



Life Cycle Impact Assessment for BOODY
A Screening LCA Study of Organic Bamboo Lyocell Supply Chain

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Project Team

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Table of Contents

Goal and Scope Definition	7
Goal of the Study	8
Scope of the Study	9
Allocation	12
System Boundary.....	13
Life Cycle Inventory Analysis.....	14
Data Sources and Product Information	15
Baselining Methodology	16
Supply Chain Overview: Organic Bamboo Lyocell Apparel and Conventional Cotton Apparel.....	17
Life Cycle Impact Assessment (LCIA).....	18
Baselined LCIA Results for 100% Organic Bamboo Lyocell Apparel	19
Bystage LCIA Results for 100% Organic Bamboo Lyocell Apparel	20

Table of Contents

Life Cycle Interpretation.....	21
Key Findings.....	22
Glossary.....	23
General and Key Assumptions.....	24

List of Figures

Figure 1: Products Included in the Scope of this Study.....	9
Figure 2: General System Boundary for the Scope of this Study.....	13
Figure 3: Supply Chain Overview for Organic Bamboo Lyocell Apparel	17
Figure 4: Supply Chain Overview for Conventional Cotton Apparel	17

Table 1: Overview of Supply Chain Used in the Study.....	10
Table 2: Economic Allocation for Organic bamboo pulp production process.....	12
Table 3: LCIA Results for 100% Organic Bamboo Lyocell Apparel Baseline with 100% Conventional Cotton Apparel (SC1) (per kg apparel).....	19
Table 4: Stagewise GWP, PED, BWC Impacts for 100% Organic Bamboo Lyocell Apparel (SC1) (per kg apparel).....	20
Table 5: Waste Scenarios and Percentages for all Manufacturing Processes.....	26
Table 6: Major Upstream Aggregated Processes used in the Models for BOODY.....	27

Goal and Scope Definition

Goal of the Study

The goal of the study is to conduct a screening LCA for apparels produced by BOODY based on a cradle-to-gate approach. The term apparel include garments such as 2-Pack LYOLYTE G-String, 2-Pack LYOLYTE Hi-Cut Bikini, 2-Pack LYOLYTE Hipster Bikini, 2-Pack LYOLYTE Racerback Bra, 2-Pack LYOLYTE Triangle Bralette, LYOLYTE™ G-String, LYOLYTE™ Hi-Cut Bikini, LYOLYTE™ Hipster Bikini, LYOLYTE™ Racerback Bra, LYOLYTE™ Triangle Bralette, LYOLYTE Ribbed High Leg Brief, LYOLYTE Ribbed Low Back Bra, LYOLYTE Full Boyleg Brief, Ribbed Square Neck Bodysuit, and Ribbed Boat Neck Bodysuit. Packaging and accessories such as buttons, zippers etc. are excluded. The LCA framework used in this study is in accordance with the ISO 14040:2006 and ISO 14044:2006 standards.

The intended audience includes BOODY and its internal stakeholders. As this is a secondary data based screening LCA study, the findings of this study are intended to be used as a basis for internal communication and for an understanding on the overall impacts from BOODY supply chain by baselining it with the impacts from geographically consistent alternative fibres.

ISO 14040:2006 - Environmental management - Life cycle assessment - Principles and framework.(2006). <https://www.iso.org/standard/37456.html>. Accessed on 2022, August 18th.
ISO 14044:2006 - Environmental management - Life cycle assessment - Requirements and guidelines.(2006). <https://www.iso.org/standard/38498.html>. Accessed on 2022, August 18th.

Scope of the Study

The product categories included in the scope of the study are 2-Pack LYOLYTE G-String, 2-Pack LYOLYTE Hi-Cut Bikini, 2-Pack LYOLYTE Hipster Bikini, 2-Pack LYOLYTE Racerback Bra, 2-Pack LYOLYTE Triangle Bralette, LYOLYTE™ G-String, LYOLYTE™ Hi-Cut Bikini, LYOLYTE™ Hipster Bikini, LYOLYTE™ Racerback Bra, LYOLYTE™ Triangle Bralette, LYOLYTE Ribbed High Leg Brief, LYOLYTE Ribbed Low Back Bra, LYOLYTE Full Boyleg Brief, Ribbed Square Neck Bodysuit, and Ribbed Boat Neck Bodysuit. Part of the listed products are shown in the Figure 1.



LYOLYTE™ Racerback Bra (100% Organic Bamboo Lyocell)



Ribbed Boat Neck Bodysuit (100% Organic Bamboo Lyocell)

LYOLYTE Triangle Bralette (100% Organic Bamboo Lyocell)



LYOLYTE Full Boyleg Brief (100% Organic Bamboo Lyocell)



Figure 1: Products Included in the Scope of this Study

Scope of the Study

Product System: The product system to be studied is a finished product from cradle to factory gate processes for one supply chain.

The overview of supply chain is presented in Table 1 below.

Table 1: Overview of Supply Chain Used in the Study

Supply Chain	Fibre	Production Stages						Apparel Products Produced
		Cultivation	Fibre Production	Seamless Knitting	Dyeing and Finishing	Heat Transfer Printing	Warehouse	
Supply Chain 1	Organic Bamboo Lyocell	Gaocheng, Hebei Province, China	Gaocheng, Hebei Province, China	Fengxian District, Shanghai, China	Min Hang District, Shanghai, China	Putuo District, Shanghai, China	Sydney, Australia	2-Pack LYOLYTE G-String, 2-Pack LYOLYTE Hi-Cut Bikini, 2-Pack LYOLYTE Hipster Bikini, 2-Pack LYOLYTE Racerback Bra, 2-Pack LYOLYTE Triangle Bralette, LYOLYTE™ G-String, LYOLYTE™ Hi-Cut Bikini, LYOLYTE™ Hipster Bikini, LYOLYTE™ Racerback Bra, LYOLYTE™ Triangle Bralette, LYOLYTE Ribbed High Leg Brief, LYOLYTE Ribbed Low Back Bra, LYOLYTE Full Boyleg Brief, Ribbed Square Neck Bodysuit, and Ribbed Boat Neck Bodysuit

Scope of the Study

Product Function: The function of the product system is to produce apparels for use by consumers.

Functional Unit: The functional unit for the study is 1 kg of finished apparel produced from one supply chain as detailed in Table 1. The environmental impacts calculated in this study are relative to the functional unit.

Selection of LCIA methodologies: The life cycle inventories are analysed based on the following three impact categories chosen after discussion with BOODY. These impact categories are:

- Global Warming Potential (kg CO₂eq.)
- Primary Energy Demand (MJ)
- Blue Water Consumption (Litres)

Data Validation: No internal or external audit of resource utilization data provided by BOODY was performed by Green Story for this study. It is assumed that data provided by BOODY and its suppliers are factual and accurate.

Critical Review: No critical review has been performed for this study. This study has been peer reviewed by Green Story's LCA review team.

Allocation

The economic allocation has been applied to distribute environmental burdens between the product and co-products for pulp production process:

- Organic bamboo whole plant is made into bamboo culms, where these are dried and converted into pulp and lignin residue. The main product is Organic bamboo pulp which is produced along with residual lignin.
- Allocation factors for the pulp production process are taken from (Mirzaie, A. (2021)) and are given in Table 2 below:

Table 2: Economic Allocation for Organic bamboo pulp production process

Products	Economic Allocation (%)
Organic bamboo pulp	94%
Residual lignin	6%

System Boundary

Fibre Production: This stage covers the cultivation of organic bamboo, pulp production and its dissolution.

Yarn Production: This stage includes the spinning process such as wet spinning technique to produce yarn.

Seamless Knitting: This process includes the knitting of yarn into a fully fashioned product.

Dyeing and Finishing: This stage includes processes such as scouring, bleaching, dyeing and other related finishing processes.

Printing: This stage includes the heat transfer printing technique.

Transport: This process covers all the inter-stage transportation for the stages of production starting from raw material acquisition to the delivery of the finished apparel to the warehouse.

Excluded Stages: Use phase and end of life.

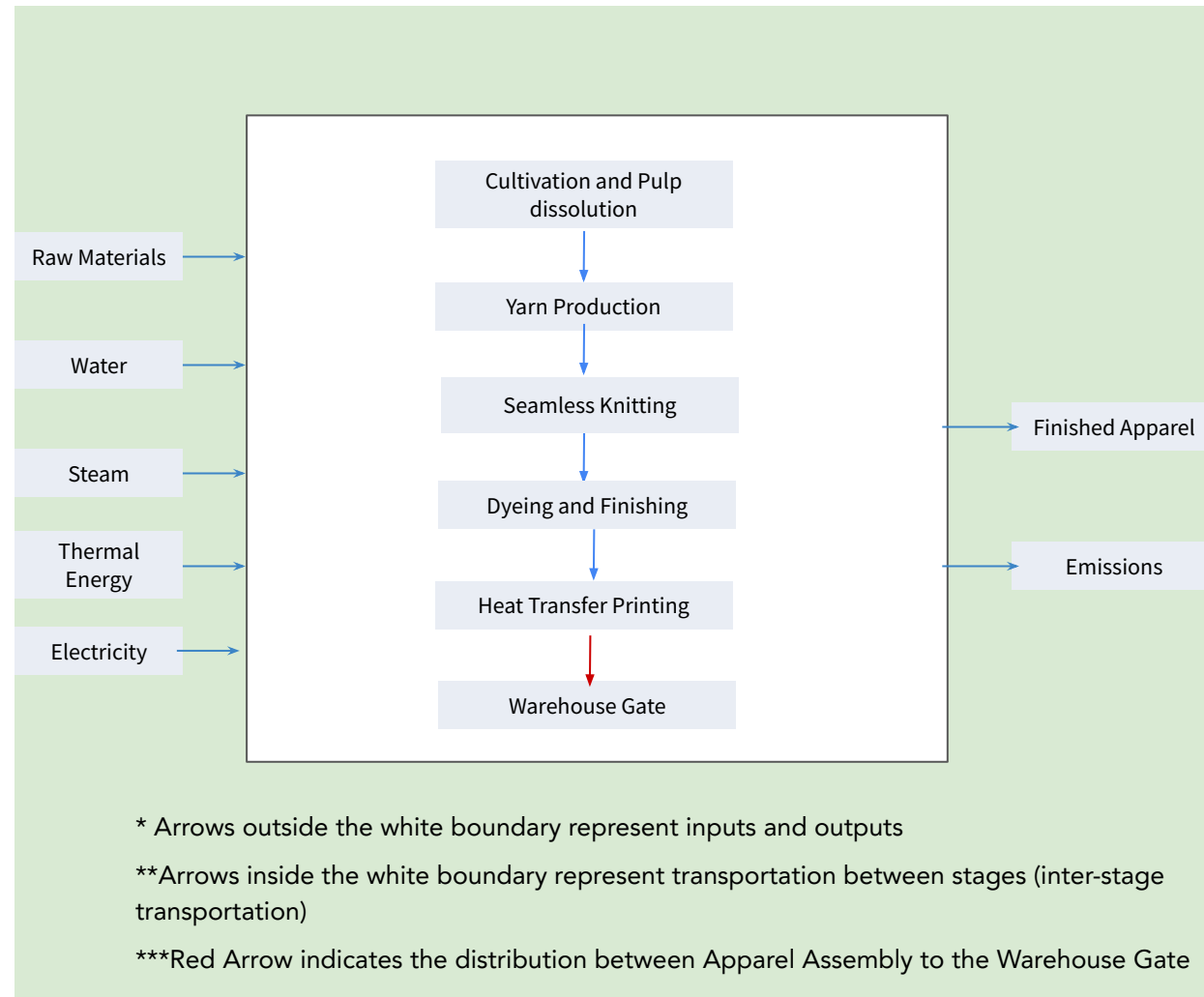


Figure 2: General System Boundary for the Scope of the Study

Life Cycle Inventory (LCI) Analysis

Data Sources and Product Information

Life cycle inventory is based on supply chain & product information and secondary data sources.

Supply Chain & Product Information provided by BOODY:

- Data for processing locations and mode of transport.
- Product details (apparel type, fibre blend, apparel weight and production quantity) are provided in order to obtain energy use and losses for apparel manufacturing.

Secondary Data Sources:

- Gabi 10.6.1 and ecoinvent 3.8 databases were used to fill data gaps and model the upstream processes associated with fuel production, electricity generation, chemical production, extraction and production of raw materials and transportation.

Baselining Methodology

In this study, BOODY supply chain are baselined with an identical supply chain. A definition for identical supply chain has been described below:

- Identical supply chain is supply chain that is geographically consistent with BOODY supply chain. The difference in the supply chain lies in the fibre production stage. The subsequent downstream processes are identical to BOODY supply chain.
- The identical supply chain baselining results would be influenced by data quality of the secondary datasets used in the LCA study. Data quality is governed by Technological/Geographical/Time representativeness, data reliability & completeness.

Supply Chain Overview: Organic Bamboo Lyocell Apparel and Conventional Cotton Apparel

Organic Bamboo Lyocell

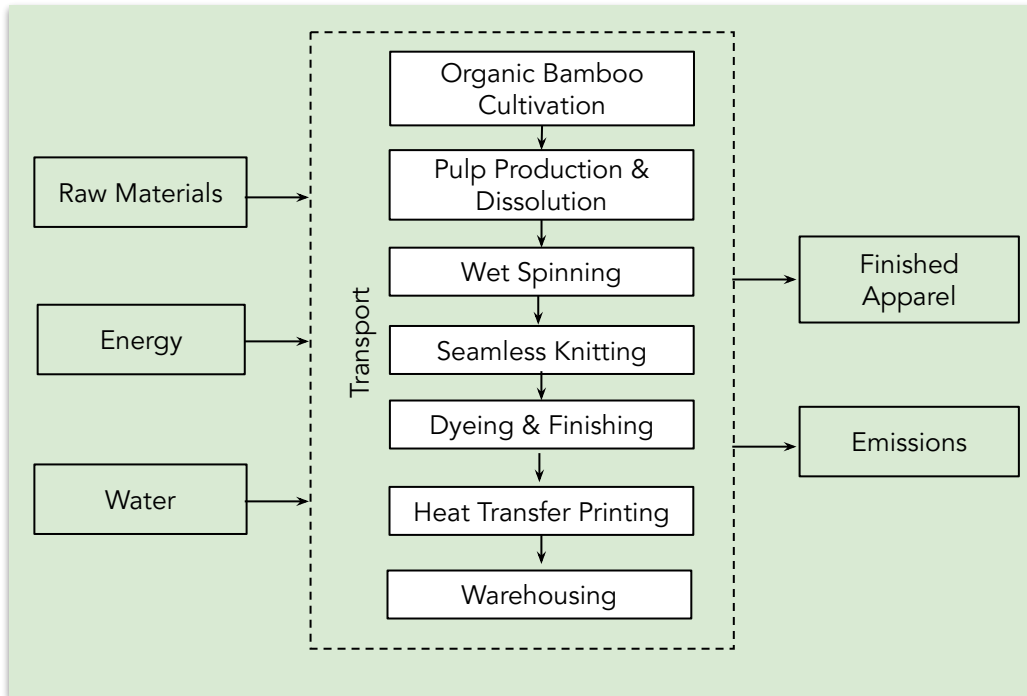


Figure 3: Supply Chain Overview for Organic Bamboo Lyocell Apparel

Baselined Fibre: Conventional Cotton

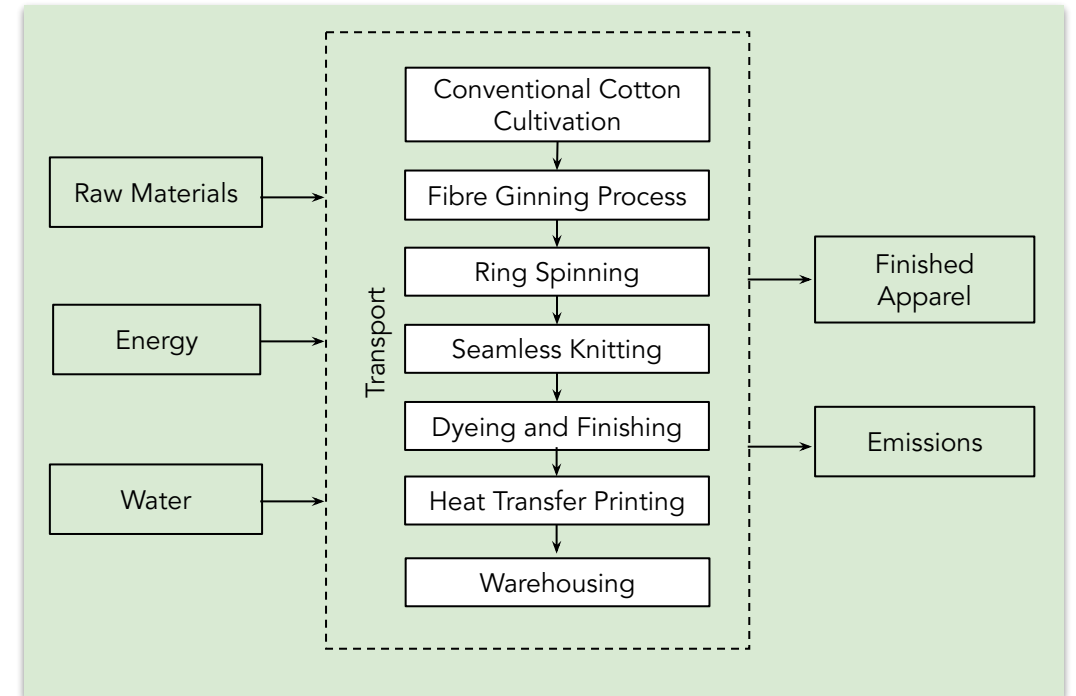
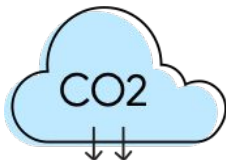

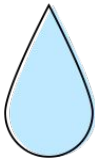


Figure 4: Supply Chain Overview for Conventional Cotton Apparel

Life Cycle Impact Assessment (LCIA)

Baselined LCIA Results for 100% Organic Bamboo Lyocell Apparel

Table 3: LCIA Results for 100% Organic Bamboo Lyocell Apparel Baselined with 100% Conventional Cotton Apparel (per kg apparel)

Environmental Impact Category		100% Organic Bamboo Lyocell	100% Conventional Cotton	Percentage Difference*
Global Warming Potential (kg CO ₂ eq)		10.3	13.7	-25%
Primary Energy Demand (MJ)		148	179	-17%
Blue Water Consumption (Litres)		32.3	489	-93%

* + sign indicates higher impact, - sign indicates lower impact

By Stage LCIA Results for 100% Organic Bamboo Lyocell Apparel

Table 4: Stagewise GWP, PED and BWC Impacts for 100% Organic Bamboo Lyocell Apparel (per kg apparel)

Environmental Impact Category	Total	Fibre Production	Seamless Knitting	Dyeing and Finishing	Heat Transfer Printing	Inner Transport	Distribution
GWP (kg CO ₂ Eq.)	10.3	6.73	1.33	1.56	0.11	0.23	0.35
PED (MJ)	148	96.6	18.30	21.40	3.60	3.55	4.81
BWC (L)	32.3	22.2	3.42	5.78	0.28	0.40	0.17

Life Cycle Interpretation

Global Warming Potential

The organic bamboo lyocell apparel has GWP emissions that are 25% lesser when baselined with conventional cotton apparel. Fibre production stage contributes 65% to the overall GWP emissions. This can be traced back to the upstream process such as thermal energy and electricity usage for pulp production and dissolution process under fibre production stage.

Primary Energy Demand

The organic bamboo lyocell apparel has PED impacts that are 17% lesser when baselined with conventional cotton apparel. Fibre production stage contributes 65% to the overall PED impacts. This is due to electricity and thermal energy usage for fibre production stage.

Blue Water Consumption

The organic bamboo lyocell apparel has BWC impacts that are 93% lesser when baselined with conventional cotton apparel. Fibre production stage contributes 69% to the overall BWC impacts. This can be traced back to water consumption for pulp dissolution and filament washing process under fibre production stage.

Glossary

Terms	Definitions
Global Warming Potential (GWP)	Gas that is able to absorb infrared radiation (from sun-wave radiation) that is reflected from the Earth's surface and reradiate it back to the earth's surface. Including carbon dioxide, methane, and water vapour (Mann, 2022; Kupfer et al. 2020).
Primary Energy Demand (PED)	The quantity of energy directly withdrawn from the hydrosphere, atmosphere or geosphere or energy source without any human-influenced changes (Kupfer et al. 2020).
Blue Water Consumption (BWC)	Blue water refers to the water withdrawn from groundwater or surface water bodies. The blue water inventory of a process includes all freshwater inputs but excludes rainwater (Pieper et al. 2018).
Inter-stage Transport	This is the transportation between the apparel supply chain stages (from the fibre production to the apparel assembly stage), as seen in Figure 2. Transportation modes include air, ship, train and truck.
Distribution (Transport)	This is the transportation between the apparel assembly stage to warehouse as seen in Figure 2. Transportation modes include air, ship, train and truck.

Mann, Michael. (2022). *Greenhouse-gas*. <https://www.britannica.com/science/greenhouse-gas>. Accessed on 2022, August 19th.

Kupfer, Dr. Thilo, Baitz, Dr. Martin, Colodel, Dr. Cecilia, Kokborg, Mortin, Schöll, Stephen, Rudolf, Matthias, Bos, Dr. Ulrike, Bosch, Fabian, Gonzalez, Maria, Schuller, Dr. Oliver, Hengstler,.. (2020). *Gabi databases & modelling principles*. Sphera.

Pieper, Maike, Kupfer, Prof. Dr.-Ing. Thilo., Thylmann, Daniel, and Bos, Ulrike. (2018). *Introduction to Water Assessment in GaBi* (pp. 1- 28). thinkstep AG https://gabi.sphera.com/fileadmin/Documents/Introduction_to_Water_Assessment_V2.2_03.pdf. Accessed on 2022, August 19th.

General and Key Assumptions

Most of the secondary datasets used in the study are taken from GaBi 10.6.1 and ecoinvent 3.8 (2021). The life cycle inventories used in addition to these datasets have been described in this section.

Organic Bamboo Lyocell Fibre Production:

- The life cycle inventory data for organic bamboo cultivation are taken from “Bamboo forestry, sustainable forest management ecoinvent 3.8” and adapted to China.
- The life cycle inventory data of organic bamboo fiber production in China are taken from Green Story’s LCA database and adapted to China.
- N-Methylmorpholine N-oxide (NMMO) production includes, processes such as methylamine production, N-Methylmorpholine (NMM) production and NMMO production, LCI data for these processes are taken from (Serena Righi 2010).

Conventional Cotton Cultivation:

- The life cycle inventory data of Conventional Cotton Cultivation are taken from the “BD: seed-cotton production, conventional ecoinvent 3.8 <u-so>” and adapted to China.

Conventional Cotton Fibre Production:

- The life cycle inventory data of Conventional Cotton fibre production were taken from the “Cotton Fiber Ginning ecoinvent 3.8 <LC>” and adapted to China.

Righi, Serena, Morfino, Andrea, Galletti, Paola, Samori, Chiara, Tugnoli, Alessandro, & Stramigioli, Carlo. (2010). *Comparative cradle-to-gate life cycle assessments of cellulose dissolution with 1-butyl-3-methylimidazolium chloride and N-methyl-morpholine-N-oxide*. Green Chemistry.

General and Key Assumptions

Yarn Production:

- The life cycle inventory data of Conventional Cotton yarn production were taken from the “IN: Yarn Production (cotton, ring spinning) ecoinvent 3.8 <LC>” and adapted for China.

Seamless Knitting:

- The life cycle inventory data of seamless knitting process are taken from Green Story’s LCA database and adapted to China.

Dyeing and Finishing :

- All dyeing and finishing process inputs are taken from GaBi 10.6.1.
- The Green Story dataset for ‘light reactive dyes in beam’ is used as a dyeing and finishing process for organic bamboo lyocell fabric. The process also includes washing and drying of the fabric. The dataset is adapted to China.

Heat Transfer Printing:

- The life cycle inventory data of heat transfer printing process are taken from Green Story’s LCA database and adopted to China.

Hasanbeigi, Ali, & Price, Linn. (2012). *A review of energy use and energy efficiency technologies for the textile industry*. *Renewable and Sustainable Energy Reviews*, 16(6), 3648-3665.
Koc, Erdem, & Kaplan, Emel. (2007). *An investigation on energy consumption in yarn production with special reference to ring spinning*. *Fibres & Textiles in Eastern Europe*, (4 (63)), 18-24.

Waste percentages are for all manufacturing processes associated with the BOODY and conventional Cotton supply chain.

Table 5: Waste Scenarios and Percentages for all Manufacturing Processes.

Manufacturing Process	Waste %	Source
Yarn Production (conventional cotton)	5.4	Sule Altun (2012)
Seamless Knitting	1.9	GS dataset
Dyeing	2.9	GS dataset

Sule, Altun. (2012). *Prediction of Textile Waste Profile and Recycling Opportunities in Turkey*. 20 (416). https://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BPW7-0023-0068/c/FTEE_94_16.pdf. Accessed on 2022, August 19th.

General and Key Assumptions

Major upstream aggregated processes used in the models for BOODY:

Table 6: Major Upstream Aggregated Processes used in the Models for BOODY

S. No.	Process	Upstream aggregated processes used
1	Electricity	China: market group for electricity, low voltage ecoinvent 3.8 China: market group for electricity, medium voltage ecoinvent 3.8 China: Electricity from photovoltaic Sphera
2	Process Steam Mixer	China: Process steam mixer has been used and is based on International Energy Agency (IEA) total energy supply data for China (2020). The contributions from hydro, wind, and solar have been excluded as they do not contribute in process steam production. This is included for all apparel production processes.
3	Thermal Energy Mixer	China: Thermal energy mixer has been used and is based on International Energy Agency (IEA) total energy supply data for China (2020). The contributions from hydro, wind, and solar have been excluded as they do not contribute in process steam production. This is included for all apparel production processes.

General and Key Assumptions

Transport Distance Calculation

- All air distances were calculated using distance.to.
- All ship distances were calculated using searates.com.
- All road distances were calculated using Google Maps.
- All distance assumptions containing unknown locations were used in accordance with Quantis (2018).

Supply Chain Number: 1

- Cultivation: Vertically integrated.
- Cultivation to Yarn Production: No transport, happened in the same place.
- Yarn Production to Seamless Knitting: Transport by truck from Gaocheng city, Hebei province, China to Fengxian District, Shanghai, China.
- Seamless Knitting to Dyeing Plant: Transport by truck from Fengxian District, Shanghai Municipality, China to Minhang, Shanghai, China.
- Dyeing Plant to Printing Facility: Transport by truck from Minhang District, Shanghai, China to Putuo District Shanghai, China.
- Printing Facility to Warehouse: Transport by ship from Putuo District Shanghai, China to stanley street, Sydney, NSW, Australia.

Distance Calculator for Air Shipping. 2022, August 19th. Retrieved from www.distance.to/.

Distance Calculator for Sea Shipping. 2022, August 19th. Retrieved from <https://www.searates.com>.

Distance Calculator for Road Shipping. 2022, August 19th. Retrieved from <https://www.google.com/maps>.

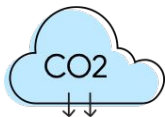


Quantis. 2018. "MEASURING FASHION". *Environmental Impact of the Global Apparel and Footwear Industries Study Full report and methodological considerations.*

<https://refashion.fr/eco-design/sites/default/files/fichiers/Measuring%20Fashion%20Environmental%20Impact%20of%20the%20Global%20Apparel%20and%20Footwear%20Industries%20Study.pdf>. Accessed on 2022, August 19th.

Annexure

Baselined LCIA Results for 100% Organic Bamboo Lyocell Apparel

LCIA Results for 100% Organic Bamboo Lyocell Apparel Baselined with 100% Bamboo Viscose Apparel (per kg apparel)

Environmental Impact Category		100% Organic Bamboo Lyocell	100% Bamboo Viscose#	Percentage Difference*
Global Warming Potential (kg CO ₂ eq)		10.3	12.9	-20%
Primary Energy Demand (MJ)		148	97.2	+52%
Blue Water Consumption (Litres)		32.3	874	-96%

#Schultz, T., & Suresh, A. (2017). Life cycle assessment comparing ten sources of manmade cellulose fiber. *Emeryville: SCS Global Services*

* + sign indicates higher impact, - sign indicates lower impact

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Company Information

Green Story is a sustainability platform that enables brands to accurately measure and communicate the positive impact of their products and make them carbon neutral.

By combining Life Cycle Assessment methodology with interactive data and impact visuals and a carbon offsetting platform, we enrich the customer experience with your green story throughout the customer lifecycle. Enhancing transparency, increasing engagement and loyalty, and driving revenue.

Partnering with hundreds of sustainable fashion players like PANGAIA, thredUP, Rent the Runway, Threads 4 Thought, Pact and Hanesbrands, Green Story has a global team of experts working to empower 1 billion people to know their impact and make choices that are better for the planet and the generations to come.

150+

Customers



Across 15 countries

30

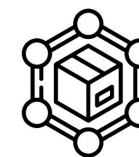
Team members



Across 3 countries

2.000+

Supply chains analyzed



Across 35+ countries

Some of Our Customers



ABOUT

KNICKEY

yumeko



Vitamin A



WHIMSY+ROW

ESPIRIT



Boyish



NO NASTIES

pact

FOR DAYS



THE VERY WARM



TO THE MARKET



ARMEDANGELS



BN3TH

THOUSAND FELL

Smannies

