


# GreenDelta

software / data / know-how



## Social and environmental impacts of a T-shirt: A life cycle approach

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GreenDelta GmbH

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# Content

- Who are we?
- What is Life Cycle Assessment (LCA) / social LCA?
- Case study: Cotton T-shirt
- Comparing different scenarios
- What to do with the results

# GreenDelta, Background

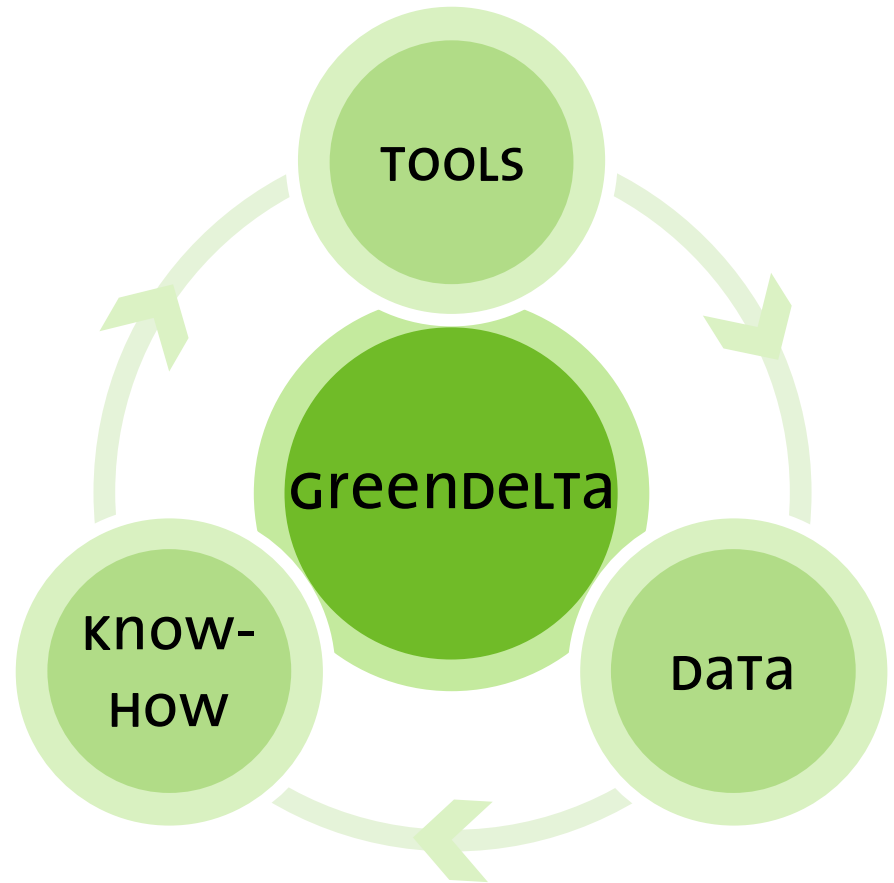
- Founded by Dr. Andreas Citroth in 2004
- 10 employees (engineers, biologists, IT specialists, business administrators)
- Office in Berlin
- Business world-wide



# GreenDelta, What we do

“The art of sustainability consulting”

- Sustainability research
- Life Cycle Assessments
- Databases
- Software for LCA and sustainability



# GreenDelta, Projects I



LCA case studies for  
bottle labels



Product comparison of  
chitosan (biopolymer)



Introducing LCA  
software in lectures



Development of Life  
Cycle impact  
assessment feature



Develop software  
for LCA



Develop and implement  
methodology for  
sustainability assessment

# GreenDelta, Projects II

**PSILca** 

Developing a global, transparent S-LCA database

**L'ORÉAL**

Advise for company sustainability metrics



Advise for company sustainability metrics and case study

Programmatore  
federaale Overheidsdienst  
**Duurzame  
Ontwikkeling** 

Full, public social LCA and environmental LCA case study



Critical review of a method for S-LCA

**FCh**  
FUNDACIÓN CHILE

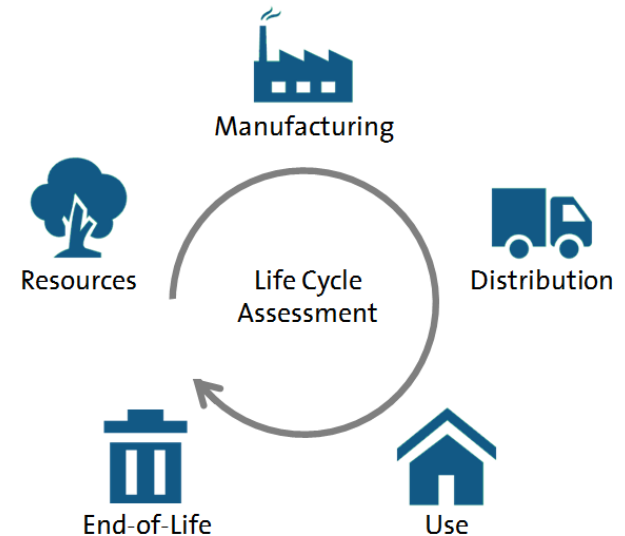
Case studies, developing an indicator system for S-LCA



# What is LCA / S-LCA

# What is Life Cycle Assessment?

*Life Cycle Assessment is a technique for assessing the **environmental impacts** that occur during all stages of a product's life cycle (from cradle-to-grave).*

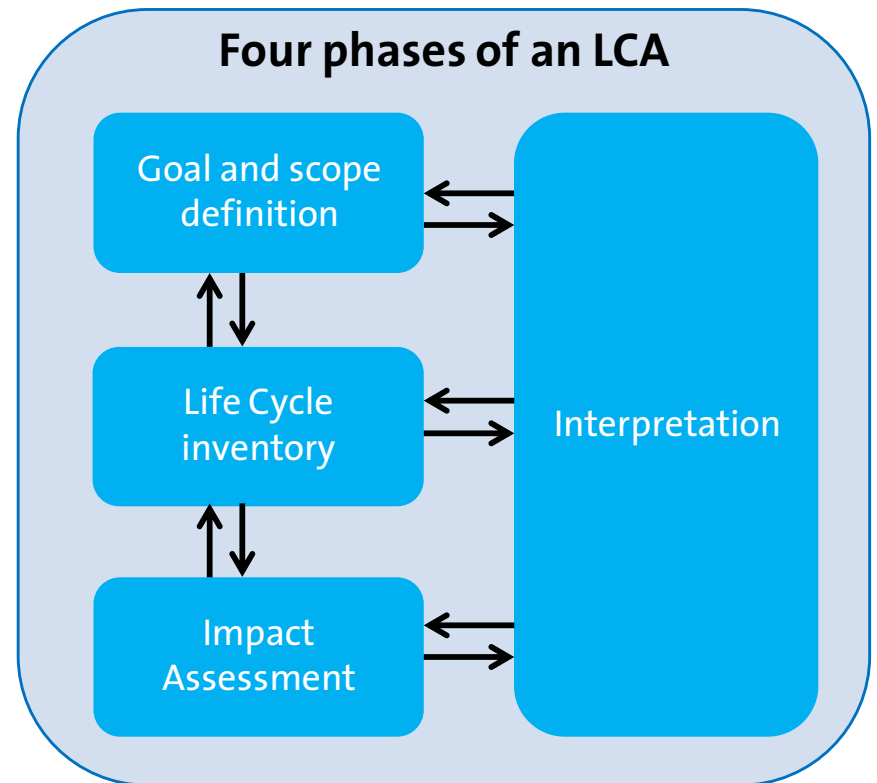
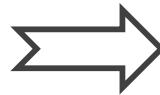
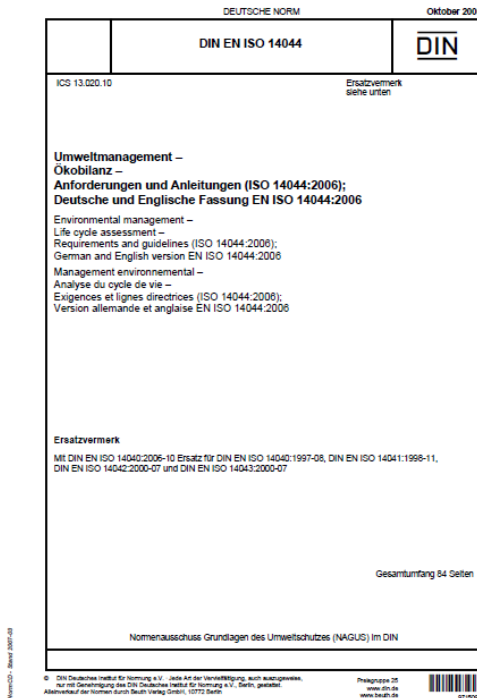


- dates back to the early nineties
- covers approaches like **carbon and water footprints**



# Life Cycle Assessment

- ISO 14040 and 14044 specify how to conduct an LCA study



# What is Social Life Cycle Assessment?

- Technique to assess **social and socio-economic aspects and impacts** along the entire life cycle of products and services
- Basic approach also defined by ISO 14040 and 14044
- In contrast to E-LCA **positive and negative aspects** are included



# Social Life Cycle Assessment?

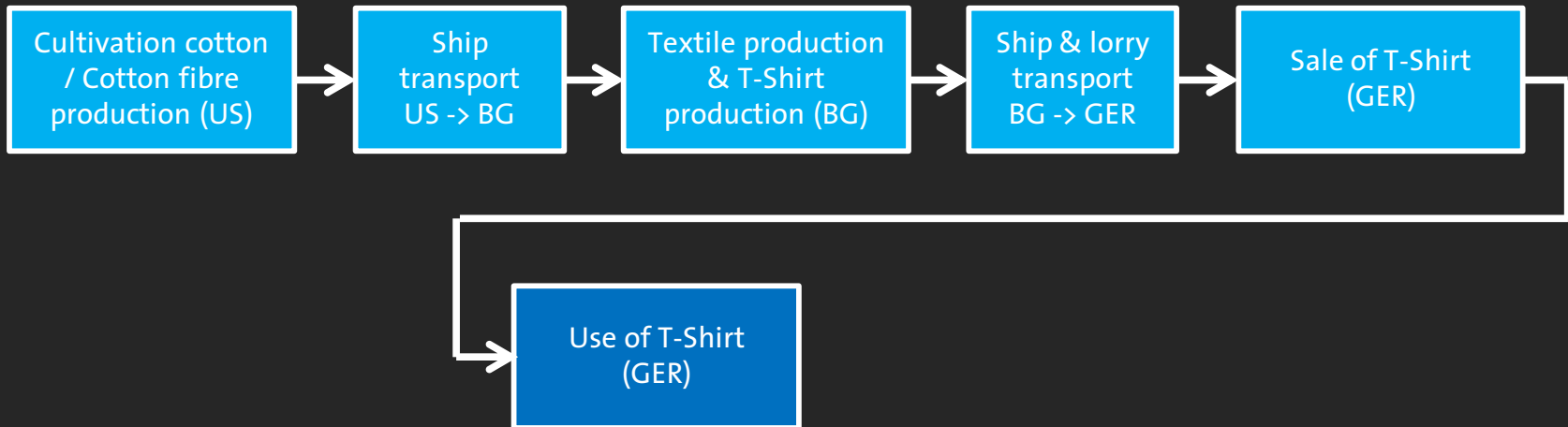
- Impacts on different **stakeholders** are assessed, like *workers, local communities, consumers...*
- Impacts are grouped by different **categories** measured by several **indicators**

WORKERS	Fair salary	Living wage, per month
		Minimum wage, per month
		Sector average wage, per month
	Working time	Hours of work per employee, per day
		Hours of work per employee, per week
		Standard weekly hours
		Standard daily hours
	Discrimination	Occurrence of discrimination
		Women in the labour force
		Men in the labour force
		Gender wage gap
	Health and Safety	Accident rate at workplace
		Fatal accidents at workplace
		Occupational risks
		DALYs due to indoor and outdoor air and water pollution
		Presence of sufficient safety measures
Workers affected by natural disasters		

A photograph of a textile spinning machine, showing a row of white cotton spindles mounted on a wooden frame. The spindles are arranged in a line, and the background is a blurred industrial setting. The image is overlaid with a semi-transparent white banner containing the text.

# Case study: Cotton T-shirt

# Life cycle of **conventional** cotton T-shirt



# Production chain conventional cotton T-shirt



# Case study assumptions

- Conventionally grown cotton
- Plain shirt without print
- Use phase of T-shirt: 5 years
- ...
- Based on data from (literature) research, and databases for background system (ecoinvent and PSILCA)

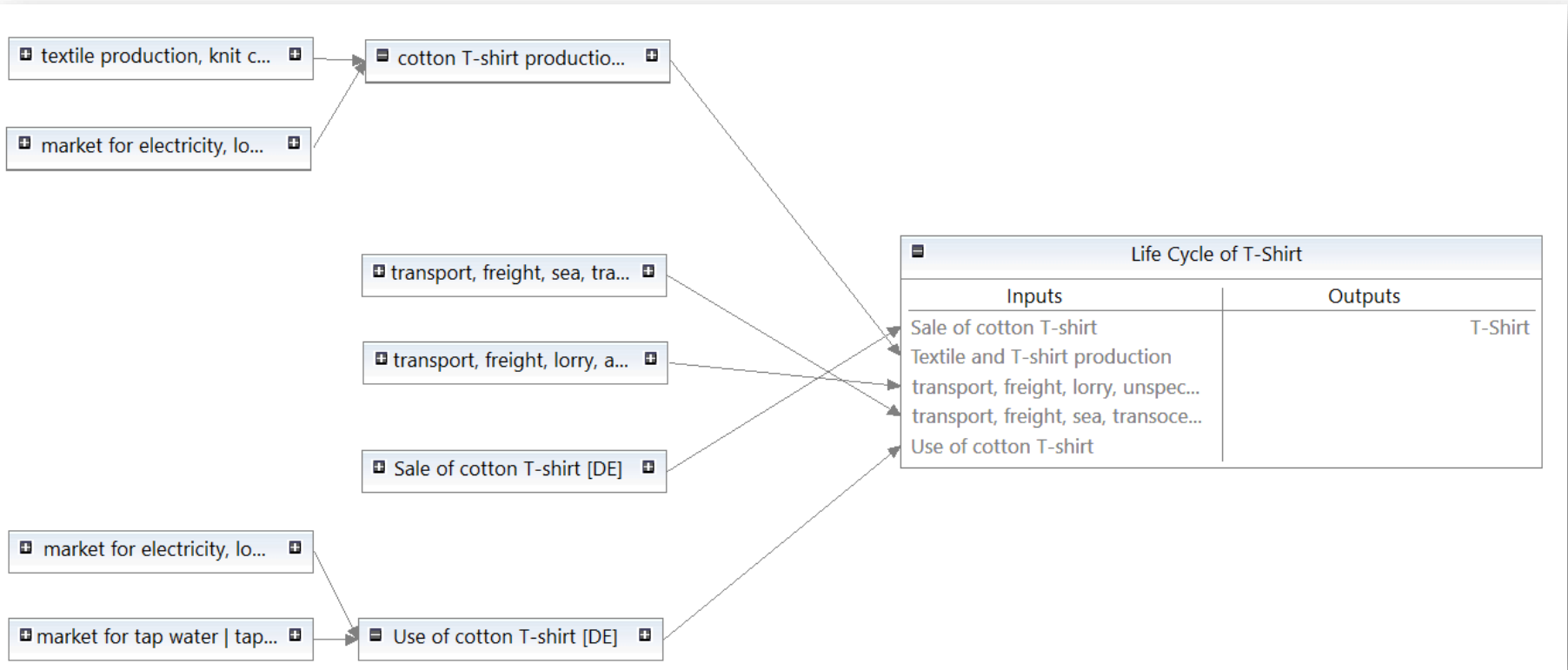
→ see **Appendix** (slide 50)  
for the references used

A photograph showing a row of white ceramic water filters mounted on a wooden shelf. The filters are arranged in a line, and the background is a blurred indoor setting. The text "Case study: Environmental impacts" is overlaid in white on the image.

## Case study: Environmental impacts



# Life Cycle of T-shirt, in software



# Overall environmental results of T-shirt over complete life cycle




## LCIA Results

### LCIA Results

Impact category	Result	Reference unit
Agricultural land occupation	5.03341	m <sup>2</sup> *a
Climate Change	22.54101	kg CO <sub>2</sub> eq
Fossil depletion	5.51497	kg oil eq
Freshwater ecotoxicity	0.74827	kg 1,4-DB eq
Freshwater eutrophication	0.02420	kg P eq
Human toxicity	17.44239	kg 1,4-DB eq
Ionising radiation	5.64224	kg U235 eq
Marine ecotoxicity	0.67453	kg 1,4-DB eq
Marine eutrophication	0.01394	kg N eq
Metal depletion	1.48642	kg Fe eq
Natural land transformation	0.00228	m <sup>2</sup>
Ozone depletion	3.62817E-5	kg CFC-11 eq
Particulate matter formation	0.03509	kg PM10 eq
Photochemical oxidant formation	0.04869	kg NMVOC
Terrestrial acidification	0.08893	kg SO <sub>2</sub> eq
Terrestrial ecotoxicity	0.10651	kg 1,4-DB eq
Urban land occupation	0.16264	m <sup>2</sup> *a
Water depletion	124.74782	m <sup>3</sup>

# Impacts on Climate Change, per life cycle stage

● Impact category ☰ Climate Change ▼

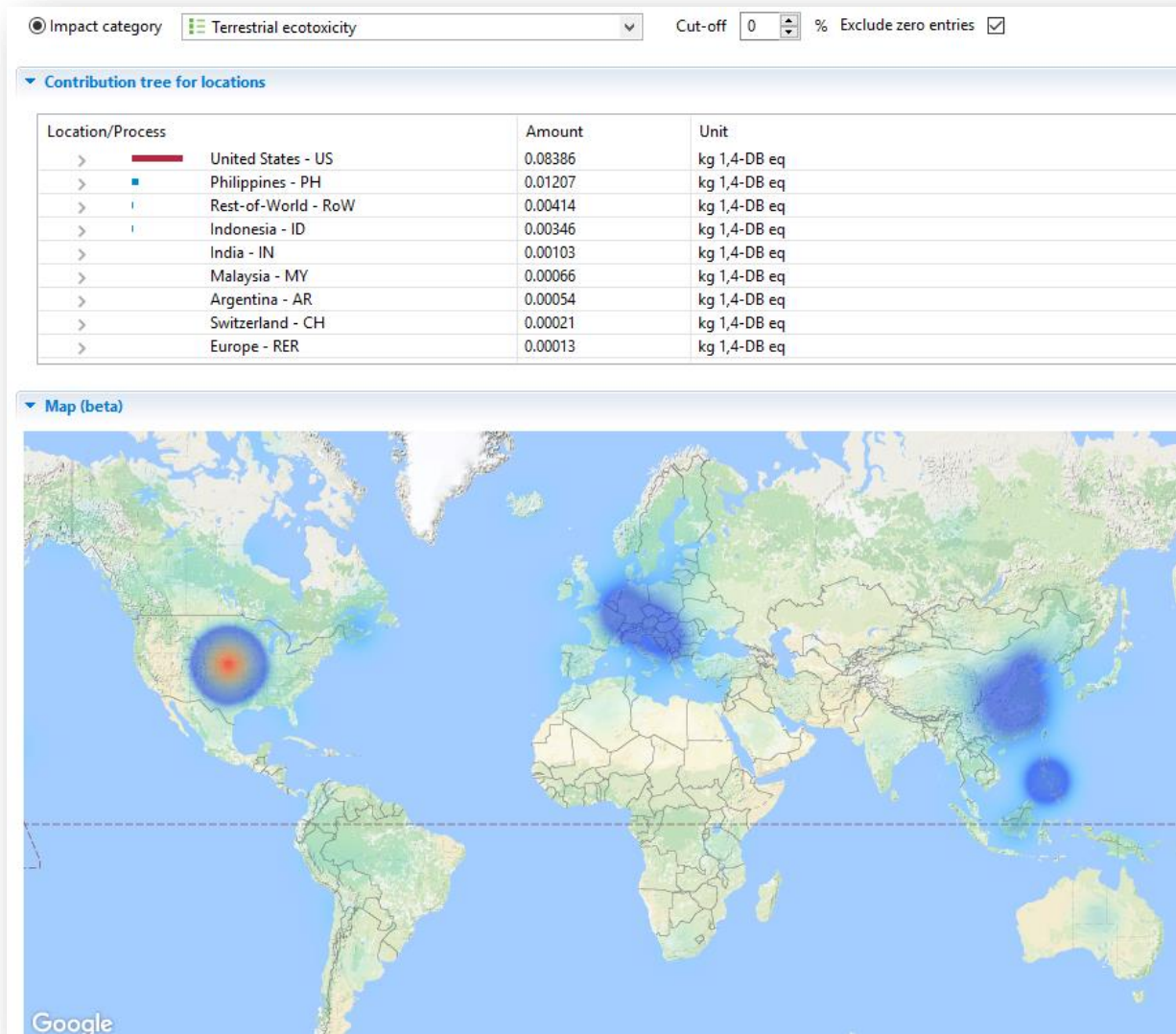
Contribution	Process	Amount	Unit
▼ 100.00%	 Life Cycle of T-Shirt	22.54101	kg CO2 eq
> 63.06%	 Use of cotton T-shirt - DE	14.21378	kg CO2 eq
> 36.02%	 cotton T-shirt production - BD	8.11828	kg CO2 eq
> 00.61%	transport, freight, sea, transoceanic ship   transport, freight, sea, transoceanic ship   cut-off, U - GLO	0.13734	kg CO2 eq
> 00.24%	transport, freight, lorry, all sizes, EURO4 to generic market for transport, freight, lorry, unspecified   ...	0.05448	kg CO2 eq
> 00.08%	Sale of cotton T-shirt - DE	0.01714	kg CO2 eq

# Impacts on Water depletion, per life cycle stage

Impact category: Water depletion

Contribution	Process	Amount	Unit
100.00%	Life Cycle of T-Shirt	124.74782	m3
> 72.69%	Use of cotton T-shirt - DE	90.67900	m3
> 27.08%	cotton T-shirt production - BD	33.78467	m3
> 27.07%	textile production, knit cotton, batch dyed   textile, knit cotton   cut-off, U - BD	33.77092	m3
00.01%	market for electricity, low voltage   electricity, low voltage   cut-off, U - BG	0.01375	m3
> 00.17%	transport, freight, sea, transoceanic ship   transport, freight, sea, transoceanic ship   cut-off, U - GLO	0.20645	m3
> 00.03%	transport, freight, lorry, all sizes, EURO4 to generic market for transport, freight, lorry, unspecified   transport, fre...	0.04285	m3
> 00.03%	Sale of cotton T-shirt - DE	0.03486	m3

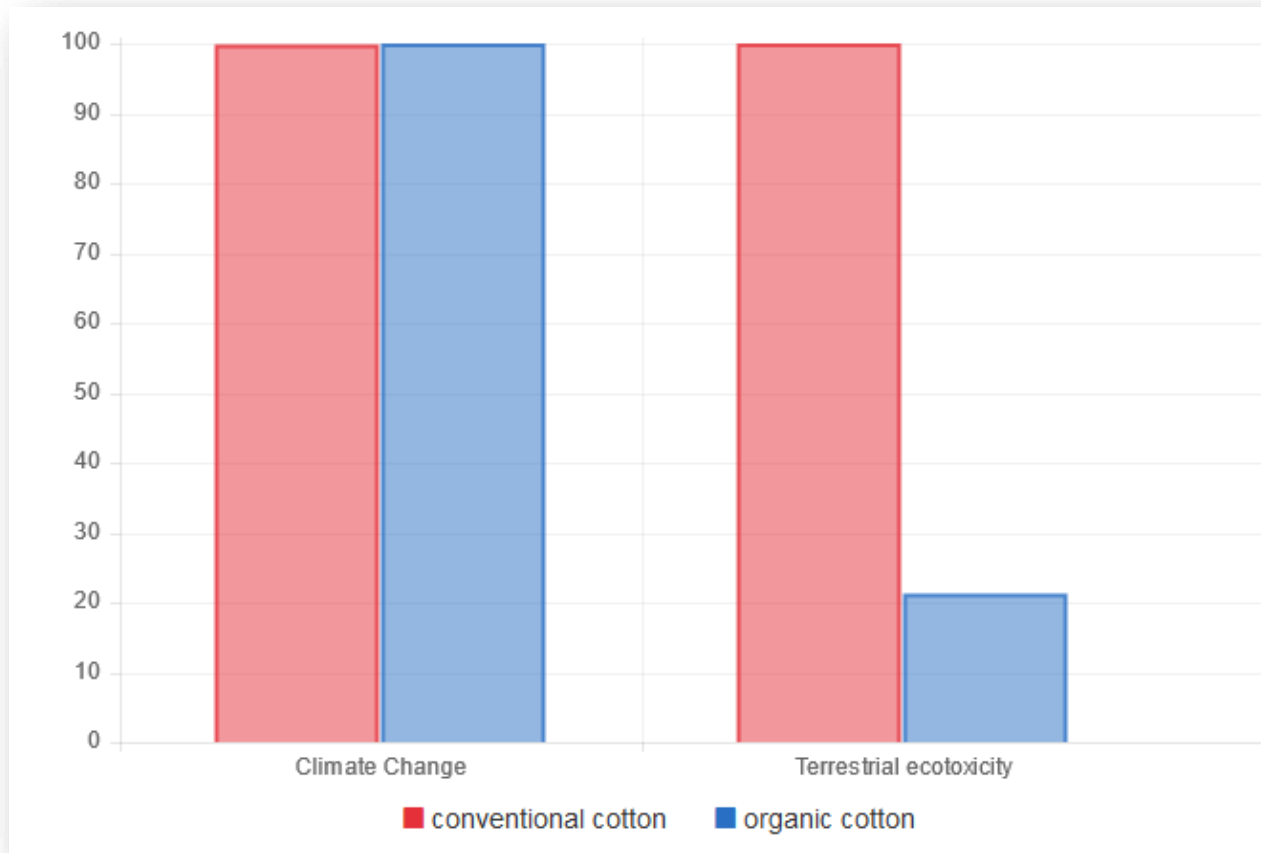
# Localisation of impacts on Terrestrial ecotoxicity



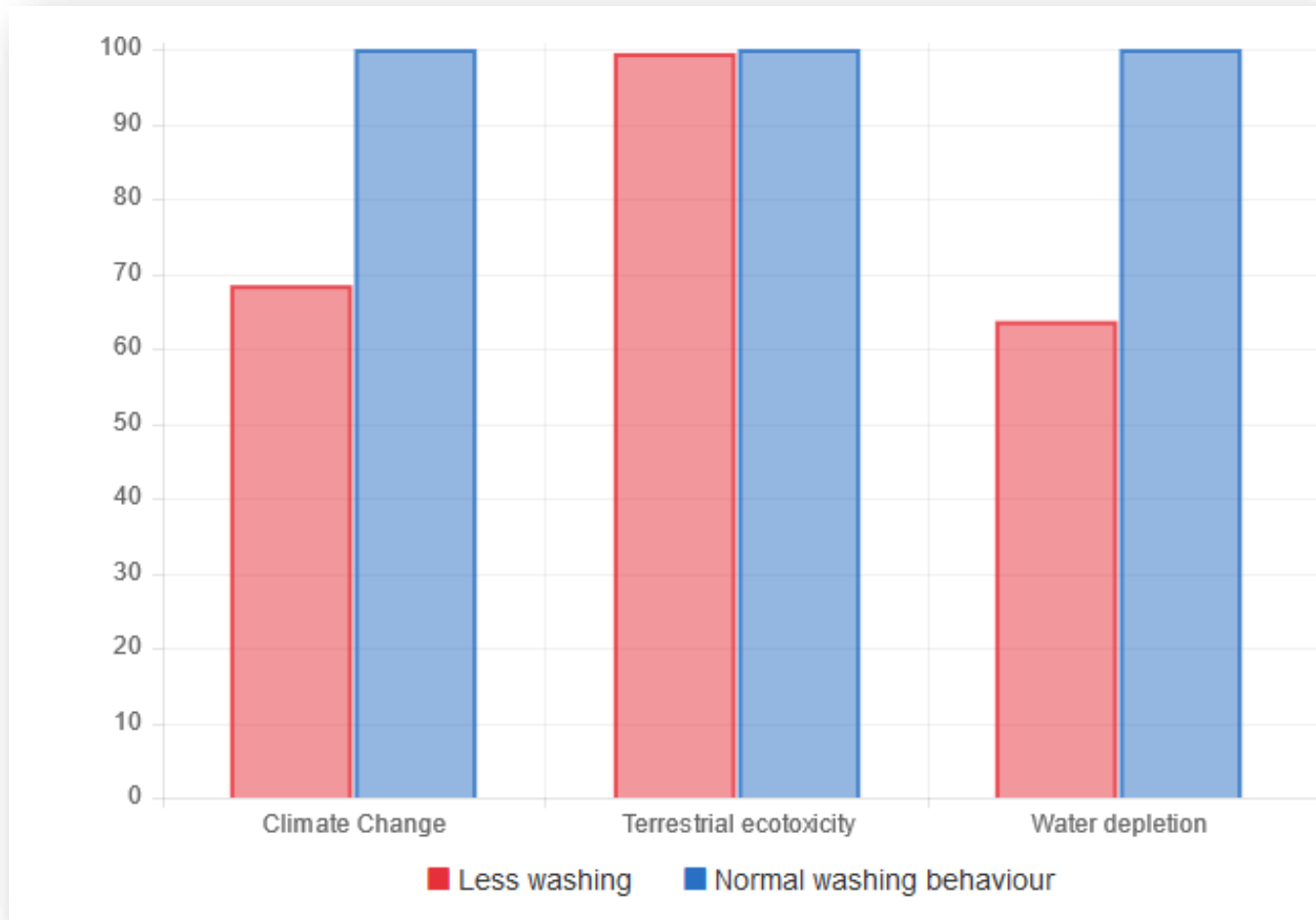


Comparing different scenarios

# Conventional vs. organic cotton growing, both in US

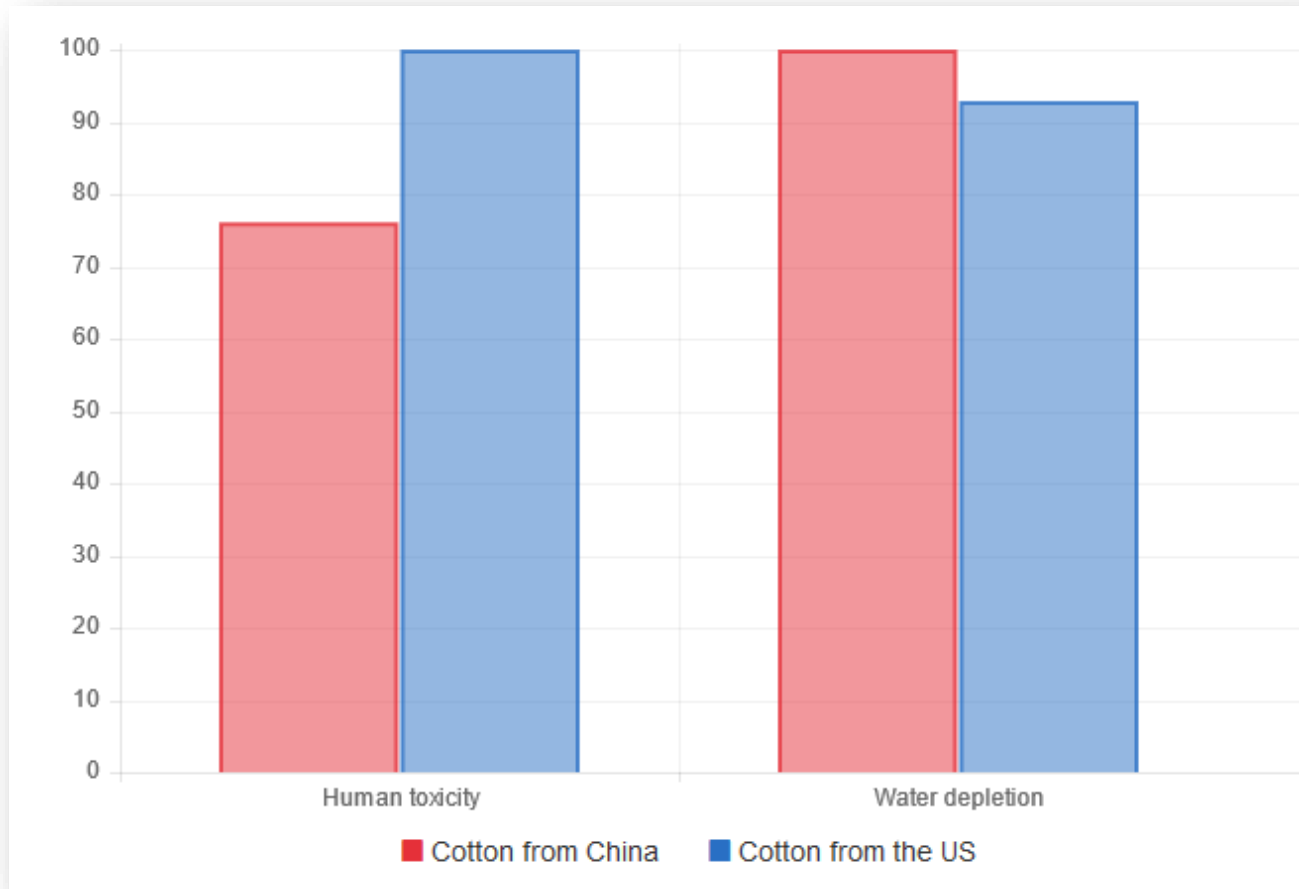


# Washing behaviour: 28 instead of 55 times/year





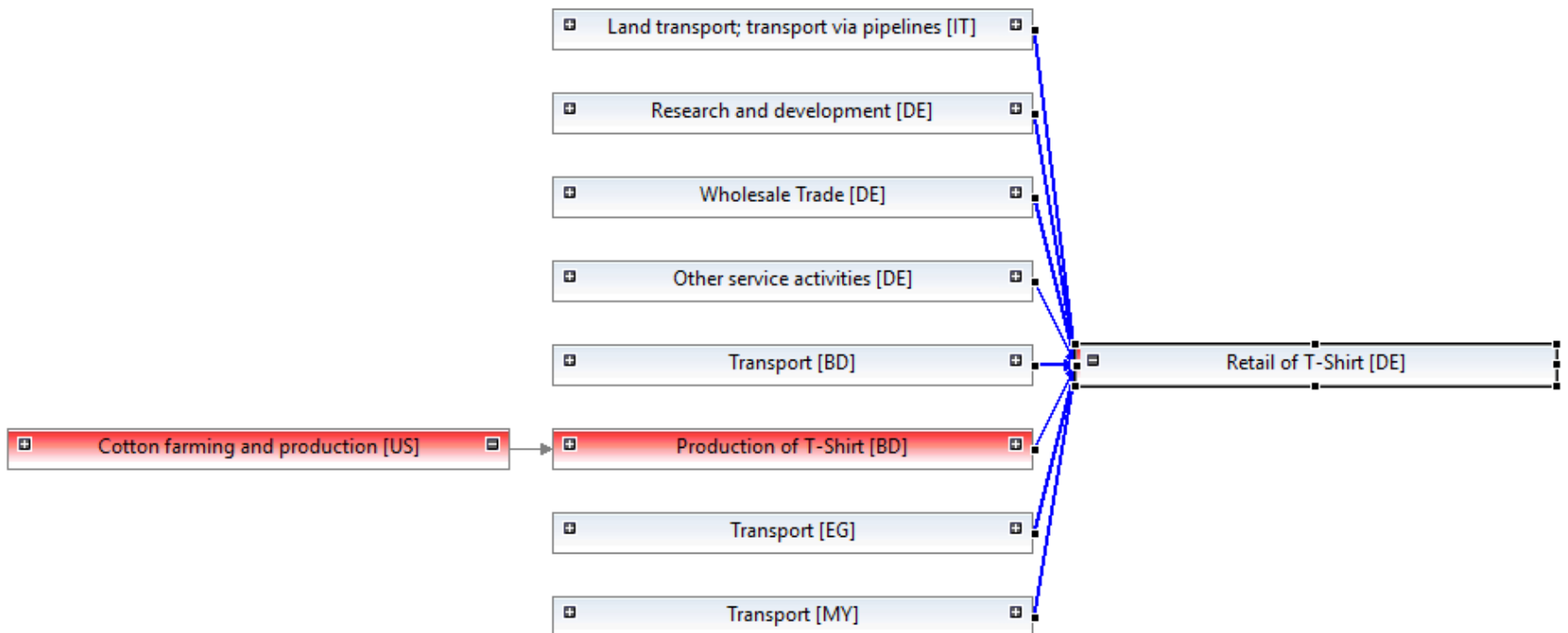
# Cotton growing in the US vs. in China





# Case study: Social impacts

# Foreground system for the S-LCA



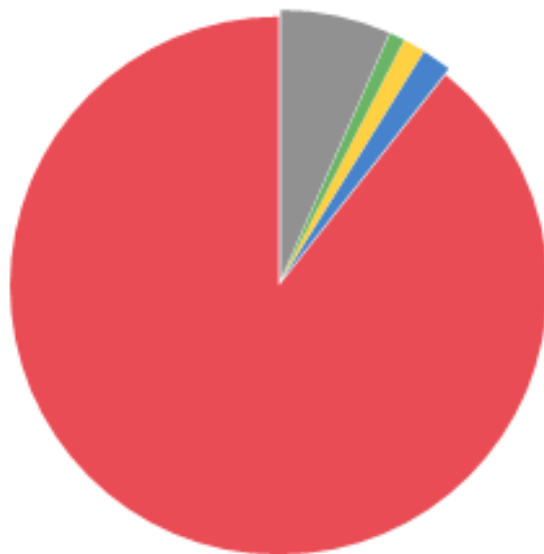
# Direct process contributions to the risk of unfair salaries

- Without calculating process upstream chains

## Direct contributions to impact category results - overview

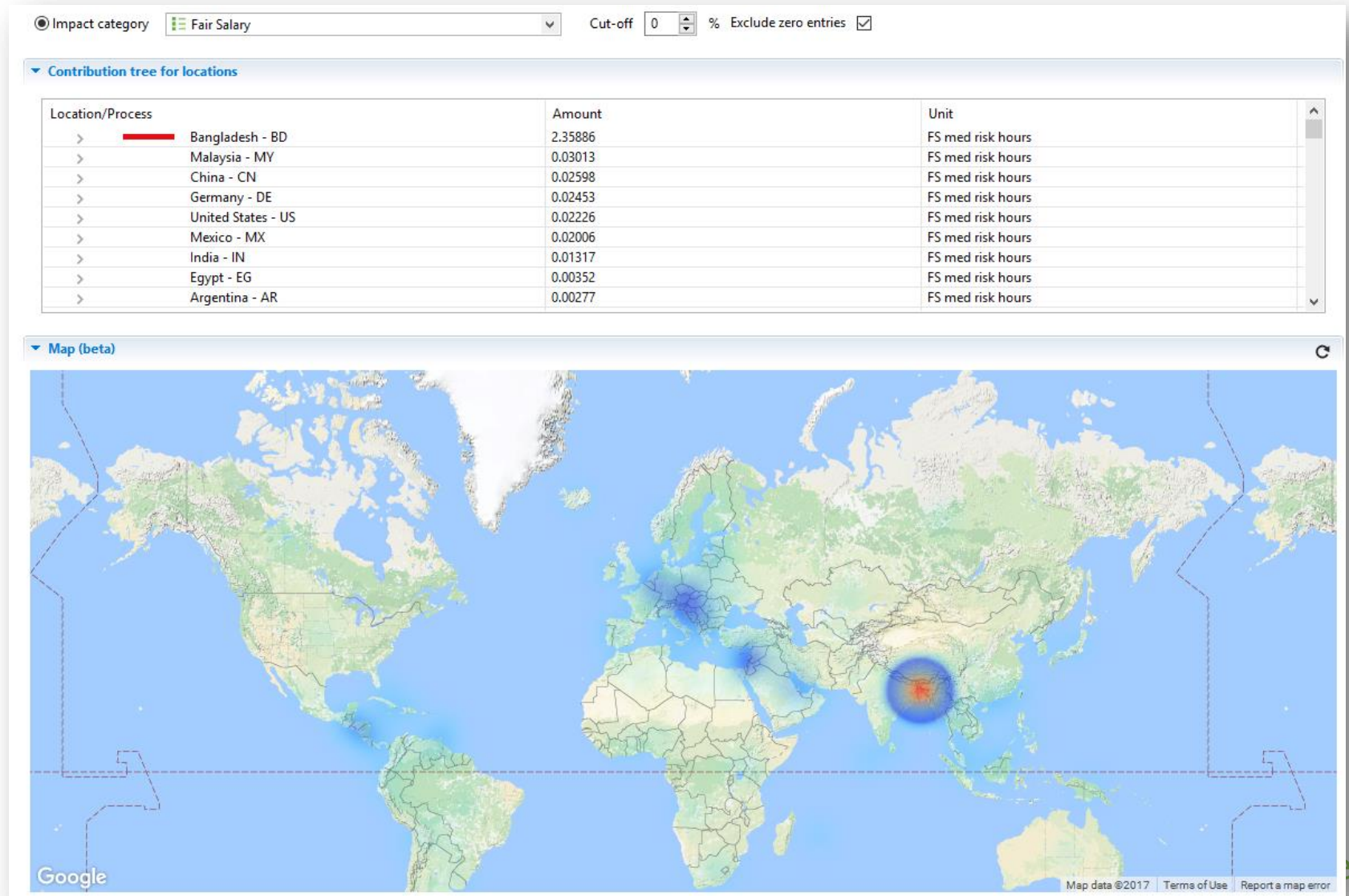
Impact category

Fair Salary



- 2.259 FS med risk hours: Production of T-Shirt - BD
- 0.045 FS med risk hours: Transport - BD
- 0.034 FS med risk hours: Textiles and Wearing Apparel - BD
- 0.023 FS med risk hours: Transport - MY
- 0.167 FS med risk hours: Other

# Social hotspots (countries) regarding the risk of unfair salaries



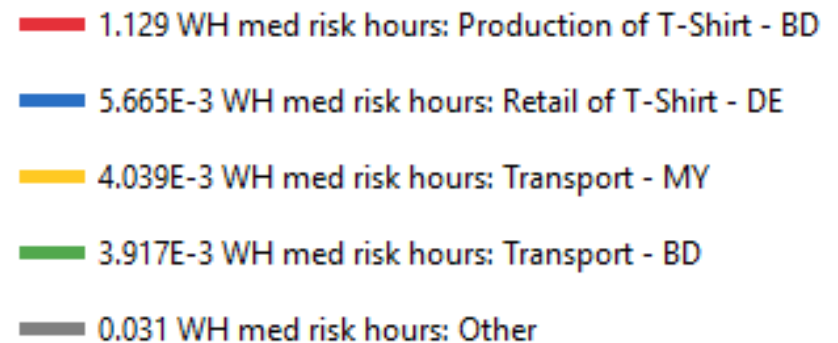
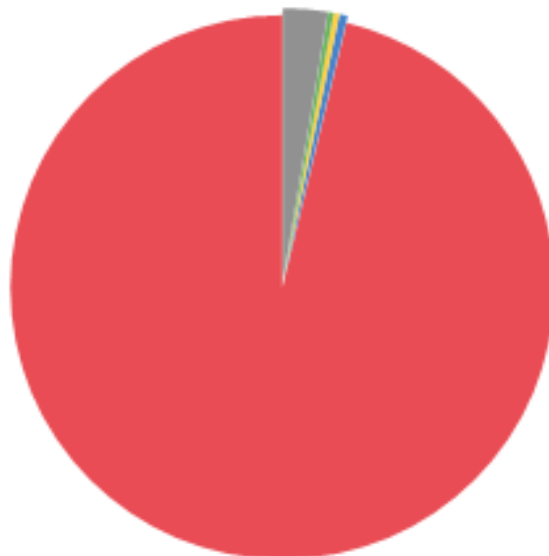
# Direct process contributions to the risk of overtime

- Without calculating process upstream chains

## Direct contributions to impact category results - overview

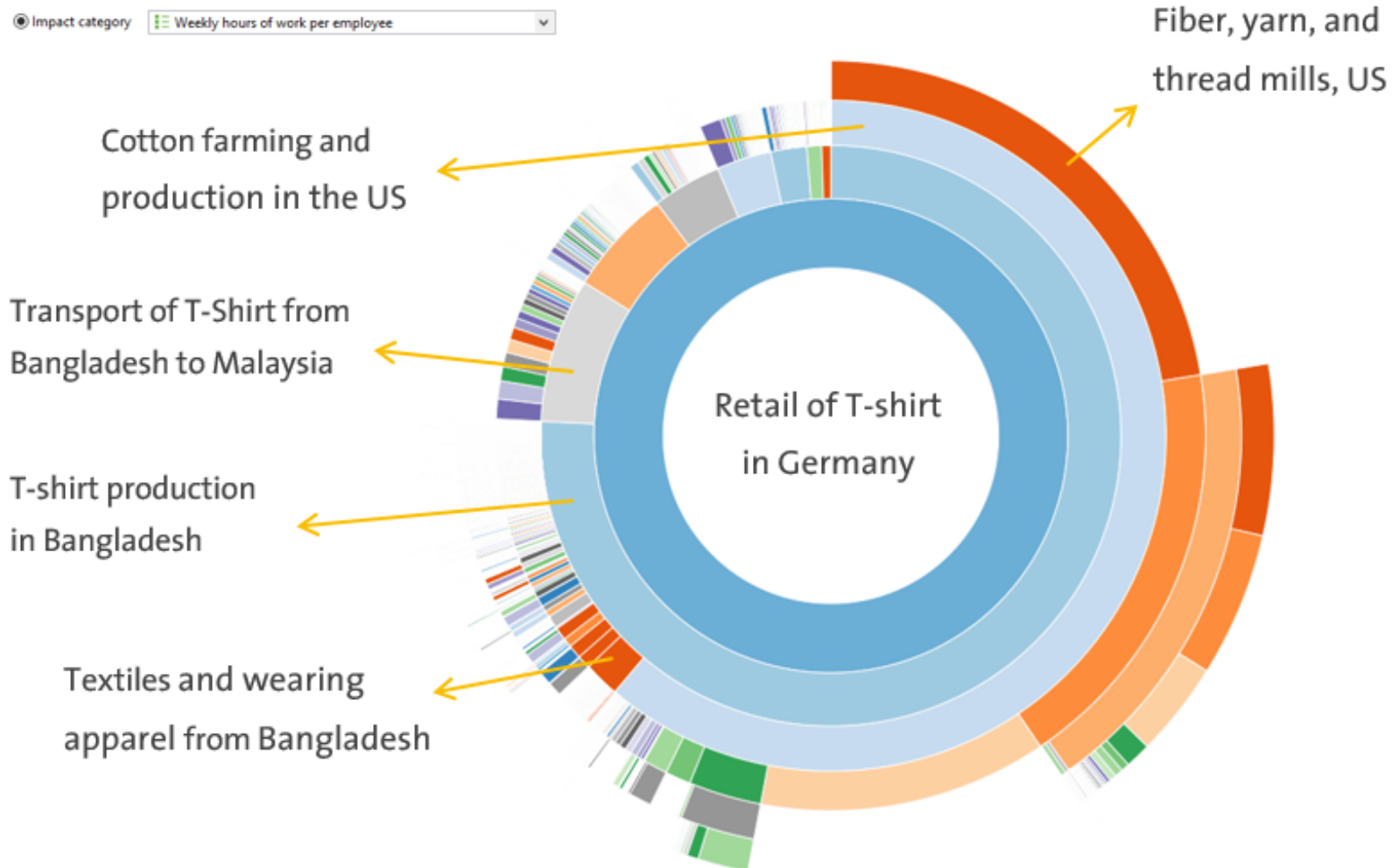
Impact category

Weekly hours of work per employee



# Sun burst diagram for the risk of overtime

- Including process upstream chains



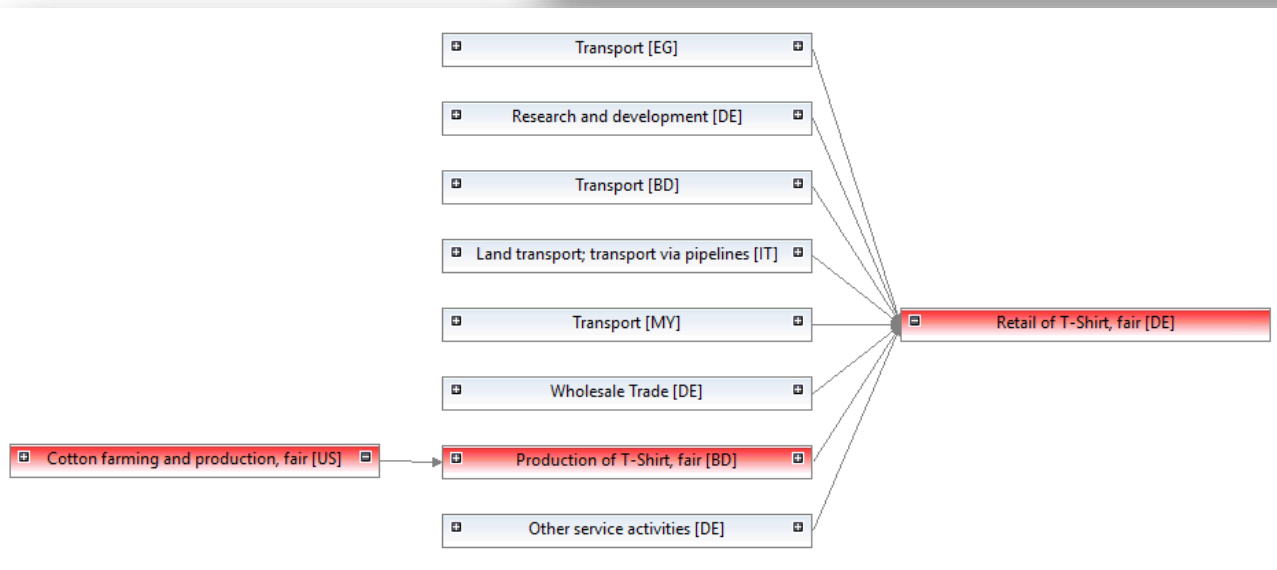
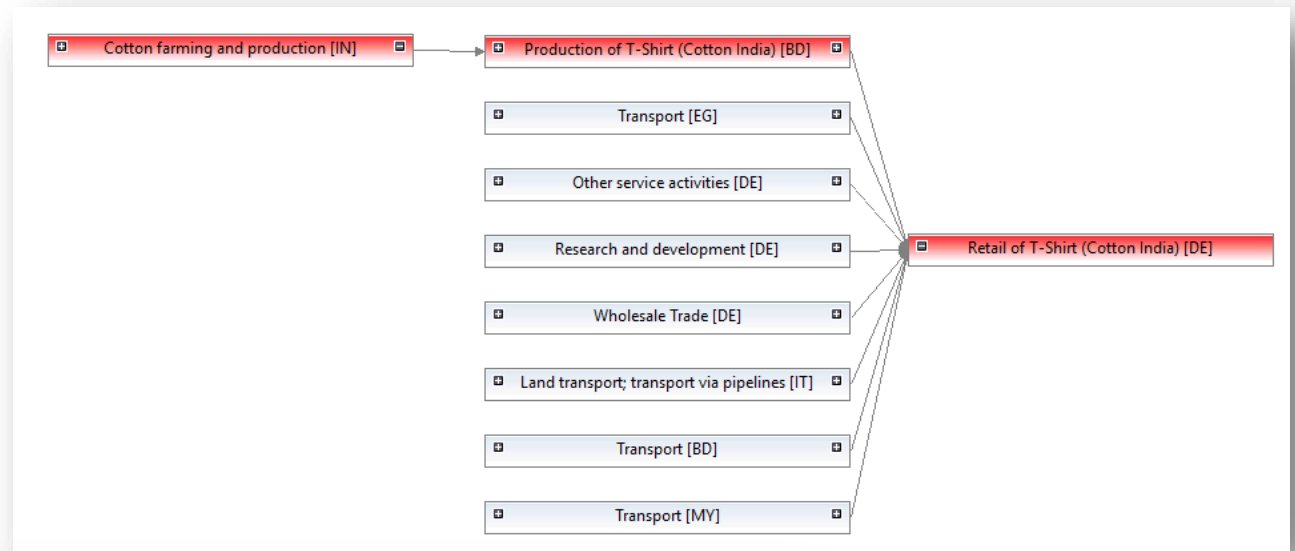


**Comparing different scenarios**



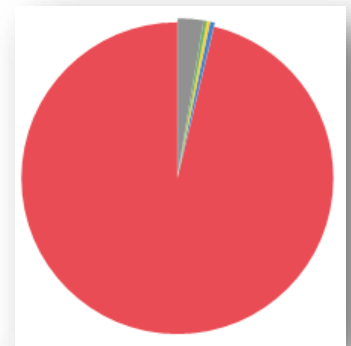
# Foreground systems for other scenarios

## Scenario 2: cotton from India

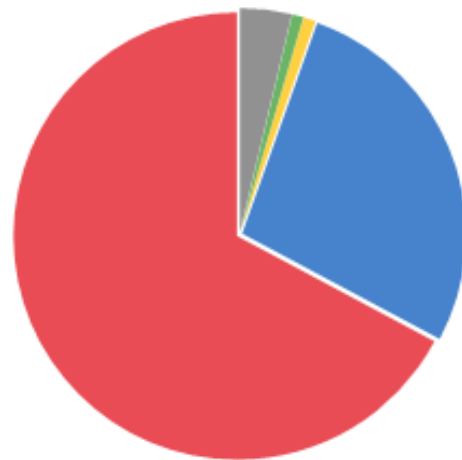


## Scenario 3: „fair“ T-shirt

# Direct process contributions to the risk of overtime



Scenario 2:  
cotton from India



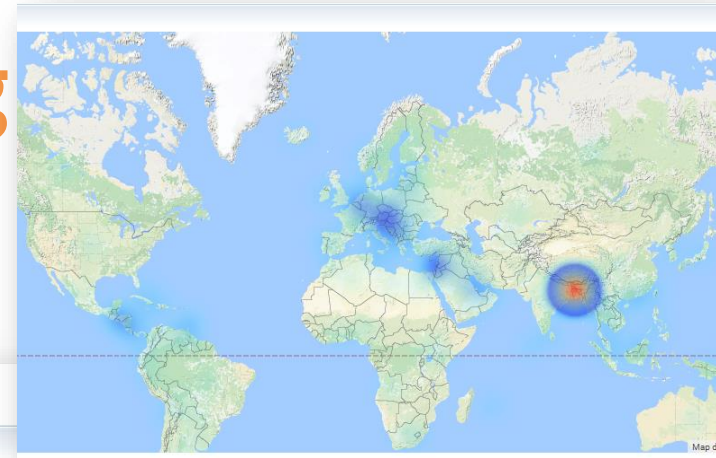
- 1.129 WH med risk hours: Production of T-Shirt (Cotton India) - BD
- 0.460 WH med risk hours: Cotton farming and production - IN
- 0.015 WH med risk hours: Cotton textiles - IN
- 0.014 WH med risk hours: Trade - IN
- 0.063 WH med risk hours: Other



- 0.014 WH med risk hours: Production of T-Shirt, fair - BD
- 5.665E-3 WH med risk hours: Retail of T-Shirt, fair - DE
- 4.039E-3 WH med risk hours: Transport - MY
- 3.917E-3 WH med risk hours: Transport - BD
- 0.031 WH med risk hours: Other

Scenario 3: „fair“ T-shirt

# Social hotspots regarding the risk of unfair salaries

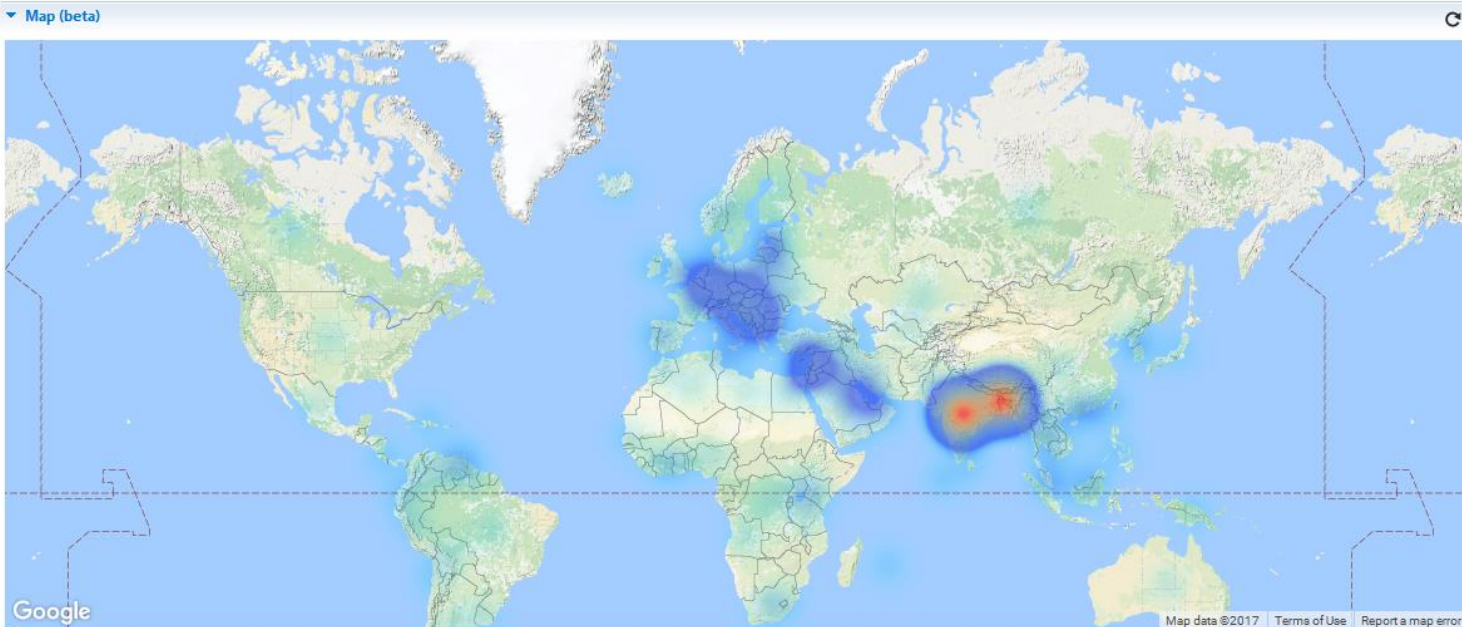


Scenario 1

Impact category: Fair Salary | Cut-off: 0 % | Exclude zero entries:

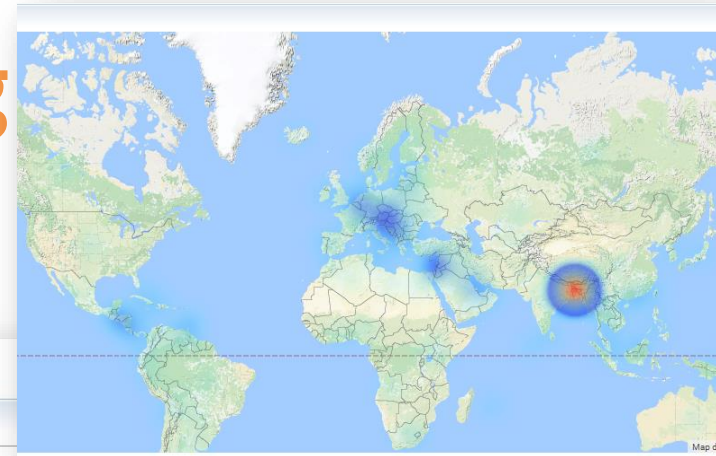
## Contribution tree for locations

Location/Process	Amount	Unit
> India - IN	2.38670	FS med risk hours
> Bangladesh - BD	2.35898	FS med risk hours
> Malaysia - MY	0.03007	FS med risk hours
> Germany - DE	0.02450	FS med risk hours
> China - CN	0.01114	FS med risk hours
> Mexico - MX	0.00494	FS med risk hours
> Egypt - EG	0.00352	FS med risk hours
> Turkey - TR	0.00245	FS med risk hours
> Italy - IT	0.00205	FS med risk hours



Scenario 2:  
cotton from India

# Social hotspots regarding the risk of unfair salaries



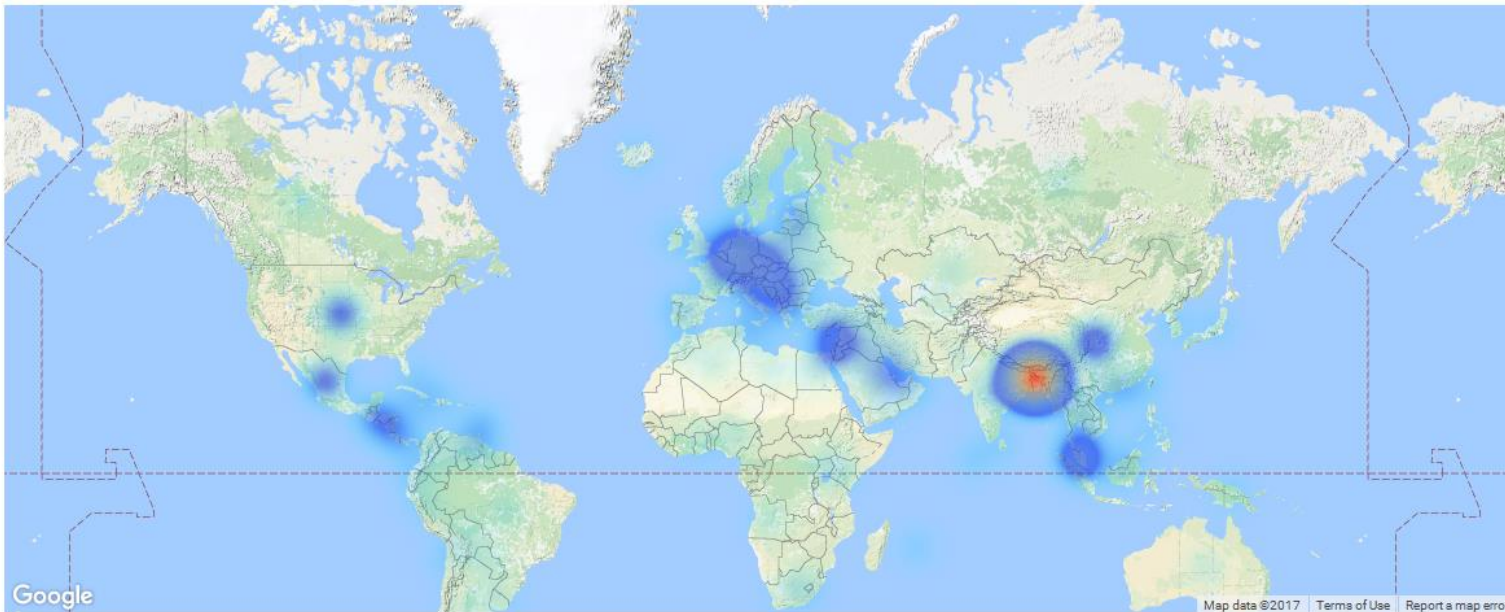
Scenario 1

Impact category: Fair Salary | Cut-off: 0 % | Exclude zero entries:

## Contribution tree for locations

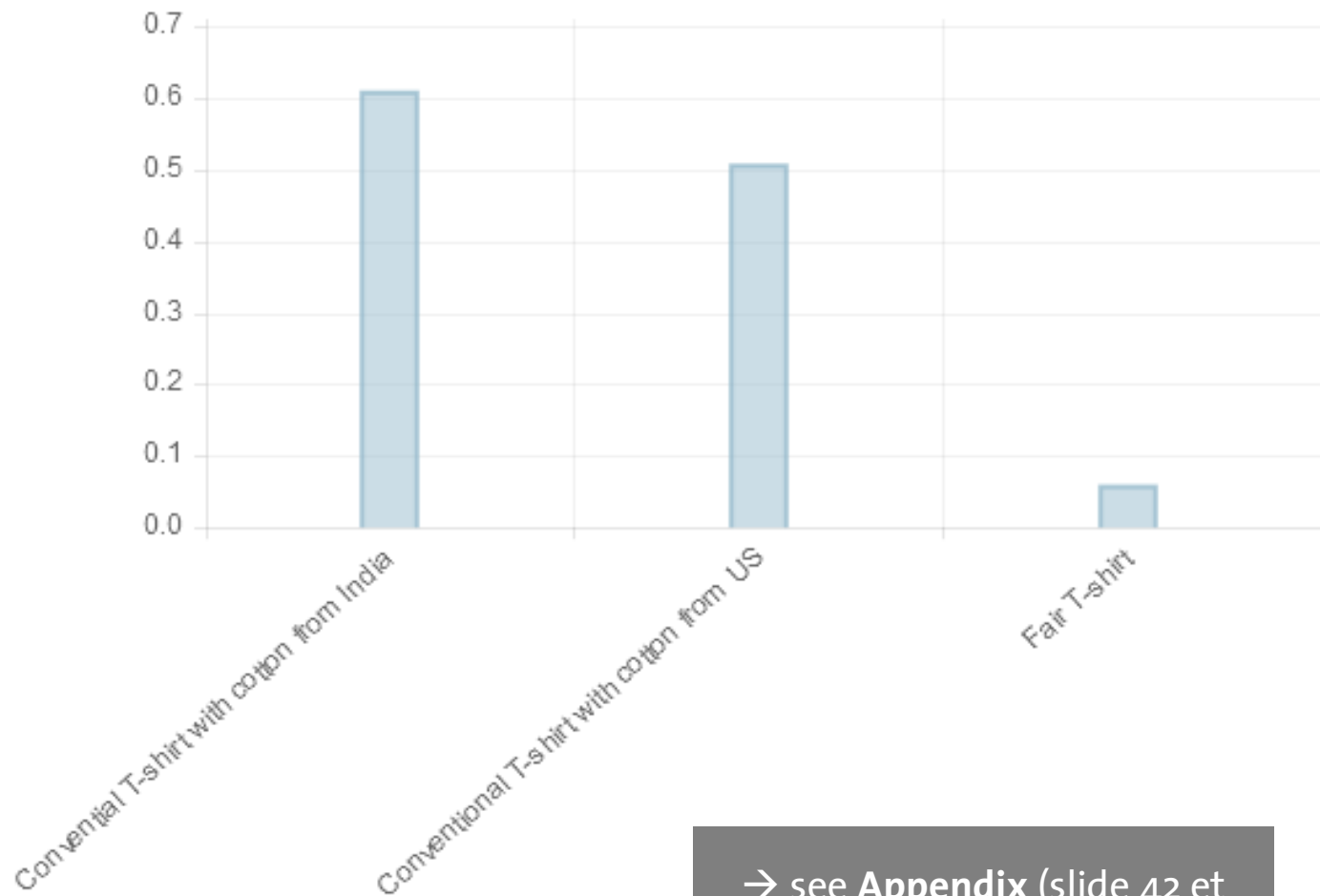
Location/Process	Amount	Unit
> Bangladesh - BD	0.27988	FS med risk hours
> Malaysia - MY	0.03013	FS med risk hours
> China - CN	0.02598	FS med risk hours
> Germany - DE	0.02453	FS med risk hours
> United States - US	0.02226	FS med risk hours
> Mexico - MX	0.02006	FS med risk hours
> India - IN	0.01317	FS med risk hours
> Egypt - EG	0.00352	FS med risk hours
> Argentina - AR	0.00277	FS med risk hours

## Map (beta)



Scenario 2:  
Fair T-shirt

# Comparison of the total risk of Non-fatal accidents



→ see Appendix (slide 42 et seq.) for further comparisons

A horizontal strip of an image showing a row of laboratory bottles on a shelf. The bottles are white with black caps and are arranged in a row. The image is overlaid with a blue gradient that fades from left to right. The text "What to do with the results" is centered over the image in white.

**What to do with the results**

# Benefits of LCA

- Transparent overview of environmental and social impacts over the entire life cycle, including use (and disposal) phase
- Identification of weaknesses and optimization potential of the investigated product
  - Uncover unexpected hotspots
- Efficient way to assess the entire life of a product

# What to do with the results

- Compare different options of products and services → for decision making in product development or improvement
- To compare and benchmark suppliers
- As a basis for certification and labelling
- As a basis for CSR
- Marketing



# GreenDelta

software / data / know-how

## Thank you!

Contact

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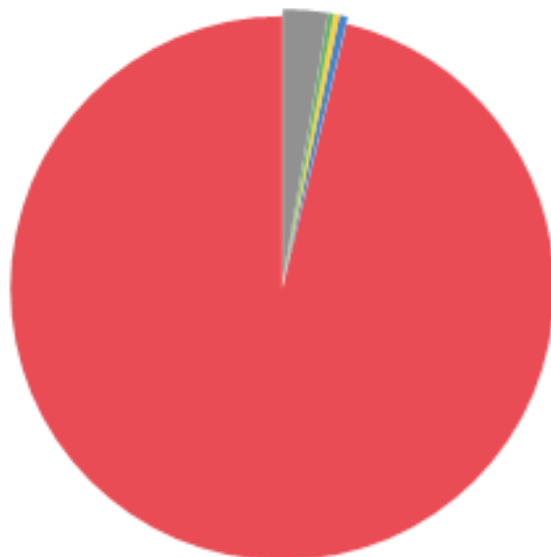
# Appendix 1: Further comparisons of S-LCA scenarios

# Direct process contributions to the risk of overtime

- Scenario 1: Cotton from US

## Direct contributions to impact category results - overview

Impact category



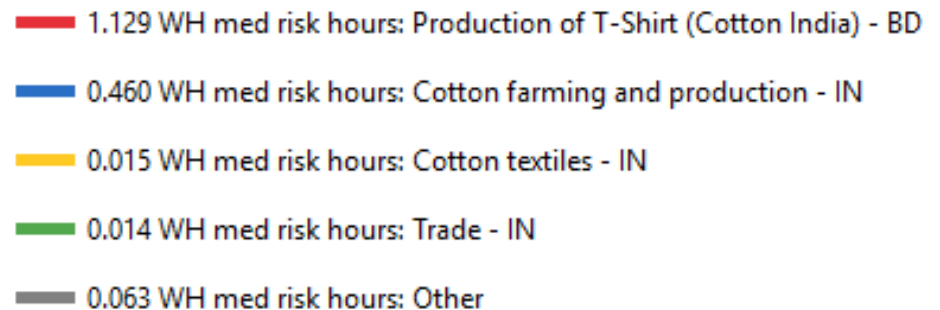
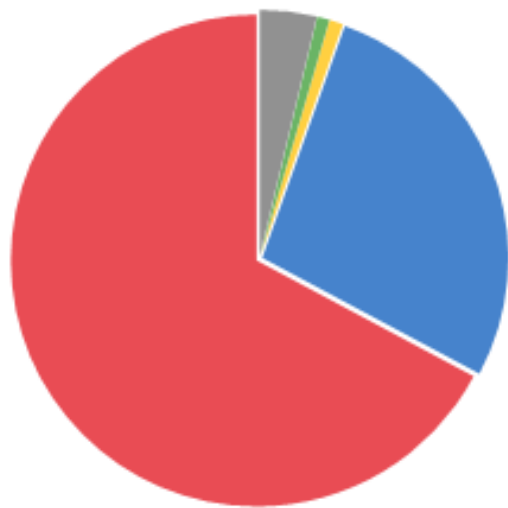
- 1.129 WH med risk hours: Production of T-Shirt - BD
- 5.665E-3 WH med risk hours: Retail of T-Shirt - DE
- 4.039E-3 WH med risk hours: Transport - MY
- 3.917E-3 WH med risk hours: Transport - BD
- 0.031 WH med risk hours: Other

# Direct process contributions to the risk of overtime

- Scenario 2: Cotton from India

## Direct contributions to impact category results - overview

Impact category



# Direct process contributions to the risk of overtime

- Scenario 3: “Fair” T-shirt

## Direct contributions to impact category results - overview

Impact category

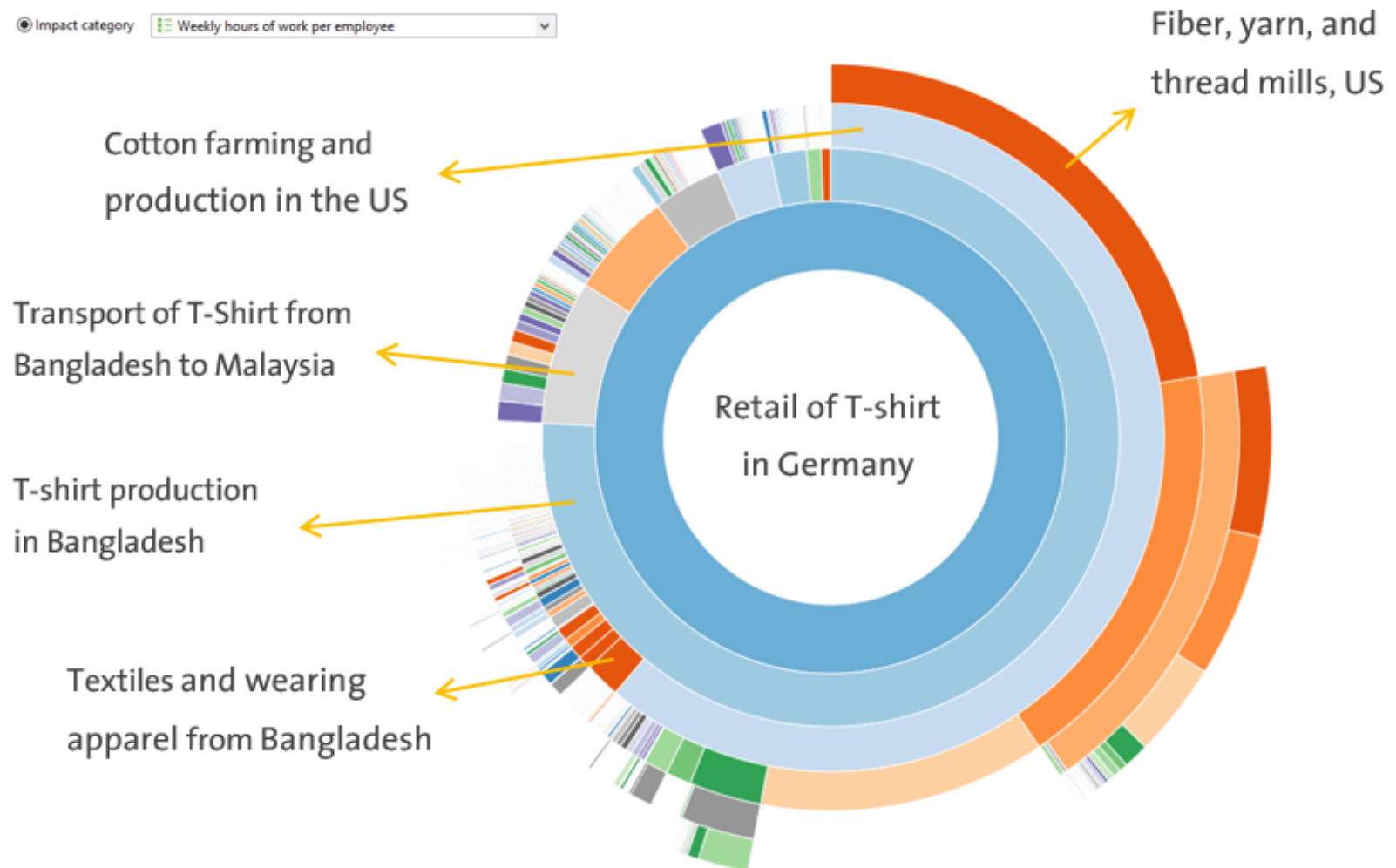


- 0.014 WH med risk hours: Production of T-Shirt, fair - BD
- 5.665E-3 WH med risk hours: Retail of T-Shirt, fair - DE
- 4.039E-3 WH med risk hours: Transport - MY
- 3.917E-3 WH med risk hours: Transport - BD
- 0.031 WH med risk hours: Other

# Sun burst diagram for the risk of overtime

- Scenario 1: Cotton from US

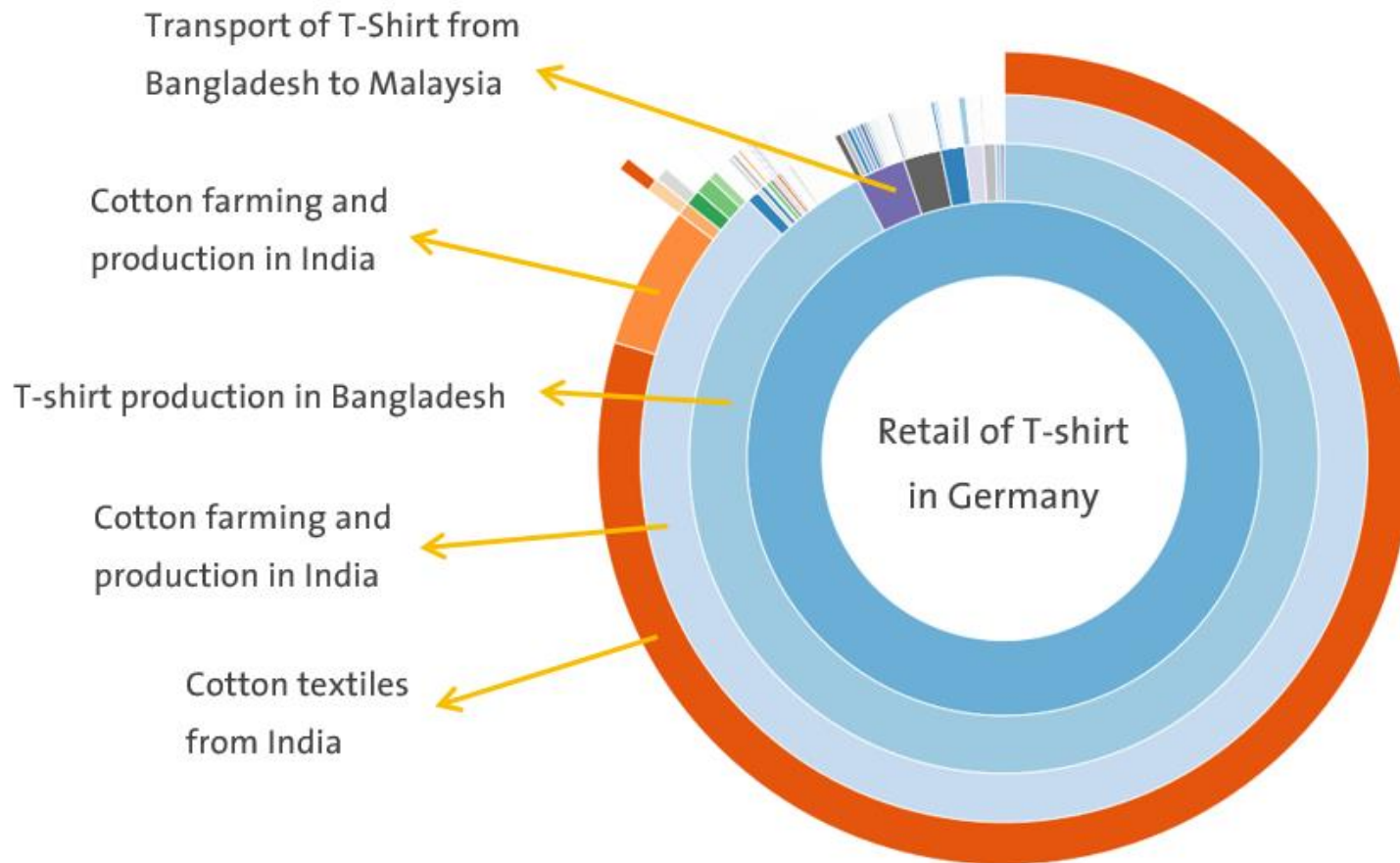
Impact category Weekly hours of work per employee



# Sun burst diagram for the risk of overtime

- Scenario 2: Cotton from India

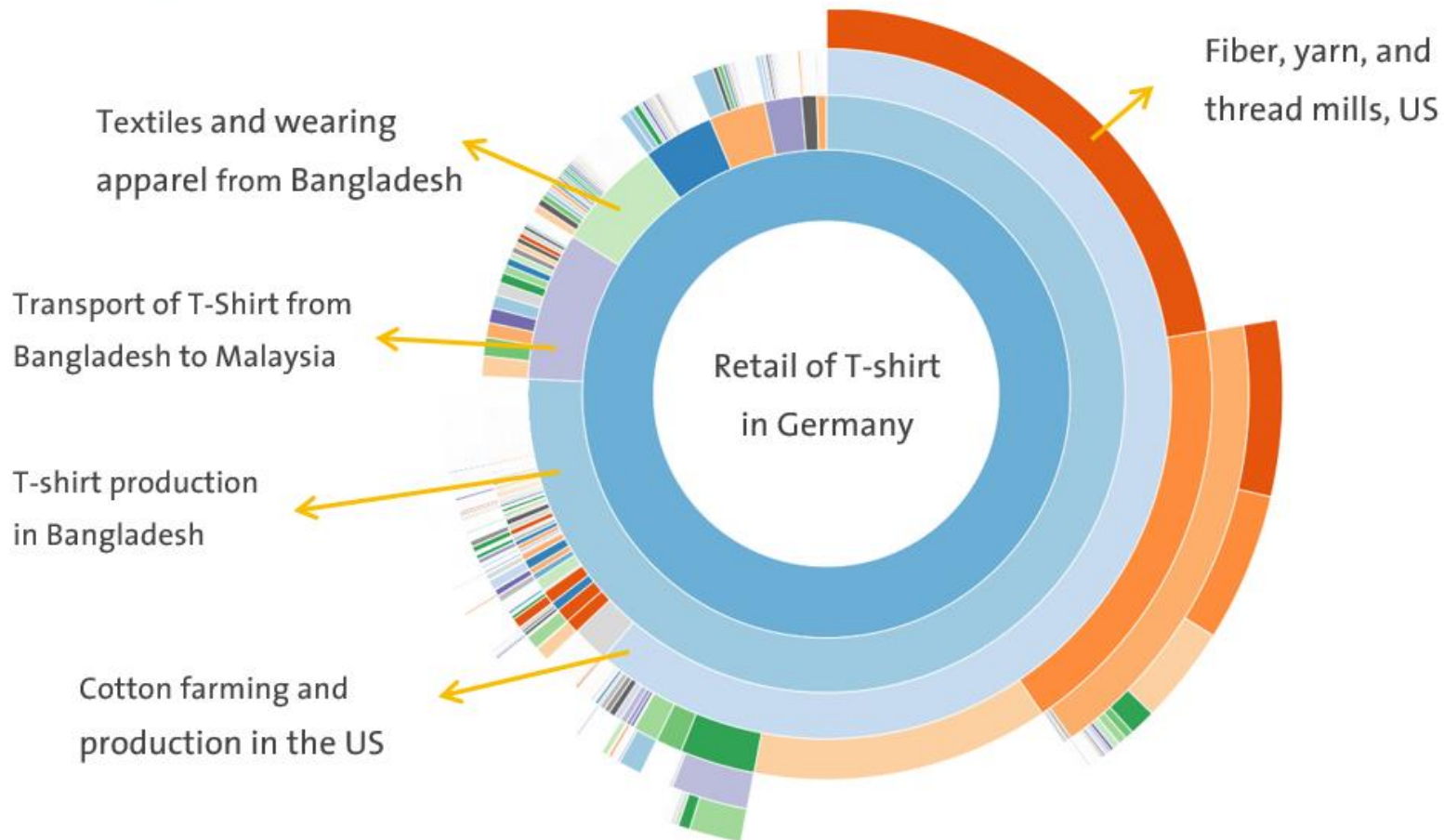
Impact category Weekly hours of work per employee



# Sun burst diagram for the risk of overtime

## Scenario 3: "Fair" T-shirt

Impact category: Weekly hours of work per employee







**Appendix 2: Literature used for  
case study**

- Transportation route, weight of T-shirt, prices of components and processes, working conditions in production sites: Uchatius, W. (2010): *Das Welthemd*. In Zeit Online. <http://www.zeit.de/2010/51/Billige-T-Shirts/seite-2> (last access: 25/01/2017)
- Assumptions from organic cotton production: Murugesh Babu, K., Selvadass, M. (2013): *Life Cycle Assessment for Cultivation of Conventional and Organic Seed Cotton fibres*. In: International Journal of Research in Environmental Science and Technology. ISSN 2249–9695.
- Cotton yield: National Cotton Council of America (2016): *Cotton Production Costs and Returns: United States*. <http://www.cotton.org/econ/cropinfo/costsreturns/usa.cfm> (last access: 25/01/2017)
- Electricity consumption of sewing machine: Stromverbrauch im Haushalt (2016): *Nähmaschinen – Stromverbrauch*. <http://www.stromverbrauch-haushalt.de/naemaschine-berechnen.html> (last access: 25/01/20017)
- Water consumption of washing machine: Waschmaschine.net (2017): *Wasserverbrauch einer Waschmaschine*. <http://www.waschmaschine.net/wasserverbrauch/> (last access: 25/01/2017)
- Electricity consumption of washing machine, Number of washing cycles per year: Stromverbrauch info (2017): *Stromverbrauch von Waschmaschinen* <http://www.stromverbrauchinfo.de/stromverbrauch-waschmaschinen.php> (last access: 25/01/2017)
- Definitions for S-LCA: Benoit, C. et al. (2009): UNEP/SETAC Life Cycle Initiative: *Guidelines for social life cycle assessment of products*. [http://www.unep.fr/shared/publications/pdf/DTIx1164xPA-guidelines\\_sLCA.pdf](http://www.unep.fr/shared/publications/pdf/DTIx1164xPA-guidelines_sLCA.pdf) (last access: 25/01/2017)
- Wages in Bangladesh, Price breakdown of a T-shirt: Deutscher Gewerkschaftsbund Bezirk Nord (2014): *Made in Hell. Textilproduktion in Bangladesch*. <http://sh-nordwest.dgb.de/++co++c324b84c-6b1c-11e4-8538-52540023ef1a/#3> (last access: 25/01/2017)
- Wages in Bangladesh: Clean Clothes Campaign (2013): *Bangladesh Minimum Wage*. <https://cleanclothes.org/livingwage/bangladesh-minimum-wage> (last access: 25/01/2017)
- World map (slide 14): <https://pixabay.com/de/karte-der-welt-internationale-1042847/> (last access: 25/01/2017)