Comparative Life Cycle Impact Assessment of Organic Cotton and Recycled PET versus Conventional Alternatives

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Analysis Overview

- The objective of this study is to compare the impact of Bhumi organic and sustainable clothing and bedding against clothing made using comparable conventional fibers. 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 Bhumi, its investors, and customers.

- This cradle-to-gate comparative life cycle inventory (LCI) encompasses the following upstream processes of apparel manufacture: farming, raw material acquisition, fiber manufacture, fabric manufacture, apparel and bedding manufacture and transportation in between production facilities and to warehouse. All the relevant life-stages of sustainable and conventional fabrics are analyzed to estimate the net impact savings across three key metrics: GHG emissions, primary energy use, and blue water consumption.

Scope of study

- This is a cradle-to-gate comparative life cycle inventory study
- Functional unit is 1 kg of apparel for each of Bhumi's and comparative conventional fabric types.
- The fibers analyzed from Bhumi are organic cotton and recycled polyester. These are compared with regular cotton and virgin polyester respectively.
- The study examines Bhumi's manufacturing in India and compares it with conventional global manufacturing.

Analysis Overview (cont.)

The following blends were analyzed:

Blend	Bhumi fibers	Conventional comparison
Blend 1	100% organic cotton	100% conventional cotton
Blend 2	95% organic cotton/ 5% spandex	95% conventional cotton/ 5% spandex
Blend 3	92% organic cotton/ 8% spandex	92% conventional cotton/ 8% spandex
Blend 4	78% organic cotton/ 22% spandex	78% conventional cotton/ 22% spandex
Blend 5	60% organic cotton/ 40% RPET	60% conventional cotton/ 40% polyester
Blend 6	57% organic cotton/ 38% RPET/ 5% spandex	57% conventional cotton/ 38% polyester/ 5% spandex
Blend 7	55% organic cotton/ 37% RPET/ 8% spandex	55% conventional cotton/ 37% polyester/ 8% spandex

Analysis Overview (cont.)

Other data

- Average electricity grid for India is used to model Bhumi manufacturing.
- Transportation distances were modeled using Bhumi inputs, Ecoinvent (2017) and GaBi 8.7 (2018) databases based on manufacturing plant locations.

Data Audit

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

Critical Review

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

Key Assumptions

Overall Fabric Assumptions

- All apparel analyses have a system boundary from cradle until factory gate.
- Transportation is included between all production plants until warehouse storage.
- Knitting and weaving are considered for apparel production while bedding and other textile as considered as weaved, based on Bhumi proprietary data.
- Only non-biogenic carbon dioxide equivalence (CO2e) is taken into account for all fabrics in this analysis as it is assumed that all biogenic CO2e stored in the apparel will be released back to the environment at end-of-life.
- The same yarn, fabric and apparel production inputs are considered for both Bhumi and conventional material production.
- All energy sources for Bhumi (electricity, diesel, thermal energy and light fuel oil) are taken for India.
- Conventional energy (electricity, steam, light fuel oil, thermal energy and diesel) is taken as a distribution based on Quantis (2018). Thermal energy and steam is also assumed to be from 50% hard coal and 50% natural gas.
- Cut & Sew electricity was not taken into account due to ambiguous data.
- The primary energy demand indicator states the impact for non-renewable energy sources.

Key Assumptions (cont.)

Overall Fabric Assumptions

- Yarn production for knitting 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).
- Circular knitting was assumed as stated in McCann et al., 2009 and input requirements taken from Van der Velden et al. (2014) and Cotton Inc (2012).
- 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).
- All materials are assumed to be fabric dyed.
- All dyeing processes are used from GaBi 8.7 (2018) and adapted to India by changing all energy grids, or using a global energy distribution as outlined in Quantis (2018).

Key Assumptions (cont.)

Overall Waste Assumptions

Waste scenario	Waste %
Yarn Production (Cotton)	12%
Yarn production (RPET)	9%
Knitting	2%
Weaving	3%
Dyeing	3%
Cut & Sew (Bedding)	4%
Cut & Sew (Apparel)	15%

Key Assumptions (cont.)

- Conventional cotton farm to ginning transportation is included but exact distance is not disclosed by GaBi 8.7 (2018).
- Conventional cotton textile and apparel is assumed as 60/40 mix of air freight to ocean freight, from ratios derived as per the Global Air Transport Association.
- Transportation distance assumptions:

Locations	km
Bhumi	
Farm to Ginning (Truck)	30
Fiber to Yarn (Truck)	500
Yarn to Fabric (Truck)	0
Fabric to Cut &Sew (Truck)	500
Cut & Sew to Warehouse (Ship + Truck)	9927.3

Locations	km
Conventional:	
Farm to Ginning	-
Fiber to Yarn	500
Yarn to Fabric	500
Fabric to Warehouse (Ship + Truck)	12133
Fabric to Warehouse (Plane + Truck)	9487

List of sources used across all materials

Secondary Sources

- Altun, Sule. "Prediction of Textile Waste Profile and Recycling Opportunities in Turk." Fibres & Textiles in Eastern Europe(2012)
- 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.
- “Cotton GSM.” ARKET, 2018, www.arket.com/en_eur/c/cs-cotton-gsm.html.
- Ecoinvent (2017) Database Ecoinvent version v3.7. The Swiss Centre for Life Cycle Inventories.
- GaBi 8.7: Leinfelden-Echterdingen GaBi Software-system and Databases for Life Cycle Engineering, Thinkstep AG, 2018.
- Hasanbeigi, Ali, and Lynn Price. "A review of energy use and energy efficiency technologies for the textile industry." Renewable and Sustainable Energy Reviews 16.6 (2012): 3648-3665.
- 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.
- Islam, Mayedul. “Wastage Area in Textile and Apparel Manufacturing Industry.” Garments Merchandising, 3 Feb. 2018, www.garmentsmerchandising.com/wastage-area-textile-clothing-industry
- Larsen, Søren Ellebæk, et al. "EDIPTEX–Environmental assessment of textiles." (2007)
- 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/.
- “How much does garment Industry actually waste?” Reverse Resources, 31 Aug. 2016, reverseresources.net/news/how-much-does-garment-industry-actually-waste

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List of sources used across all materials (cont.)

Secondary Sources

- Van Eynde, Hannes. "Comparative Life Cycle Assessment of hemp and cotton fibres used in Chinese textile manufacturing." (2015)
- Uddin, Mohammad. (2015). Study on fabric wastages in knit dyeing industries of Bangladesh. Journal of Textile Engineering. TE 2. 19-23.

Primary Sources

- Bhumi supplier data
- Bhumi proprietary data

List of sources: all analyses

Specific Organic Cotton Secondary Sources

- Amon, T, and J Boxberger. “Biogas Production from Farmyard Manure.” Institute for Agricultural, Environmental and Energy Engineering, University for Agricultural Sciences.
- Brentrup, Frank, et al. "Methods to estimate on-field nitrogen emissions from crop production as an input to LCA studies in the agricultural sector." The International Journal of Life Cycle Assessment 5.6 (2000): 349.
- l’IFTH. Institut Francais du textile et de l'habillement. Aide à la prise en compte de l’environnement dans la conception d’articles textiles.
- Le Mer, Jean, and Pierre Roger. "Production, oxidation, emission and consumption of methane by soils: a review." European journal of soil biology 37.1 (2001): 25-50.
- PE International . Life Cycle Assessment (LCA) of Organic Cotton: A Global Average. Textile Exchange, 2014, Life Cycle Assessment (LCA) of Organic Cotton: A Global Average.
- Pennsylvania State University . Compose Analysis Report. 2016, Compose Analysis Report.
- NRCCA. “Northeast Region Certified Crop Adviser (NRCCA) Study Resources.” Certified Crop Advisor Study Resources (Northeast Region), 2010, nrcca.cals.cornell.edu/.
- USGS. “NGDB Soil Sample #D174234 (Grassland/Grazing Land).” U.S. Geological Survey, 2018, mrdata.usgs.gov/ngdb/soil/show-ngdbsoil.php?lab_id=D174234.

Specific RPET Secondary Sources

- Kägi, T., M. Zschokke, and C. Stettler. "Life Cycle Inventories for Swiss Recycling Processes-Part Carbotech: Recycling of Cardboard, Glass, PE, PET, Tinplate." Im Auftrag des BAFU(2017)

Organic cotton vs conventional cotton
Comparative impact

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Key Assumptions

- Farming and ginning inputs inventory for various organic cotton growing regions in India has been adapted from PE International (2014).
- Neem kernel, leaves extract, and tricoderma upstream impacts are not considered as they are of insignificant impact.
- 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.
- Soil carbon sequestration is not considered as to align to the PE International (2014).
- Cotton fabric is dyed with reactive dyes.
- Economic allocation was used to assign burden between organic cotton linters and fibre for the ginning process
- Proportions of various India regions for organic cotton cultivation were taken as follows:

Region	% contribution
Andhra Pradesh	33%
Odisha	33%
Maharashtra	34%

System Boundary

Organic cotton

Transport

Cultivation
↓
Fibre Manufacture
↓
Yarn Manufacture
↓
Fabric Production
↓
Dyeing & Finishing
↓
Cutting & Sewing
↓
Warehousing

Conventional cotton

Transport

Cultivation
↓
Fibre Manufacture
↓
Yarn Manufacture
↓
Fabric Production
↓
Dyeing & Finishing
↓
Cutting & Sewing
↓
Warehousing

Bhumi's organic cotton clothing vs. conventional cotton global comparative LCI (per kg of apparel)

Net impact difference between organic cotton and conventional cotton

Per kg of fabric	Unit	Bhumi organic	Conventional cotton	Percentage lower
GHG emissions	kgCO2e	12.5	19.5	36%
Water consumption	litres	384	2935	87%
Energy	MJ	131	223	41%

Net impact equivalence (difference between organic cotton and conventional cotton) per kg of apparel

13.8kms
of driving emissions avoided

289.3 days
of drinking water conserved

1196.7 bulbs
powered for an hour

Bhumi's organic cotton knitted bedding vs. conventional cotton global comparative LCI (per kg of apparel)

Net impact difference between organic cotton and conventional cotton

Per kg of fabric	Unit	Bhumi organic	Conventional cotton	Percentage lower
GHG emissions	kgCO2e	11.3	17.7	36%
Water consumption	litres	347	2650	87%
Energy	MJ	118	203	42%

Net impact equivalence (difference between organic cotton and conventional cotton) per kg of apparel

10.3 kms
of driving
emissions avoided

261.6 days
of drinking water
conserved

1111.2 bulbs
powered for an
hour

Bhumi's organic cotton woven bedding vs. conventional cotton global comparative LCI (per kg of apparel)

Net impact difference between organic cotton and conventional cotton

Per kg of fabric	Unit	Bhumi organic	Conventional cotton	Percentage lower
GHG emissions	kgCO2e	18.9	24.3	22%
Water consumption	litres	392	2700	85%
Energy	MJ	196	277	29%

Net impact equivalence (difference between organic cotton and conventional cotton) per kg of apparel

8.8 kms
of driving
emissions avoided

262.7 days
of drinking water
conserved

1004.3 bulbs
powered for an
hour

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RPET vs polyester Comparative impact

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Key Fiber Assumptions

- Recycled PET granulate and PET granulate production processes are taken as Switzerland processes from Ecoinvent (2017) and adapted to India through fuel, electricity grid and other input raw materials' geographical source changes.
- Bottle collection process and sorting for recycled PET are also based on Swiss data and modified to India through key process and fuel source substitutions.
- Transportation from granulate factory to fabric manufacture plant is not taken into account for both recycled and virgin polyester fibers due to uncertainty in location of the granulate factory.
- Yarn production covers the spinning of granulate material to partially-orientated yarn and the drawing and texturing for draw textured yarn. Inputs needed for these processes are taken from van der Velden et al. (2014).
- Sizing and warping processes for weaving fabric is replicated from hemp production from Van Eynde (2015) due to insufficient data.
- Polyester fabric is dyed with disperse dyes.

System Boundary

Recycled PET

Transport

1. Bottle collection
2. Sorting
3. Recycle treatment
4. Granulate prod.
5. Fibre extrusion
6. Fabric production
7. Dyeing & finishing
8. Cutting & sewing
9. Warehousing

Virgin Polyester

Transport

1. Resource extract
2. Polymerization
3. Granulate prod.
4. Fibre extrusion
5. Fabric production
6. Dyeing & finishing
7. Cutting & sewing
8. Warehousing

Bhumi's RPET clothing vs. virgin polyester global comparative LCI (per kg of apparel)

Net impact difference between rPET and virgin polyester

Per kg of fabric	Unit	Bhumi RPET	Virgin polyester	Percentage lower
GHG emissions	kgCO2e	15.4	18	14%
Water consumption	litres	73.4	99.2	26%
Energy	MJ	181	272	33%

Net impact equivalence (difference between rPET and virgin polyester) per kg of apparel

4.6 kms
of driving emissions avoided

3.1 days
of drinking water conserved

1688.2 bulbs
powered for an hour

Bhumi's RPET knitted bedding vs. virgin polyester global comparative LCI (per kg of apparel)

Net impact difference between rPET and virgin polyester

Per kg of fabric	Unit	Bhumi RPET	Virgin polyester	Percentage lower
GHG emissions	kgCO2e	14	16.4	15%
Water consumption	litres	66.4	89.9	26%
Energy	MJ	164	248	34%

Net impact equivalence (difference between rPET and virgin polyester) per kg of apparel

4.2 kms
of driving
emissions avoided

2.8 days
of drinking water
conserved

1581.3 bulbs
powered for an
hour

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Bhumi's RPET woven bedding vs. virgin polyester global comparative LCI (per kg of apparel)

Net impact difference between rPET and virgin polyester

Per kg of fabric	Unit	Bhumi RPET	Virgin polyester	Percentage lower
GHG emissions	kgCO2e	21	22.3	6%
Water consumption	litres	104	112	7%
Energy	MJ	236	315	25%

Net impact equivalence (difference between rPET and virgin polyester) per kg of apparel

0 kms
of driving emissions avoided

1.1 days
of drinking water conserved

1474 bulbs
powered for an hour

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 bottled water 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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