eq, which is 20.2%.

- Acidification impacts decline from a baseline of 0.070 moles H+ eq to 0.060 moles H+ eq, reflecting a reduction of about 14.3% .

- Eutrophication remains unchanged at 0.029 kg phosphate eq.

- For ADP fossil, the baseline value of 3.9 MJ decreases to 1.9 MJ in the scenario, representing a reduction of about 51.3%. The large percentage decrease in ADP fossil reflects the strong coupling of that indicator to fossil based electricity that is removed by the scenario.

- Blue water consumption decreases from a baseline of 2.0 kg water to 1.2 kg in the scenario, a reduction of about 40% , but the absolute change is very small because Tanzania CmiA Organic is not irrigated. The same logic applies to water use, which decreases from a baseline of 0.10 m^3 world eq to approximately 0.00 m^3 world eq after rounding.

- The parent TE Cotton LCA recommends renewable energy use at ginnery as a robust intervention to lower the carbon footprint of cotton. However, the AbTF has already investigated this option. Practical feasibility is constrained by operational conditions at ginneries. Electricity demand is high during the ginning season, which operates continuously for only three to five months per year, while electricity demand is low in the remaining months. This creates a substantial challenge for onsite renewable supply, particularly because the required storage capacity would be large and associated capital costs are considerable. In many producing regions, surplus electricity cannot be fed back into the grid, which further limits the viability of fully renewable supply. Partial substitution with renewable electricity may be possible, but it requires careful planning and does not represent a low complexity intervention from an operational perspective.

4.2.10 Soil carbon sequestration

Scope and rationale:

The TE Cotton LCA applies screening assessment that uses soil organic carbon, SOC, as a soil health proxy. The modeling follows IPCC Tier 1, assumes linear stock change over 20 years in the top 30 cm, and does not support claiming removals. A reference system is defined for every cultivation system: steady state SOC, medium carbon input intensity, full tillage. Four SOC scenarios are evaluated against this reference:

- SOC_TILLAGE: Switch from full tillage to no tillage
- SOC_INPUT_HIGH: Switching from medium organic input intensity (baseline, see above) to high carbon input intensity. This would represent the use of green manure or cover crops, but without manure applied (IPCC, 2019).
- SOC_INPUT_HIGH_WITH_MANURE: Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure (ibid).
- SOC_COMBINED: Combination of no tillage and high input with manure (best case SOC scenario).

The SOC factors are climate zone specific (detailed tables are in Annex J of the TE Cotton LCA report). It needs to be stressed again that these are indicative potentials from a Tier 1 screening assessment and must not be treated as reportable removals (limitations and the screening nature of the results are described in section 7.1 of the TE Cotton LCA report). The potentials and limitations around measuring and reporting soil carbon sequestration are discussed further and in detail in Textile Exchange's Biogenic Carbon Guideline (Textile Exchange, 2024a) and Textile Exchange's Regenerative Agriculture Landscape Analysis (Textile Exchange, 2022) and are therefore not repeated here.

Findings for Tanzania CmiA Organic:

Reference climate change result for Tanzania CmiA Organic is 0.89 kg CO_2 eq per kg fiber. Scenario values and the implied SOC credit are as follows:

- SOC_TILLAGE, switch from full till to no till
  Scenario climate change for Tanzania CmiA Organic: −1.5 kg CO_2 eq per kg fiber.
  SOC sequestration potential credited: 2.3 kg CO_2 eq per kg fiber.
  Per hectare increase: 0.2 t C per ha per year.
- SOC_INPUT_HIGH, high carbon input without manure
  Scenario climate change for Tanzania CmiA Organic: −1.9 kg CO_2 eq per kg fiber.
  SOC sequestration potential credited: 2.8 kg CO_2 eq per kg fiber.
  Per hectare increase: 1.0 t C per ha per year.
- SOC_INPUT_HIGH_WITH_MANURE, high input with regular manure
  Scenario climate change for Tanzania CmiA Organic: −10.4 kg CO_2 eq per kg fiber.

SOC sequestration potential credited: 11.3 kg CO_2 eq per kg fiber.
Per hectare increase: about 3.8 t CO_2 eq per ha per year.

- SOC_COMBINED, no till plus high input with manure
  Scenario climate change for Tanzania CmiA Organic: −12.8 kg CO_2 eq per kg fiber.
  SOC sequestration potential credited: 13.7 kg CO_2 eq per kg fiber.
  Per hectare increase: about 4.6 t CO_2 eq per ha per year.

- As expected the per kilogram reductions are large for Tanzania CmiA Organic in the manure and combined scenarios. Systems with lower yields show more pronounced per kilogram SOC credits because a larger land area is associated with the same fiber output. In needs to be stressed again that these are indicative potentials from a Tier 1 screening assessment and must not be treated as reportable removals (see above).

- It should also be noted that the removal potentials are assessed relative to a "counterfactual baseline"[11], that is, a hypothetical scenario assuming full tillage and no application of organic fertilizer. Since the cultivation system assessed reportedly practices reduced or no tillage[12] and the use of organic fertilizers over an extended period, the actual removal potential is likely to be considerably smaller in reality. It should also be noted that the IPCC Tier 1 approach assumes that carbon sequestration potentials apply for a period of 20 years, after which it is assumed that a new equilibrium is reached. Please refer to the discussion in the TE Cotton LCA (TE Cotton LCA, section 7.1) for a detailed discussion of limitations of the screening assessment.

4.2.11 Sensitivity analysis and uncertainty assessment

In a strict methodological sense, scenario analysis, sensitivity analysis, and uncertainty analysis are distinct approaches within life cycle assessment, each with its own objectives and techniques[13]. However, there is also conceptual and practical overlap between these methods, particularly in how they can be applied to explore variability and assess the robustness of results. In the TE Cotton LCA, and therefore in this summary study as well, the primary focus is on scenario analysis, as it was considered the most appropriate and transparent approach for addressing both uncertainty and sensitivity (interpreted here in a broader sense) in many of the cases examined.

Referring to sensitivity analysis specifically, the model used to assess cotton cultivation related impacts is mainly based on linear relationships. This, combined with the detailed contribution analysis provided, allows for a straightforward assessment of sensitivity, showing how changes in inputs affect specific emission categories. Since results are expressed per kilogram of product, increasing yields result in lower emissions per kilogram of fiber. These relationships are directly proportional. Similarly, changes in allocation have a one-to-one effect on results: if the allocation to seeds increases by 5%, the emissions assigned to lint will decrease by the same amount. These straightforward relationships can assist in interpreting the variability and uncertainty of the results.

A common approach to addressing statistical uncertainty is through Monte Carlo simulation, which can yield a distribution of possible outcomes for environmental impacts. However, given the complex nature of the TE Cotton LCA, including multiple cultivation systems across different countries, the interrelated nature of many variables and input parameters, and missing data on input variable distribution, a full Monte Carlo analysis was deemed beyond the scope of the parent study and this summary study.

11 A counterfactual baseline is the hypothetical scenario describing what would have occurred in the absence of a specific intervention (project, program or certification activity). It represents the "business-as-usual" or no-intervention trajectory against which impacts (such as emission reductions or removals) are measured (GHG Protocol, 2023).
12 Reported average adoption rate for reduced tillage for Tanzania CmiA Organic was 61%.
13 Scenario analysis is performed to compare results between different sets of assumptions or modelling choices. Sensitivity analyses are performed to test the sensitivity of the results towards changes in parameter values that are based on assumptions or otherwise uncertain. Uncertainty analysis is performed to test the robustness of the results towards the combined parameter uncertainty.

5 INTERPRETATION

5.1 IDENTIFICATION OF RELEVANT FINDINGS

The LCA of CmiA Organic cotton from Tanzania characterizes a low input, rainfed smallholder cultivation system with limited mechanization, no mineral fertilizer input and no irrigation. These characteristics shape the environmental profile across all impact categories and determine the main environmental hotspots identified for the system.

Field emissions represent the dominant source of impacts for the climate change and eutrophication categories. They are mainly driven by nitrogen-related emissions (N_2O, NO_3^-, and NH_3) resulting from the application of farmyard manure (FYM). Although absolute nitrogen inputs and per ha emissions are low, emissions per kilogram of lint are elevated due to low yields and the correspondingly high land requirement per unit of product. However, the absence of mineral fertilizers and irrigation results in no impacts associated with fertilizer production and water consumption. Consequently, several hotspots common to more intensive cotton cultivation systems are not applicable to CmiA Organic cotton from Tanzania.

Remaining uncertainties primarily relate to the nutrient content and application rates of organic fertilizers, the provision impacts of these inputs, and the emission factors used in the modeling of field emissions. These uncertainties were tested through scenario analysis and were found to have a significant influence (differences of 20% or more) on results for climate change and several other impact categories. Absolute values reported here should therefore be interpreted with caution. However, it should also be noted that conservative estimates were applied where data gaps occurred, and that the direction of uncertainty is generally two-sided, meaning actual results could be either higher or lower than those reported.

Energy use at the ginnery constitutes the second most relevant hotspot for the Tanzanian system, as the use of grid electricity based on fossil sources results in notable contributions to the carbon footprint and abiotic resource depletion. Scenario analysis indicates that switching to renewable electricity at the ginnery could reduce total greenhouse gas emissions of Tanzania CmiA Organic cotton by about 20%.

Crop protection contributes to freshwater ecotoxicity. These impacts are almost entirely related to the assumed use of biopesticides, which were included in the model through proxy data. While this approach ensures completeness, the related uncertainty is high because the toxicity characterization factors for biopesticides are not well established.

A screening assessment of soil carbon sequestration potential suggests that practices combining reduced or no tillage with the regular application of organic amendments could enhance soil organic carbon stocks. However, these results represent an indicative potential relative to a counterfactual baseline with full tillage and no organic fertilizer use. They must not be interpreted as reportable removals, as the actual incremental benefit is likely to be smaller in practice.

5.2 ASSUMPTIONS AND LIMITATIONS

In this section, limitations specific to the Tanzania CmiA Organic cotton dataset are discussed. For a more general discussion of the limitations related to the underlying cotton LCA methodology, please refer to the full study and Textile Exchange's *Integrity in Use of LCA* paper (Textile Exchange, 2025).

- Field emissions of nitrogen compounds (N_2O, NO_3^-, NH_3) are calculated using IPCC Tier 1 emission factors as applied in the agricultural LCA model applied in the TE Cotton LCA agricultural model. These factors represent global averages and may not fully capture emission dynamics under local soil, climate, or management conditions in Tanzania (see also section 4.2.7).

- Application rates and nutrient contents of organic fertilizers are based on estimates derived from crop N uptake. It is assumed that the full N requirement of the crop, plus a 20% adjustment for losses, is supplied by applied organic fertilizers. This assumption likely overestimates actual fertilizer inputs, as part of the N supply may originate from non-fertilizer N sources such as soil organic matter mineralization, biological nitrogen fixation, atmospheric deposition, and residual nitrogen from previous crops in the rotation.

- Biopesticide use was modeled using proxy application rates and active ingredient composition (azadirachtin as main active ingredient in neem extract). This ensures completeness but introduces uncertainty regarding actual toxicity profiles and related ecotoxicity impacts.

- Fuel use was estimated using secondary data on agricultural energy intensity from the Sphera Agricultural Model, supported by FAO country-level statistics. While this approach is consistent across the TE Cotton LCA, actual mechanization levels in the assessed cultivation system might vary and in fact be lower, which would translate into lower fuel related contributions to impacts where diesel use is a relevant driver.

- The energy use at ginnery was modeled using secondary data. Variation between ginneries is possible, particularly concerning energy source and efficiency, but not captured in the dataset.

- Soil carbon sequestration potentials were modeled only in the scenario analysis, not as a dynamic stock change in the base model. The results represent an indicative potential relative to a counterfactual baseline with full tillage and no organic fertilizer use, rather than measured removals.

- No economic analysis is included in the TE Cotton LCA or this summary report. Consequently, the results do not provide information on the economic performance or cost efficiency of the assessed production system. Human labor and social aspects are excluded as well from this study, which focuses solely on environmental impacts, and are addressed separately through various impact evaluation studies commissioned by AbTF. A comprehensive sustainability assessment would therefore need to integrate these additional dimensions before drawing conclusions on the overall sustainability performance of the cultivation system.

- The study assessed impact categories commonly used in LCA studies which do not fully capture potentially beneficial effects of organic cultivation systems on parameters such as soil health, biodiversity, or ecosystem resilience. These aspects are inherently difficult to quantify within standardized LCA frameworks.

- All results are expressed per kilogram of lint cotton. Given the low yield typical for smallholder organic systems, per-unit impacts are sensitive to yield variations. A change of ±10% in yield would translate into an approximately proportional change in most impact results.

5.3 DATA QUALITY ASSESSMENT

The TE Cotton LCA applies a modified Product Environmental Footprint data quality rating (DQR), adapted to reflect challenges when the default approach is applied to agricultural inventories (see section 6.3.1 of the TE Cotton LCA). For cultivation datasets, five primary inventory groups are scored for technological representativeness (TeR), temporal representativeness (TiR), precision (P), and geographical representativeness (GeR). For details including the evaluation criteria please refer to section 6.3.1 of the TE Cotton LCA. In the TE Cotton LCA overall DQR outcomes are grouped into three Data Quality Levels, DQL. Level 1 indicates good quality and fit for purpose. Level 2 indicates medium quality primary or validated secondary data. Level 3 indicates limited quality or proxy values. Most cultivation datasets fall between DQR 1.5 and 3.5. The following scores are reported for Tanzania Organic cultivation system in the TE Cotton LCA and where not recalculated for this summary (values follow the 1 to 5 scale where lower is better):

- TeR 2.5
- TiR 1.3
- P 2.1
- GeR 1.0
- DQR 1.7,
- DQL Level 1.

Strengths: Very good geographical representativeness, and strong time coverage (three years covered, although latest data is from 2023, reflected in high TiR rating); low input, low output system in general lower uncertainty of input data because of lower relevance; no irrigation

Weaknesses: organic fertilizer inputs are uncertain (typical for smallholder organic systems, reflected in lower TeR and P rating). This parameter is a known driver for N-related emissions; nutrient-related uncertainties addressed through the scenario analysis (see section 4.2.8).

5.4 RECOMMENDATIONS

To improve future data robustness and reduce key uncertainties in the impact assessment, the following areas are identified for potential improvements:

- Specific measurements of FYM application rates and nutrient content should replace proxy assumptions to better capture nitrogen-related emissions.

- More detailed records of biopesticide use, including active ingredients and application rates, should be collected to refine ecotoxicity estimates (however, this would not solve the uncertainty related to characterization of the applied biopesticides).

- Energy data from ginning operations should be metered and supported by documentation of electricity sourcing to verify the share of renewable energy and identify opportunities to further increase it.

- The potential for assessing and reporting greenhouse gas removals should be investigated further. The low-intensity, organic production system applied in Tanzania may contribute to gradual soil organic carbon (SOC) accumulation, but current uncertainties regarding appropriate quantification pathways and the definition of baselines limit the robustness of such estimates. However, in addition to soil carbon, other removal pathways such as carbon stored in on-farm biomass or through the application of biochar represent less uncertain and more directly measurable options. These should be considered for inclusion in subsequent assessments to provide a more comprehensive understanding of the removal potential within CmiA Organic cotton systems.

For interpretation and communication, results should be presented as ranges rather than point values, emphasizing sensitivities to FYM nutrient content and IPCC factor selection. The study should be used within its non-comparative scope and remain methodologically consistent with the TE Cotton LCA framework. For any cross-system or contextual interpretation, reference should be made to the TE Cotton LCA as the parent study.

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ANNEX A – REVIEW STATEMENT

CRITICAL REVIEW REPORT

The aim of a critical review is to clarify whether the LCA study meets the requirements for methodology, data, evaluation, and reporting, and whether it complies with the principles of the ISO 14040 series.

1.1 PROCEDURAL ASPECTS

The Critical Review of the study "LCA of CmiA Organic cotton from Tanzania" was commissioned by the Aid by Trade Foundation, Hamburg, Germany (thereafter referred to as AbTF) in August 2025. The LCA study was carried out by Daniel Thylmann, Berlin, Germany. The review was carried out by Dr. Ulrike Eberle, corsus-corporate sustainability GmbH, Hamburg, Germany.

Aim of the LCA study "LCA of CmiA Organic cotton from Tanzania" was to present the relevant country and system specific results from the TE Cotton LCA in a concise, accessible format for the AbTF and its stakeholders for organic cotton from Tanzania as a standalone report.

The critical review is a review by an external expert according to ISO 14040 section 7.3.2 [1] and ISO 14044 6.2 [2]. Due to the fact that no comparative assertions of different systems are included in the LCA study and due to the fact, that the study is an excerpt of a large LCA study on cotton that commissioned by Textile Exchange and already critically reviewed by a panel, this is considered sufficient. The reviewer is neutral with regard to and independent from particular commercial interests.

The review did not include an assessment of the model and calculation methods used for the life cycle inventory and impact assessment, as the study was an excerpt from a large LCA study that had already been critically reviewed by a panel. The large LCA study was carried out by the same LCA practitioner. The aim of the LCA study reviewed here was to present the results for just one country producing organic cotton according to the Cotton made in Africa (CmiA) standard by the Aid by Trade Foundation (AbTF). Thus, the review focused on the documentation of the approach of the LCA for organic cotton from Tanzania, the presentation of the results and the interpretation included in this excerpt. The large LCA study that forms the basis for the excerpt was made available to the reviewer.

The review process started with a kick-off meeting in which the LCA practitioner presented the structure of the report. In the following the LCA practitioner prepared a draft report and handed over the draft report and the large LCA study to the reviewer for reviewing on 19th November 2025. On 1st December 2025 comments were submitted to the commissioner and the practitioner. Thereafter, on 10th December 2025, the reviewer received the final draft of the LCA study report, in which the reviewer's comments on the draft report have been satisfactorily incorporated. The statement below is based on this final draft report.

The review report does not contain a description of how comments were provided, discussed, and implemented. The reviewer's comments and the author's revisions in response to them are documented in several drafts of the life cycle assessment study, but are not reproduced in detail here.

1.2 CRITICAL REVIEW STATEMENT

According to the LCA-framework standard ISO 14040 section 6.1 [1]:

“The critical review process shall ensure that:
- the methods used to carry out the LCA are consistent with the international Standard;
- the methods used to carry out the LCA are scientifically and technically valid;
- the data used are appropriate and reasonable in relation to the goal of the study;
- the interpretations reflect the limitations identified and the goal of the study;
- the study report is transparent and consistent.”

In the following sections these items are discussed to my best judgement and considering the ISO standards 14040 [1] and 14044 [2].

The study has been performed according to the international standards ISO 14040 and 14044. The methodological framework, goal and scope are described comprehensively. The life cycle inventory is presented in an understandable manner. Also the impact assessment methods applied are consistent with the ISO standards 14040 and 14044. The included impact categories and inventory level indicators are meaningful and their inclusion is explained.

The methods used are scientifically and technically state of the art. Specific data were used for the AbTF production system. The data used are already third party validated. It was not part of this critical review to check the correctness of the primary data collected. However, a cross-check of certain data did not reveal any inconsistencies compared to similar studies. All data sets used for the included unit processes are sufficiently characterised according to the system boundaries (technical, geographical and time related). Thus, the data can be seen appropriate regarding the goal of the study.

The interpretation in the report is based on the detailed data analysis performed. The interpretation is meaningful and limitations and recommendations are transparently stated. The report’s interpretation sections deal with all issues from the goal and scope sufficiently.

The report was revised in the final version according to the reviewer’s comments increasing the transparency and comprehensibility of the final report. The line of argument from inventory over impact assessment to interpretation and recommendations is transparent and comprehensible.

It can be stated that this LCA study has been conducted in accordance with the ISO 14040 and 14044 standards. It should be noted that this critical review statement is valid only for the final report as presented to the reviewer.

Hamburg, 16 December 2025; Dr. Ulrike Eberle

REFERENCES

[1] DIN EN ISO 14040:2006: Environmental management - Life cycle assessment - Principles and framework

[2] DIN EN ISO 14044:2006: Environmental management - Life cycle assessment - Requirements and guidelines

ANNEX B – ADDITIONAL IMPACT CATEGORY RESULTS

Table B-1: Additional inventory metric results

Inventory metric	Unit	TZ CmiA Organic
N balance (N input fertilizer - net crop uptake)	[kg N/ha]	4.7
Green water use	[m³/kg fiber]	19.7
Land occupation	[m²/kg fiber]	29.6

Table B-1 provides additional inventory metrics results. Strictly speaking, all three indicators belong to the inventory phase of the LCA. However, they are included under results because they are an output of the model and generated during the impact assessment phase rather than being directly collected as input data.

The nitrogen (N) balance is calculated as the difference between total nitrogen applied (via fertilizers) and the nitrogen taken up in the harvested part of the crop[14], the result may be a surplus or a deficit. It provides valuable interpretive context for the impact assessment categories that directly depend on the ratio of nitrogen application and yield, i.e. climate change, eutrophication, and acidification.

It should be noted that several nitrogen input sources are not included in this calculation. Specifically for Tanzania, potential omissions are soil organic matter mineralization, biological nitrogen fixation, atmospheric deposition, and residual nitrogen from previous crops in the rotation. In addition, as outlined in previous sections, there is considerable uncertainty regarding the nutrient content of organic fertilizers. N balance result for Tanzania's organic cotton reflects the estimated nitrogen input from organic fertilizer applications, which in this case was approximated based on expected crop nitrogen uptake. Tanzania is characterized as a low-input, low-output cotton production system, with very low fertilizer application rates, a pattern that is also supported by national statistics such as those from ICAC (ICAC, 2024). The modest nitrogen surplus is consistent with these conditions and suggests that nutrient inputs are in the best case just high enough to meet crop demand (see also scenario 4.2.8).

Green water consumption refers to the rainwater use of crops (Hoekstra, Chapagain, Aldaya, & Mekonnen, 2011). Green water consumption is usually not measured. These values are therefore always modelled, with a lot of uncertainty. University of Twente has published an updated dataset on blue and green water use for important crops with global coverage (Mialyk et al., 2023). Their country specific green water consumption values are used in this study, not differentiating crop systems. Green water use is reported to complete the water inventory; however, it is generally not interpreted as an environmental impact itself. This is because green water refers to naturally occurring rainfall, and agricultural systems typically do not alter rainfall patterns or divert rainwater from other potential uses. Consequently, rainwater falling on agricultural land is not considered an environmental burden, unlike rain falling on natural systems.

Land occupation refers to area use, i.e. is the reciprocal to the crop yield. The amount of land occupation does not include any information on the quality, intensity or impact of the land use and has therefore limited informational value with respect to environmental impacts. It is included here as it is the minimum requirement for land tracking metrics listed in the GHG Protocol Land Sector and Removals Guidance (GHG Protocol, 2022).

14 Seed cotton, assumed N content 3.3%, based on USDA. (2021). Plant Nutrient Tool.

Table B-2 LCIA Results for Additional Impact Categories for Tanzania CmiA Organic, all results per kg fiber after ginning

Impact category	Acidification	Abiotic Depletion (ADP fossil)	Water resources depletion/scarcity
Method	**EF 3.1**	**CML 2016 (Higg MSI)**	**EF 3.1 (Water use)**
Unit	**moles H+ eq.**	**MJ**	**m^3 eq.**
Biomass combustion	0	0	0
Crop protection	0	0.02	0
Field	0.06	0.1	0.02 [1)]
Ginning	0	2.45	0.04
Irrigation	0	0	0
LUC	0	0	0
Machinery	0	1.05	0
Provision of fertilizer	0	0.02	0
Transport to ginnery	0	0.22	0
Transport	0	0.01	0
Total	**0.07**	**3.87**	**0.05**

1) Contribution from field caused by seed provision process which is included in this category

Table B-2 presents LCIA Results for additional impact categories for Tanzania CmiA Organic:

- Acidification impacts are closely linked to N application and eutrophication potential, with field emissions being the primary hotspot and the main driver of differences across cultivation systems in all countries assessed in the TE Cotton LCA. This means that most of the context provided to explain eutrophication results (see section 4.1) also applies to acidification. It should also be noted that the scaling effects observed for eutrophication can also be observed for acidification. E.g. for Tanzania, acidification impacts per ha are relatively low because this is a low-intensity system with low yields and minimal fertilizer use, resulting in lower nutrient inputs. However, some baseline emissions related to the application of organic fertilizer still occur and are scaled according to the area used.

- For abiotic depletion impacts, the primary hotspot and key driver of differences in impacts across the cultivation systems assessed in the TE Cotton LCA are the provision of mineral fertilizer and irrigation impacts, based on background data (mineral fertilizer production and provision of energy). Since these impact categories both do not apply to Tanzania CmiA Organic, the results are dominated by energy use at ginnery.

- The water resources depletion impact category reflects regionalized water scarcity, calculated by multiplying blue water consumption with characterization factors derived from the AWARE method (Boulay, et al., 2017). The results are primarily driven by blue water consumption, and since cotton in Tanzania is not irrigated, the absolute value is very low and only determined by water use in background processes (generic seed provision process and energy provision at ginnery).

Table B-3 provides the results for the complete EF 3.1 impact categories. As outlined in section 2.7, it is included to ensure methodological compliance and transparency, but no contribution analysis or additional interpretation is provided.

Table B-3 EF 3.1 Impact categories

EF 3.1 Impact categories	TZ CmiA Organic
EF 3.1 Acidification [Mole of H+ eq.]	6.56E-02
EF 3.1 Climate Change - total [kg CO_2 eq.]	8.94E-01
EF 3.1 Climate Change, biogenic [kg CO_2 eq.]	1.85E-03
EF 3.1 Climate Change, fossil [kg CO_2 eq.]	8.91E-01
EF 3.1 Climate Change, land use and land use change [kg CO_2 eq.]	1.31E-03
EF 3.1 Ecotoxicity, freshwater - total [CTUe]	2.29E+01
EF 3.1 Ecotoxicity, freshwater inorganics [CTUe]	9.88E+00
EF 3.1 Ecotoxicity, freshwater organics [CTUe]	1.30E+01
EF 3.1 Eutrophication, freshwater [kg P eq.]	3.89E-03
EF 3.1 Eutrophication, marine [kg N eq.]	2.30E-02
EF 3.1 Eutrophication, terrestrial [Mole of N eq.]	2.86E-01
EF 3.1 Human toxicity, cancer - total [CTUh]	1.34E-09
EF 3.1 Human toxicity, cancer inorganics [CTUh]	3.24E-09
EF 3.1 Human toxicity, cancer organics [CTUh]	3.23E-09
EF 3.1 Human toxicity, non-cancer - total [CTUh]	9.84E-12
EF 3.1 Human toxicity, non-cancer inorganics [CTUh]	2.23E-07
EF 3.1 Human toxicity, non-cancer organics [CTUh]	2.23E-07
EF 3.1 Ionising radiation, human health [kBq U235 eq.]	2.20E-10
EF 3.1 Land Use [Pt]	1.37E+03
EF 3.1 Ozone depletion [kg CFC-11 eq.]	3.91E-13
EF 3.1 Particulate matter [Disease incidences]	4.71E-07
EF 3.1 Photochemical ozone formation, human health [kg NMVOC eq.]	2.43E-03
EF 3.1 Resource use, fossils [MJ]	4.00E+00
EF 3.1 Resource use, mineral and metals [kg Sb eq.]	4.56E-08
EF 3.1 Water use [m^3 world equiv.]	5.45E-02

ABOUT THE AID BY TRADE FOUNDATION

The Aid by Trade Foundation (AbTF) was founded in 2005 and is now an internationally renowned and active nonprofit organization for sustainable raw materials. Through its work, it makes a decisive and measurable contribution to improving the living conditions of people and animals and to protecting the environment. With its certified raw materials Cotton made in Africa (CmiA), Cotton made in Africa Organic (CmiA Organic), Regenerative Cotton Standard (RCS) and The Good Cashmere Standard (GCS), the foundation puts its goals into practice. A globally active alliance of textile companies and brands requests the certified raw materials and pays a license fee to the foundation's marketing company, ATAKORA Fördergesellschaft GmbH. This entitles the partners to market their goods with the labels of the standards. In view of the increasing challenges small-scale farmers and textile companies are facing, the standards are of fundamental importance for their resilience and future viability. The AbTF works in close cooperation with industry experts, animal welfare and nature conservation specialists.

With the Cotton made in Africa (CmiA) initiative,AbTF is putting its principles into practice. The trade partners of the CmiA Demand Alliance source African cotton produced according to the CmiA standard and pay the foundation a volume-based license fee that is reinvested in the cultivation areas. Consumers recognise products by the CmiA label and make a valuable contribution to protecting the environment and supporting smallholder farmers and their families in Africa.

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COTTON MADE IN AFRICA Organic