Comparative Life Cycle Impact Assessment for Greendigo

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Analysis Overview

- The objective of this study is to compare the impact of Greendigo's sustainable apparel against comparative conventional fabrics. The findings of the study are intended to be used as a basis for communication and future process improvements. The primary audience for this study is Greendigo, its investors and customers.
- This cradle-to-gate comparative life cycle inventory (LCI) encompasses all upstream processes of apparel manufacture from, raw material acquisition to fiber and fabric manufacture. All the relevant life-stages of sustainable and conventional fabric apparels are analyzed to estimate the net impact savings across three key metrics: GHG emissions, primary energy use, and blue water consumption.
- This analysis does not include impact assessment except for Global warming potential impact. It does not attempt to determine the fate of emissions, or the relative risk to humans or to the environment due to emissions from the systems.

Scope of Study

- This is a cradle-to-gate comparative life cycle inventory study
- Functional unit is 1 kg of finished apparel for each Greendigo and comparative conventional fabric type
- The study examines Greendigo apparel manufacturing and compared it with conventional apparel manufacturing.

Analysis Overview (cont.)

Other data

- Transportation is included between all production stages and until warehouse storage.

Data Audit

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

Critical Review

- No third-party critical review has been performed for this study.

Key Assumptions

Overall assumptions

- Greendigo supply chains are compared to supply chains of the equivalent material produced in the same country as Greendigo's production.
- Impacts for CO_2 emissions are given as non-biogenic carbon dioxide equivalence (CO_2e) as it is assumed that all biogenic CO_2e stored in the apparel will be released back to the environment at their end-of-life.

Key Assumptions (cont.)

Fiber (Organic Cotton)

- Farming and ginning inputs inventory for organic cotton were adapted from PE International (2014).
- Cow dung manure is taken as a waste-product of the livestock industry and thus the burden is borne by that industry.
- Calculations for nitrate leaching was taken from Brentrup et al. (2000).
- Soil carbon sequestration is not considered as to align to the PE International (2014).
- Infrastructure creation like shed, trailer and tractor are not considered.
- Heavy metals amount in soil are taken from the United States, Lubbock region and calculated with soil erosion rates in India.
- Economic allocation was used to assign burden between organic cotton linters and fibre for the ginning process, with prices taken from based on PE International (2014).
- Waste for ginning production is taken as 30%, as done in PE International (2014).
- Renewable primary energy requirement for the production of ginned fiber was taken from “Cotton fiber (organic) (at gin gate)” dataset from Textile Exchange in GaBi 8.7 (2018) as renewable energy is not disclosed by PE International (2014).
- Cultivation is taken for the Orissa region as per Greendigo’s supply chain.
- Environmental impacts for conventional cotton fiber was taken from C&A Foundation (2018) for fiber produced in Madhya Pradesh, India.

Key Assumptions (cont.)

Fabric

- The same yarn, fabric, and apparel production inputs are considered for both Greendigo and conventional apparel production.
- Yarn production includes the spinning of fibers into yarn and includes all subprocesses; blowing, cleaning, combing, carding, groving, and winding. Input requirements are taken from Hasanbeigi (2014) and Koç & Kaplan (2007).
- Cut & Sew energy for apparel production was taken from Sustainable Energy Saving for the European Clothing Industry (n.a.) with product weight from Greendigo. Cut & Sew energy use for bag and blanket production was excluded for both Greendigo and conventional production due to lack of data.
- Waste amount for Cut & Sew was retrieved from European Commission JRC (2014) based on Greendigo product categories. Waste amount was excluded for bags due to lack of data for both Greendigo and conventional supply chain.
- Both knitting and weaving were considered as per to Greendigo product types.
- The knitting process consists of circular knitting and compacting with input requirements taken from Van der Velden et al. (2014) and Cotton Inc. (2012).
- The weaving process includes sizing and warping, weaving, and sanforizing with inputs requirements from Van Eynde (2015) and Cotton Inc (2012).
- Sanforizing inputs are calculated with the assumption of material weight as 170 gsm (ARKET, 2018).
- Rotary screen printing was assumed based on Greendigo products, "O Ecotextiles" (2012), and “Washing/Rinsing in textile industry” (2013) for both Greendigo and conventional supply chains.
- Washing of printed textile is assumed to be open width as per Arioli & C S.R.L., (1984).
- Knitting energy for socks production and waste was taken from Ross (2013).

Key Assumptions (cont.)

Greendigo Supply chains

Material	Cultivation	Fiber	Yarn	Fabric	Cut & Sew	Warehouse
Organic Cotton (SC 1)	Kalahandi, Orissa	Rajasthan	Chandigarh	Kolkata	Kolkata	Mumbai
Organic Cotton (SC 2)	Tiruppur	Tiruppur	Tiruppur	Tiruppur	Tiruppur	Mumbai

Conventional Supply chains

Material	Cultivation	Fiber	Yarn	Fabric	Cut & Sew	Warehouse
Cotton	India	India	India	India	India	Mumbai

Key Assumptions (cont.)

Overall waste (General)

Waste scenario	Waste %
Yarn Production (Cotton)	12%
Knitting	2%
Weaving	3%
Dyeing	3.5%
Cut & Sew Apparel	14.6%
Cut & Sew Blankets	3%
Cut & Sew Socks	1%

Key Assumptions (cont.)

Transport

- All transportation between raw material production until warehouse storage is taken into consideration for both Greendigo and conventional production.
- A distance of 1000 km is applied when production processes are done in the same country but cities are unknown, as indicated by Quantis (2018).
- An inner-city standard transportation distance of 30km is assumed for production processes in the same city with different facilities when exact locations are unknown.
- Conventional printing is assumed to be done at the same facility as fabric production, hence no transportation is included at this stage.
- All distances were calculated with SeaRates LP (2018).
- No transport to cut & sew is included for socks as they are knitted directly into the end product.

Key Assumptions (cont.)

Greendigo Transport

Stages	Organic Cotton (SC 1) (km)	Organic Cotton (SC 2) (km)	Conventional Cotton (km)
Cultivation to Fibre (Truck)	1518	90	Not disclosed by C&A Foundation (2018)
Fibre to Yarn (Truck)	569	30	1000
Yarn to Fabric (Truck)	1741	30	1000
Fabric to Cut & Sew (Truck)	30	30	1000
Cut & Sew to Warehouse (Truck)	2174	1007	2174

List of sources

Fiber

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- NRCCA. “Northeast Region Certified Crop Adviser (NRCCA) Study Resources.” Certified Crop Advisor Study Resources (Northeast Region), 2010, nrcca.cals.cornell.edu/.

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Fabric

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- European Commission JRC. “Environmental Improvement Potential of Textiles (IMPRO Textiles). JRC Scientific and Policy Reports. (January 2014).
- GaBi 8.7: Leinfelden-Echterdingen GaBi Software-system and Databases for Life Cycle Engineering, Thinkstep AG, 2018.
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- Koç, Erdem, and Emel Kaplan. "An investigation on energy consumption in yarn production with special reference to ring spinning." Fibres & Textiles in Eastern Europe 4 (63) (2007): 18-24.
- Sustainable Energy Saving for the European Clothing Industry. “Benchmarking energy efficiency in apparel production”. (n.a).

Primary Sources

- Greendigo proprietary data

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Fabric (Knit & Weave)

- Cotton Inc, 2012. Life Cycle Assessment of Cotton Fibre and Fabric. Pre-pared for VISION 21, a project of The Cotton Foundation and managed by Cotton Incorporated, Cotton Council International and The National Cotton Council. The research was conducted by Cotton Incorporated and PE Inter-national.
- Van der Velden, Natascha M., Martin K. Patel, and Joost G. Vogtländer. "LCA benchmarking study on textiles made of cotton, polyester, nylon, acryl, or elastane." The International Journal of Life Cycle Assessment 19.2 (2014): 331-356.
- Cotton GSM.” ARKET, 2018, www.arket.com/en_eur/c/cs-cotton-gsm.html.

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Printing

- Arioli & C S.R.L. (1984) System for the continuous and open-width washing of a fabric. US.
- O ECOTEXTILES (2012), https://oecotextiles.wordpress.com/tag/flat-screen-printing/.
- “Washing/Rinsing in textile industry”. Wiki.zero-emissions.at. (2013), from http://wiki.zero-emissions.at/index.php?title=Washing/Rinsing_in_textile_industry.

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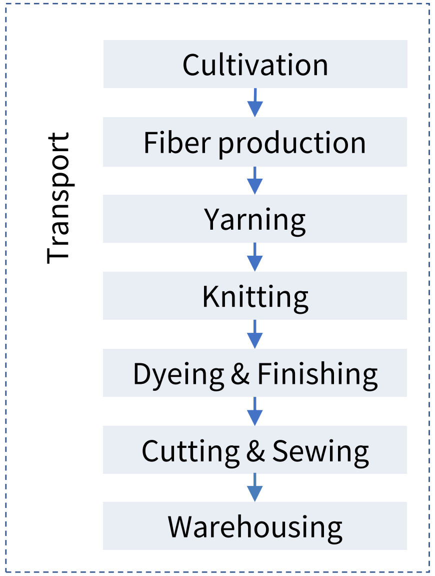
Transport

- Quantis. “Measuring Fashion. Environmental Impact of the Global Apparel and Footwear Industries Study. Full report and methodological considerations.” 2018
- SeaRates LP. “Current Market Rate.” SeaRates, 2018, www.searates.com/reference/portdistance/.

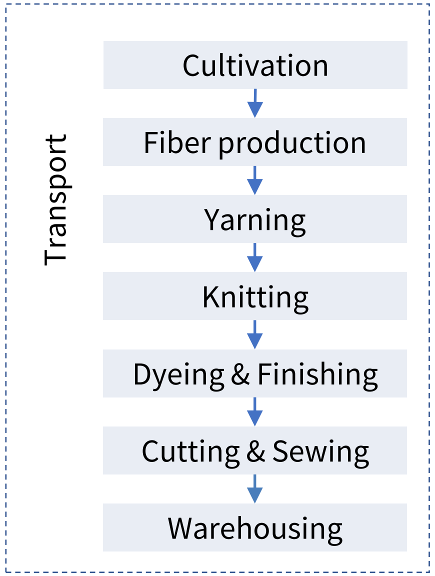
Organic Cotton vs Conventional Cotton
Comparative Impact Calculation Results

System boundary

Organic cotton



Conventional cotton



Organic cotton apparel (SC 1) vs. Conventional cotton apparel comparative LCI (per kg of clothing)

Net impact difference

Per kg of apparel	Unit	Organic Cotton	Conventional Cotton	Percentage lower
GHG emissions	kgCO2e	27.8	28.35	2%
Blue water consumption	litres	103.8	1233	92%
Energy	MJ	446.02	454.1	2%

Net impact difference in equivalences

Per kg of apparel	Unit	Equivalence	Value
GHG emissions	kgCO2e	km of driving emissions	0.26
Blue water consumption	litres	days of drinking water	1.9
Energy	kWh	light bulbs powered for an hour	0.013

Organic cotton blankets (SC 1) vs. Conventional cotton blankets comparative LCI (per kg of clothing)

Net impact difference

Per kg of apparel	Unit	Organic Cotton	Conventional Cotton	Percentage lower
GHG emissions	kgCO2e	22.5	23.16	3%
Blue water consumption	litres	87.24	1082	92%
Energy	MJ	363.37	373.2	3%

Net impact difference in equivalences

Per kg of apparel	Unit	Equivalence	Value
GHG emissions	kgCO2e	km of driving emissions	0.26
Blue water consumption	litres	days of drinking water	1.9
Energy	kWh	light bulbs powered for an hour	0.013

Organic cotton bags (SC 1) vs. Conventional cotton bags comparative LCI (per kg of clothing)

Net impact difference

Per kg of apparel	Unit	Organic Cotton	Conventional Cotton	Percentage lower
GHG emissions	kgCO2e	30.36	30.47	0.361%
Blue water consumption	litres	111.7	1084	90%
Energy	MJ	480.33	481.6	0.263%

Net impact difference in equivalences

Per kg of apparel	Unit	Equivalence	Value
GHG emissions	kgCO2e	km of driving emissions	0.26
Blue water consumption	litres	days of drinking water	1.9
Energy	kWh	light bulbs powered for an hour	0.013

Organic cotton apparel knit (SC 2) vs. Conventional cotton apparel comparative LCI (per kg of clothing)

Net impact difference

Per kg of apparel	Unit	Organic Cotton	Conventional Cotton	Percentage lower
GHG emissions	kgCO2e	25.51	27.81	8%
Blue water consumption	litres	102.5	1231	92%
Energy	MJ	407.07	448.7	9%

Net impact difference in equivalences

Per kg of apparel	Unit	Equivalence	Value
GHG emissions	kgCO2e	km of driving emissions	0.26
Blue water consumption	litres	days of drinking water	1.9
Energy	kWh	light bulbs powered for an hour	0.013

Organic cotton apparel weave (SC 2) vs. Conventional cotton apparel comparative LCI (per kg of clothing)

Net impact difference

Per kg of apparel	Unit	Organic Cotton	Conventional Cotton	Percentage lower
GHG emissions	kgCO2e	34.58	37.22	7%
Blue water consumption	litres	162.61	1302.38	88%
Energy	MJ	541.84	589.37	8%

Net impact difference in equivalences

Per kg of apparel	Unit	Equivalence	Value
GHG emissions	kgCO2e	km of driving emissions	0.26
Blue water consumption	litres	days of drinking water	1.9
Energy	kWh	light bulbs powered for an hour	0.013

Organic cotton bags & bibs knit (SC 2) vs. Conventional cotton blankets comparative LCI (per kg of clothing)

Net impact difference

Per kg of apparel	Unit	Organic Cotton	Conventional Cotton	Percentage lower
GHG emissions	kgCO2e	20.56	22.49	9%
Blue water consumption	litres	84.10	1048.24	92%
Energy	MJ	327.38	362.20	10%

Net impact difference in equivalences

Per kg of apparel	Unit	Equivalence	Value
GHG emissions	kgCO2e	km of driving emissions	0.26
Blue water consumption	litres	days of drinking water	1.9
Energy	kWh	light bulbs powered for an hour	0.013

Organic cotton socks (SC 2) vs. Conventional cotton bags comparative LCI (per kg of clothing)

Net impact difference

Per kg of apparel	Unit	Organic Cotton	Conventional Cotton	Percentage lower
GHG emissions	kgCO2e	25.74	27.97	8%
Blue water consumption	litres	103.40	1173.00	91%
Energy	MJ	427.12	467.60	9%

Net impact difference in equivalences

Per kg of apparel	Unit	Equivalence	Value
GHG emissions	kgCO2e	km of driving emissions	0.26
Blue water consumption	litres	days of drinking water	1.9
Energy	kWh	light bulbs powered for an hour	0.013

About Green Story

The Green Story team is led by Akhil Sivanandan and Navodit Babel. Both members received their sustainability reporting training from the Global Reporting Initiative.

- Navodit has 10+ years of experience in consulting and product management with global corporations. He has successfully overseen the launch of national card strategies in Canada. During his MBA at the University of Toronto, he developed a sustainability ranking algorithm for mining projects for Sustainalytics which used in the company's global operations.
- Akhil has worked on sustainability projects for companies such as Philips Lighting and given presentations and interviews on the topic for multiple publications including the New York Times. He was also intimately involved in the Ontario Cap and Trade and Offsets programs as part of the Government. Akhil received his MBA from the University of Toronto.

Green Story's mission is help companies communicate environmental and social impact to stakeholders in a clear, credible and relatable manner.

We work with a range of companies from waste management firms to one of North America's largest ecofashion manufacturers to engage stakeholders and measure and communicate impact.

Green Story is a Ministry of Environment Agent of Change, Social Capital Markets scholarship recipient, a member of the MaRS Centre for Impact Investing and of Ryerson University's Social Venture Zone.

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