GreenDelta

LCA CASE STUDY

Organic cotton sweater

OpenLCA Version: 1.11.0

Date: 20 September 2022

Marie Loubert
loubert@greendelta.com

Table of Contents

List of figures

List of tables

Abbreviations

EF Environmental Footprint

LCA Life Cycle Assessment

LCI Life Cycle Inventory

LCIA Life cycle Impact Assessment

PEF Product Environmental Footprint

Introduction

It is currently estimated that the clothing sector represents between 2 and 10 % of the environmental impacts of Europeans, a number which is bound to increase as the consumption of garments has accelerated over the last decades (European Parliament, 2019). Cotton is widely used for fabric for clothes, with over 20 million tons of cotton fiber produced every year worldwide (FAO, 2022). The most important producers of this cotton are China, India and the United States. Even though the production of polyester dominates, cotton represents an important part of the market, estimated at 24% on 2020 (Textile Exchange, 2021). The production of conventional cotton has significant impacts on the environment, due to the large amounts of water and pesticides it requires. As most of consumers and manufacturers are becoming aware of those impacts, alternatives such as organic cotton are more and more popular. India is by far the most important producer of organic cotton, producing 50% of fibers worldwide, followed by China and Kirghizstan (Textile Exchange, 2021).

Holistic approaches such as life cycle assessment (LCA) are widely used to assess the impacts of products and processes. LCA studies found in literature (S. Rana, 2015; Shah, 2018) comparing conventional and organic cotton show that organic cotton performs overall better. The reduction of impacts is particularly significant for Eutrophication and Global Warming potentials. However, organic cotton products have their own impacts and challenges, which need to be identified to act accordingly. Therefore, the object of this study a hooded sweatshirt made with organic cotton, produced in India. Figure 1 shows a typical example of such product.

Figure 1: Organic cotton hooded sweatshirt (source: https://en.zalando.de/)

This case study complies with ISO 14040 (ISO, 2006), and thus consists of four major phases:

- Goal and Scope,
- Inventory Analysis,
- Impact Assessment,
- Interpretation and conclusions.

A goal definition is first performed in order to identify why the study is done, what problems it is supposed to tackle and who will use the results of the LCA. The goal definition sets the context of the LCA study and is the basis of the scope definition. In this second step the functions of the products are defined, as well as the system boundary. The scope highlights precisely which processes are included in the life cycle assessment and what are the geographical and temporal boundaries of the system. The impact assessment method used is also defined. In this study, the EF3.0 method from the Environmental Footprint initiative is used. Once the context and limits of the study are set, a life cycle inventory (LCI) is carried out. The goal of this step is to collect information about the physical flows entering and leaving the system and to create a model accordingly. In this study the product is modelled in openLCA, and the database used is EcoInvent 3.8 cut-off. Finally, a life cycle impact assessment is made, which assess the overall environmental impacts for the categories previously defined. Recommendations and conclusions are drawn from the contribution of processes and life cycle stage to the global impacts of the product.

I. Goal and Scope

Goal

This study has two intended goals. The first one is to identify the stages of the life cycle of the hooded sweater that contribute the most to its environmental impacts. The second one is to assess the variability of those impacts depending on the production site or the behavior of the user. This LCA is carried as an internal request from GreenDelta, to provide openLCA users with a guided case LCA study.

In this study, the results only cover the categories of the method EF 3.0.

Functional unit

The functional unit chosen for this study is "1 organic cotton 2XL hooded sweater, with a weight of 750g, used for 1 year". It is assumed that the product is worn twice a week and that it is washed once a week. The sweater is therefore washed 52 times in 1 year.

System boundary

The product is assessed in a cradle-to-grave system, from the extraction of raw materials to the disposal of the used product. The extraction of raw materials and pre-processing consist of the production of the cotton fabric, the zipper, and polyester resin. This life cycle stage, as well as the manufacturing stage, take place in India. The product is then exported to Berlin where it is used and disposed. The system boundary of the system as well of the foreground processes are illustrated Figure 2.

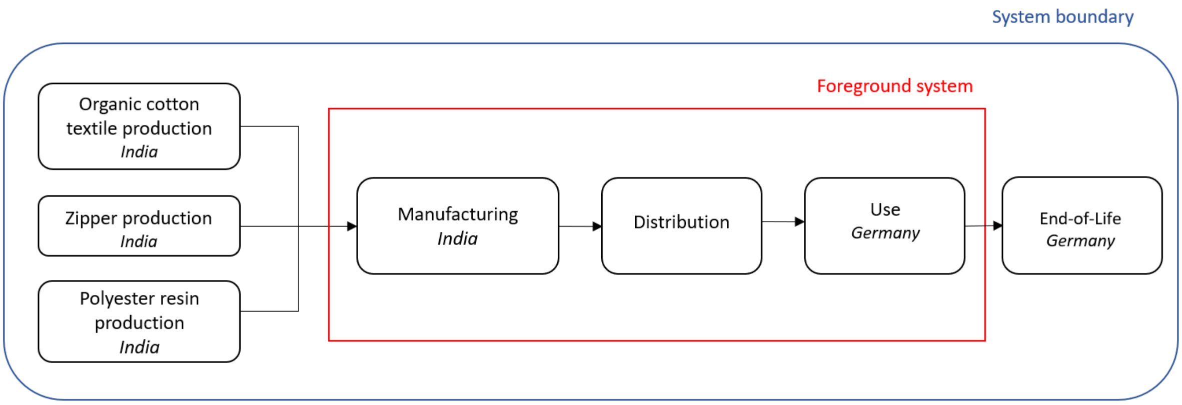

Figure 2:System diagram

Scenarios

This LCA studies a product manufactured in India, as it is the most important producer of organic cotton worldwide. The model is downscaled to two location of production: Maharashtra and Odisha. These two regions are part of the top producers of organic cotton in India (Jadhav, 2022).

Additional scenarios are investigated regarding the behavior of the user. The base case illustrates a realistic use of a washing machine in Germany (Rüdenauer, 2008), corresponding to a washing of 3.8 kg of clothes on average, over the 6kg capacity of the machine. The alternative scenario models an idealistic use of the washing machine, with a full load of 6kg of clothes. The frequency of use is also expected to influence the life cycle impacts and is thus assessed in Scenario 3, with a washing every two weeks instead of every week. The last scenario considers a case where the sweater is tumble-dried after the washing instead of air-dried. Table 1 summarizes the state of the parameters for all four scenarios.

Table 1: Parameters of the model depending on the scenario treated

	Manufacturing	Washing machine load	Number of washes	Type of drying
Base case	Maharashtra	3.8 kg	52	Air
Scenario 1	Odisha	3.8 kg	52	Air
Scenario 2	Maharashtra	6 kg	52	Air
Scenario 3	Maharashtra	3.8 kg	26	Air
Scenario 4	Maharashtra	3.8 kg	52	Tumble-dryer

LCIA Method

The LCIA method is the Environmental Footprint 3.0. The impact categories assessed in this study are the following:

- Acidification (mol H+ eq),
- Climate change (kg CO2 eq),
- Ecotoxicity, freshwater (CTUe),
- Eutrophication, marine (kg N eq),
- Eutrophication, freshwater (kg P eq),
- Eutrophication, terrestrial (mol N eq),
- Human toxicity, cancer, in Comparative toxic unit for humans (CTUh),
- Human toxicity, non-cancer (CTUh),
- Ionizing radiation, human health (kBq U-235 eq),
- Land Use,
- Ozone depletion (kg CFC11 eq),
- Particulate matter (disease incidence),
- Photochemical ozone formation, human health (kg NMVOC eq),
- Resource use, fossils (MJ),
- Resource use, minerals and metal (kg Sb eq),
- Water use (m3 deprived water).

Assumptions and limitations

The weight portion of the fabric, the zipper and the polyester resin were estimated from own calculations. The amount of packaging during the distribution stage was also assumed. The washing machine is assumed to be a type C with a load capacity of 6 kg. The manufacturer of the sweater is assumed to be located 50 km from the production site of the fabric.

This LCA has limitations regarding the quality of data. Indeed, as the product and its manufacturer are fictious, no primary data was collected. Background data use global processes for the supply chains of the zipper and the polyester resin. The production of organic cotton fabric is modelled with a process in India that does not allow differentiation between the two regions of the scenarios. No recycling or reuse was modelled for the End-of-life stage. This limitation is a result of the lack of data regarding the percentages of reused and recycled textiles in Germany, as well as the complexity of the recycling process at the time being. The waste of textile is thus modelled as market for municipal waste in Germany.

II. Life cycle inventory

This section provides a description and the corresponding modelling of each life cycle stage. The overall structure of the model is illustrated in Figure 3. The full LCI can be found in the annex. The database used for this LCA is Ecoinvent 3.8, Cut off.

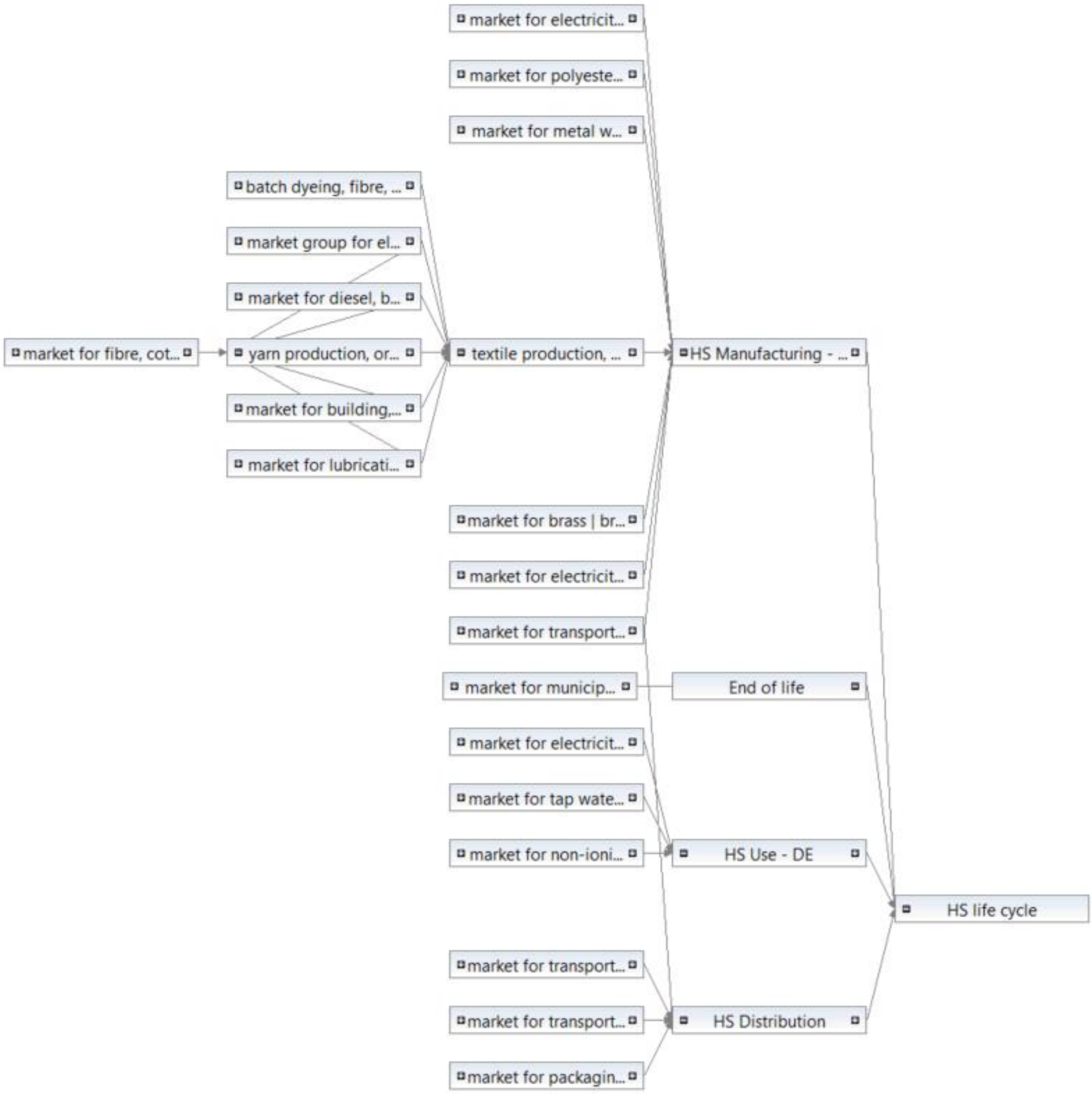

Figure 3: Model graph of the product

Raw materials extraction and pre-processing

The hooded sweater is composed of a cotton fabric, a brass zipper, and polyester resin to glue these two elements together. The brass used for the zipper contains 70% of copper and 30% of zinc. The weight of each element is defined as follows:

w_{resin} = Volume * density = 2,4 cm^3 * 8,55 g/cm^3 = 20,52 g

w_{zipper} = Volume * density = 16,6 cm^3 * 1,4 g/cm^3 = 23,24 g

$w_{fabric} = w_{Sweater} - w_{resin} - w_{zipper}$ = 706,24 g

The volumes are estimated based on own measurements.

The organic cotton fabric results from several processes. The seed cotton is cultivated and goes through ginning. The cotton fiber is then transformed to a yarn by a spinning process. The modelling of this process is adapted from *Yarn production, cotton, ring spinning | yarn, cotton | Cutoff, U-IN,* using fibres of organic cotton instead of conventional cotton. The waste is assumed to be 5% of the finished yarn. The yarn is then knitted, and batch died. The textile and yarn waste are estimated to represent 2.5% of the produced fabric (Maeen Md. Khairul Akter, 2022). The yarn production, knitting and dyeing are assumed to take place in the same location in this study.

The polyester resin and the zipper are modelled with global data as no data were available for India specifically. Both processes include the transportation to the manufacturing site.

Manufacturing

The manufacturing takes place in India, in the two different regions specified above. The fabric is cut, sewed, and assembled with the rest of the raw materials. The textile waste from cutting the fabric is estimated to represent 11,8 % of the fabric input. The amount of electricity needed for this stage is estimated from an LCA for textiles and clothing (Eryuruk, 2015). The distance between the manufacturer and the fabric producer is assumed to be 50 km. The transportation of Metal working of copper was used as a proxy to model the transformation of brass into a brass zipper.

Distribution

The finished product is transported from India to Berlin. The distances travelled by truck and by boat are assessed using the Product Environmental Footprint (PEF) recommendations (EC, 2021):

- 1000 km by truck (>32 t, EURO 4), for the sum of distances from harbour to factory outside and inside Europe;

- 11401.18 km and 13.31 km of boat transport on sea and inland respectively, calculated by Sea Rates calculator (Sea rates, 2022).

Use

The use of the product consists of the washing of the sweater.

A process was modelled with 1 kg of washed clothes as its main output. The amount of soap and tap water used during a cycle were retrieved from the Ecoinvent process *Washing, drying and finishing laundry | washing, drying and finishing laundry | Cutoff, U.* However, to be able to differentiate the scenarios with a tumble-dryer, the electrical consumption of the washing machine was taken from a detailed LCI of textiles (Steinberger, 2009). The washing machine is modelled as a type C machine with a capacity of 6 kg. The washing temperature is assumed to be 60 Celsius degrees.

The total input of washed clothes over the lifetime of the sweater is defined by the formula:

$$Weight_{total} = Weight_{sweater} * \text{Number of washes} * \text{Machine capacity} / \text{Filling}$$

The weights are expressed in kilograms. The number of washes is 52 is the base scenario. *Machine capacity* is assumed to be 6 kg. The parameter *Filling* represents the actual amount of clothes filled in the washing machine, expressed in kilograms. It is estimated at 3.8 kg in the base scenario, according to the average load in Germany (Rüdenauer, 2008). Scenario 2 illustrates an optimum use of the washing machine with a load ("filling") of 6 kg.

End of Life

The worn-out sweater is assumed to be treated as municipal waste. The process *Market for municipal solid waste | municipal solid waste | Cutoff, U – DE* is used for the modelling. Due to lack of data no recycling or reuse is considered, which is a limitation to this study.

III. Life cycle impact assessment

Hotspot analysis

The impact results for the base case, calculated with the method EF3.0, are detailed in Table 2.

Table 2: Impacts results for one sweater of 0.750g, in organic cotton, for one year

Impact categories	Value	Units
Acidification	1.42E-01	mol H+ eq
Climate change	2.60E+01	kg CO2 eq
Ecotoxicity, freshwater	7.42E+02	CTUe
Eutrophication, freshwater	3.37E-02	kg P eq
Eutrophication, marine	1.20E-01	kg N eq
Eutrophication, terrestrial	4.08E-01	mol N eq
Human toxicity, cancer	2.05E-08	CTUh
Human toxicity, non-cancer	2.78E-07	CTUh
Ionising radiation	2.68E+00	kBq U-235 eq
Land use	7.02E+02	Pt
Ozone depletion	9.37E-07	kg CFC11 eq
Particulate matter	6.58E-07	disease inc.
Photochemical ozone formation	8.15E-02	kg NMVOC eq
Resource use, fossils	3.31E+02	MJ
Resource use, minerals and metals	3.60E-04	kg Sb eq
Water use	1.59E+01	m3 depriv.

The contribution of each life cycle stage to the total impacts are illustrated in Figure 4. It can be seen from this contribution analysis that most of the environmental impacts are due to the use phase as well as the extraction and pre-processing of raw materials. The contribution of manufacturing, distribution and end of life is not significant.

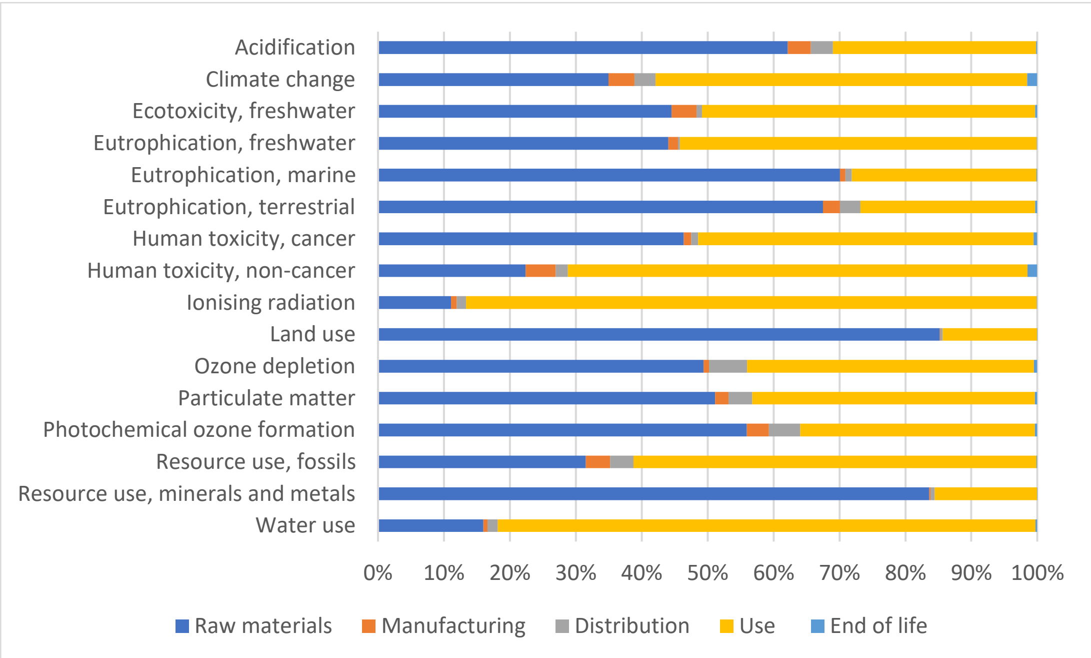

Figure 4: Contribution of the life cycle stages to the overall impacts of the product

The impacts of the raw materials are the results of several factors. The resource use of minerals and metals is particularly significant for the raw materials stage due to the extraction and working of brass to produce the zipper of the sweater. The land footprint mainly originates from the cultivation of cotton requires arable lands. The acidification impacts come from the production of seed-cotton, but also from diesel burning within the dyeing process. The marine and terrestrial eutrophication, as well as the freshwater eutrophication, result mainly from the cultivation of cotton. For terrestrial eutrophication, a significant part of the impacts also come from the fuel consumption in the dyeing process. Regarding the climate change impacts, the burdens are divided between yarn production, due to its electrical consumption, and batch dyeing, due its electrical and fuel consumption. The impacts on ozone come mostly from batch dyeing, while particles particularly form during the cultivation of seed-cotton.

The use phase is the most important contributors to a lot of the categories, particularly Ionising radiation and water use. The first one is due to the consumption of electricity by the washing machine, and the nuclear power share in the German electricity grid. As for the water footprint, it is a result of the water consumption of the washing machine. The electricity consumption of the washing machine is also responsible for the high impacts for human toxicity (non-cancer), climate change, freshwater eutrophication and the resource use of fossils. The use of non-ionic surfactant has a high impact on human toxicity (cancer).

Normalized results

The results are normalized and weighted with EF 3.0 normalization and weighting set. Table 3 summarizes the normalized and weighted impacts overall the life cycle of the hooded sweater

The normalized and weighted impacts show that the most contributing impact categories are Climate change, Eutrophication freshwater, Resource use of minerals and metals and Resource use of fossils.

Table 3: Normalized and weighted results using EF 3.0. sets, and contribution to the total impacts

Impact category	Normalized	Weighted (Pt)	Contribution
Acidification	2.55E-03	1.58E-04	4.7%
Climate change	3.22E-03	6.77E-04	20.3%
Ecotoxicity, freshwater	1.74E-02	3.34E-04	10.0%
Eutrophication, freshwater	2.10E-02	5.87E-04	17.6%
Eutrophication, marine	6.11E-03	1.81E-04	5.4%
Eutrophication, terrestrial	2.31E-03	8.57E-05	2.6%
Human toxicity, cancer	1.21E-03	2.58E-05	0.8%
Human toxicity, non-cancer	1.21E-03	2.22E-05	0.7%
Ionising radiation	6.35E-04	3.18E-05	1.0%
Land use	8.57E-04	6.80E-05	2.0%
Ozone depletion	1.75E-05	1.10E-06	0.0%
Particulate matter	1.10E-03	9.90E-05	3.0%
Photochemical ozone formation	2.01E-03	9.59E-05	2.9%
Resource use, fossils	5.09E-03	4.24E-04	12.7%
Resource use, minerals and metals	5.65E-03	4.27E-04	12.8%
Water use	1.39E-03	1.18E-04	3.5%

Figure 5 illustrates the most contributing processes to the category Climate change. A very large part of the impacts is due to the electrical consumption of the washing machine. Within the raw materials, the cotton fabric is responsible for most of the impacts, shared between the yarn production, batch dyeing and the electrical consumption from knitting and manufacturing.

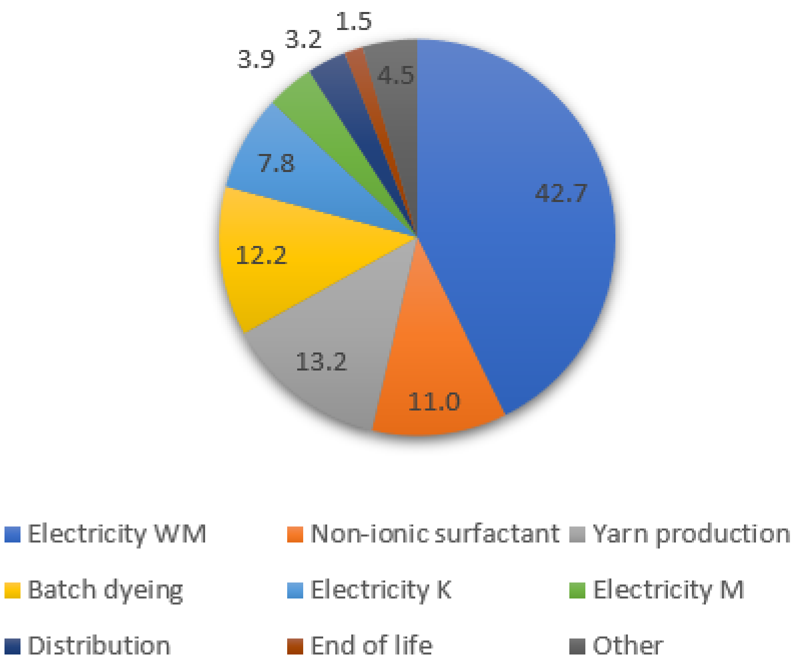

Figure 5: Most contributing processes to Climate change. WM= Washing machine, K= knitting, M=Manufacturing

Figure 6 shows the contribution of the processes for the category Eutrophication, freshwater. The electrical consumption of the washing machine represents nearly half of the total impacts. The impacts of the raw materials mainly come from the yarn production for the cotton fabric. It is itself mainly due to the cultivation of seed-cotton.

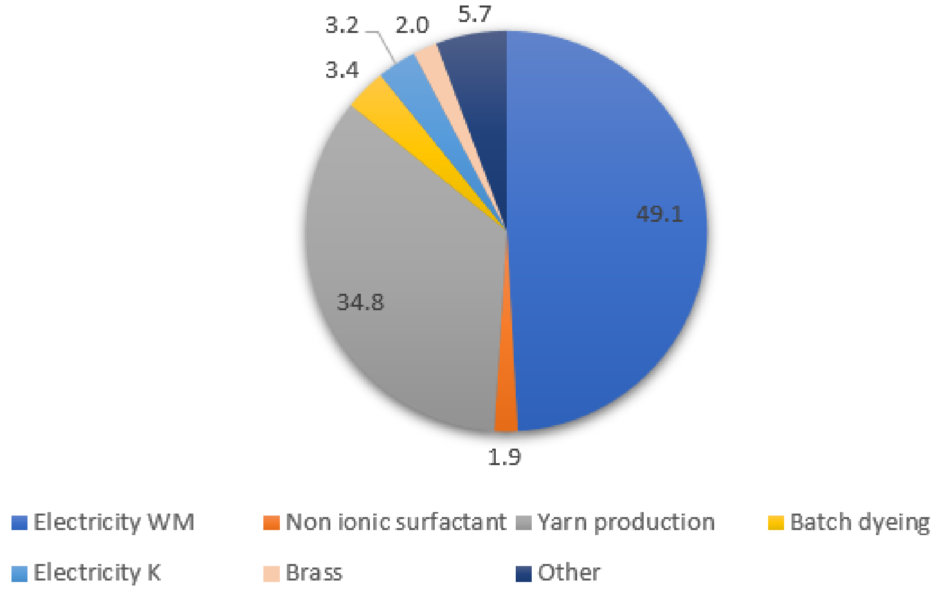

Figure 6: Most contributing processes to Eutrophication, freshwater. WM=Washing machine, K=Knitting, M=Manufacturing

Figure 7 illustrates the most contributing processes to the category Resource use of fossils. The electrical consumption of the washing machine is once again very impacting. The distribution of impacts is very similar as for climate change, with a fewer part due to the end of life.

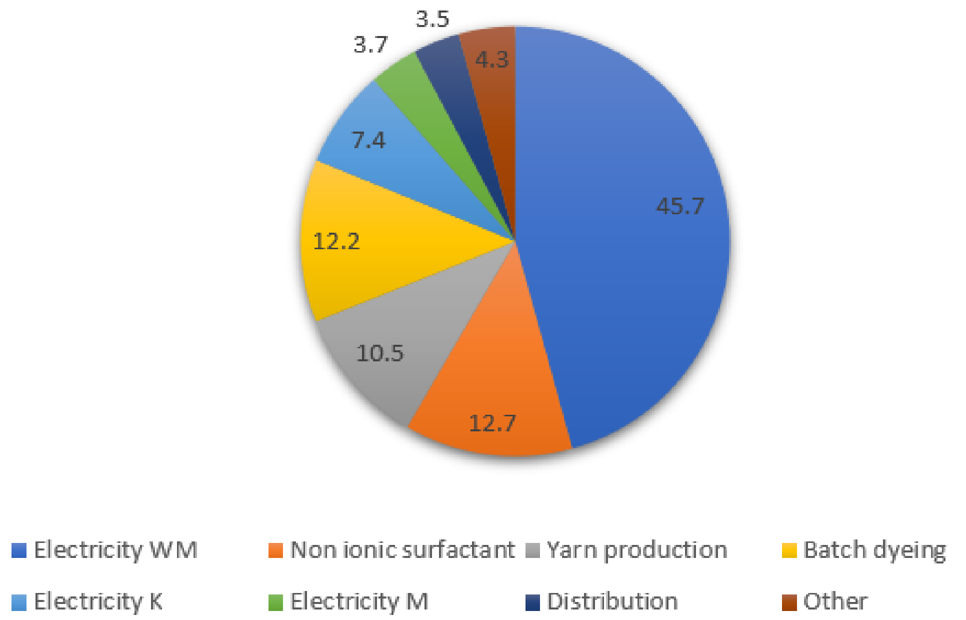

Figure 7: Most contributing processes to Resource use of fossils. WM=Washing machine, K=Knitting, M=Manufacturing

Figure 8 illustrates the most contributing processes to the category Resource use and metals. Even though the use phase still represents 15% of the impacts overall, the biggest contributor is the raw materials, particularly the production of brass and its transformation into a zipper.

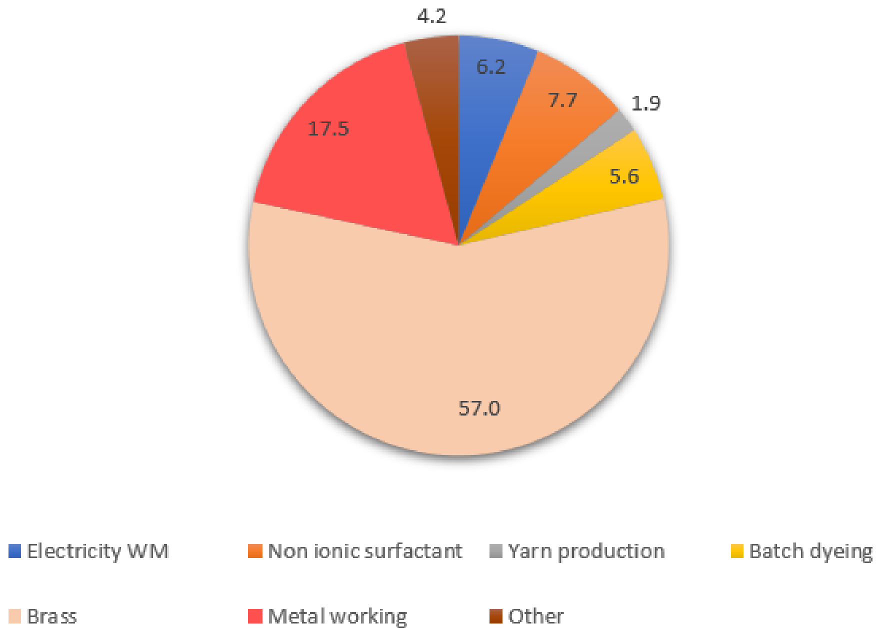

Figure 8: Most contributing processes to Resource use of minerals and metals. WM=Washing machine

Overall the electrical consumption of the washing machine during the use phase is very impacting. Its evolution depending on the scenarios is expected to show significant variation of the results.

Scenarios: Location of production

The variability of impacts depending on the location for raw materials and manufacturing are assessed in this section. The base case takes place in Maharashtra, while the alternative case takes place in Odisha. The LCIA for both scenarios are reported in Table 4.

As it can be seen from the results, the location of production has a very negligible impact on the overall environmental impacts of the product. It can be partly explained by the limits of the model. Indeed, the background data were modelled for India in general, as the process did not allow to differentiate between several regions of India. Therefore, the only input that changes from one scenario from the other is the electricity mix for manufacturing. As seen in the hotspot analysis previously, the manufacturing stage is not a significant contributor to the overall footprint of the product. Moreover, the two electrical mix are not radically different between the Eastern and the Western grid. It results into very little changes in the overall impacts.

Table 4: LCIA Results for the base case (Maharashtra) and the alternative case (Odisha)

Impact categories	Maharashtra	Odisha	Units
Acidification	1.42E-01	1.42E-01	mol H+ eq
Climate change	2.60E+01	2.61E+01	kg CO2 eq
Ecotoxicity, freshwater	7.42E+02	7.45E+02	CTUe
Eutrophication, freshwater	3.37E-02	3.37E-02	kg P eq
Eutrophication, marine	1.20E-01	1.20E-01	kg N eq
Eutrophication, terrestrial	4.08E-01	4.09E-01	mol N eq
Human toxicity, cancer	2.05E-08	2.05E-08	CTUh
Human toxicity, non-cancer	2.78E-07	2.79E-07	CTUh
Ionising radiation	2.68E+00	2.66E+00	kBq U-235 eq
Land use	7.02E+02	7.02E+02	Pt
Ozone depletion	9.37E-07	9.36E-07	kg CFC11 eq
Particulate matter	6.58E-07	6.59E-07	disease inc.
Photochemical ozone formation	8.15E-02	8.17E-02	kg NMVOC eq
Resource use, fossils	3.31E+02	3.32E+02	MJ
Resource use, minerals and metals	3.60E-04	3.60E-04	kg Sb eq
Water use	1.59E+01	1.60E+01	m3 depriv.

Scenarios: Behaviour of the user

Several scenarios are studied to assess the impact of the user behaviour on the life cycle of the sweater:

- Full load: the washing machine is filled with 6kg of clothes instead of 3.8kg,
- Less cycles: the hooded sweater is washed half as much as the base case,
- Tumble-dryer: the clothes are tumble-dried instead of air-dried.

The relative impacts of the four scenarios are calculated and illustrated Figure 9. For each category, the maximum result is set to 100% and the other results are displayed in relation to the maximum.

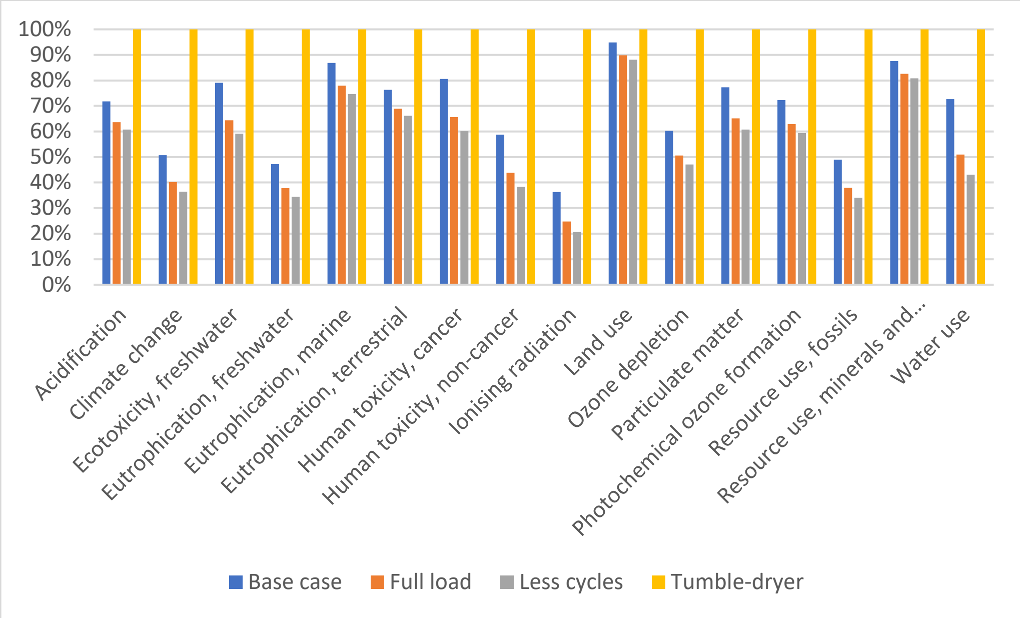

Figure 9: Relative impacts of the three use scenarios, comparatively to the base case

Overall full load and less cycles reduce impacts in all categories, while the use of a tumble-dryer increases every type of impacts. The climate change impacts are reduced by 21.6% and 29.4% when filling the machine or washing less frequently, while they nearly double with the use of the tumble drier compared to the base case. The relative variations are also quite significant for freshwater eutrophication and resource use of fossil fuels. The impacts regarding the resource use of minerals and metals follow the same trend, albeit not in the same proportion. The impacts of every scenario relatively to the base case are detailed in Table 5.

Table 5: Relative impacts of the scenarios compared to the base case, for the four most impacting impact categories

	Climate change	Eutrophication, freshwater	Resource use, fossils	Resource use, minerals and metals
Full load	-21.6%	-19%	-22.4%	-5.7%
Less cycles	-29.4%	-27.7%	-30.6%	-7.9%
Tumble-dryer	+96%	+112.7%	+104.1%	+13.6%

As shown by the tumble-dryer scenario, the electrical consumption has a significant impact on the results. Indeed, the impacts of the whole product double or more for the three most contributing impact categories. As the choice of the washing temperature modifies the electricity consumption, is it relevant to carry new scenarios regarding this parameter. In addition to the base case which models a washing temperature of 60 degrees, scenarios at 40 and 90 Celsius degrees are modelled. The corresponding data for the electrical consumption were taken from Steinberger et al. (2009). The relative impacts of these three cases are illustrated Figure 7.

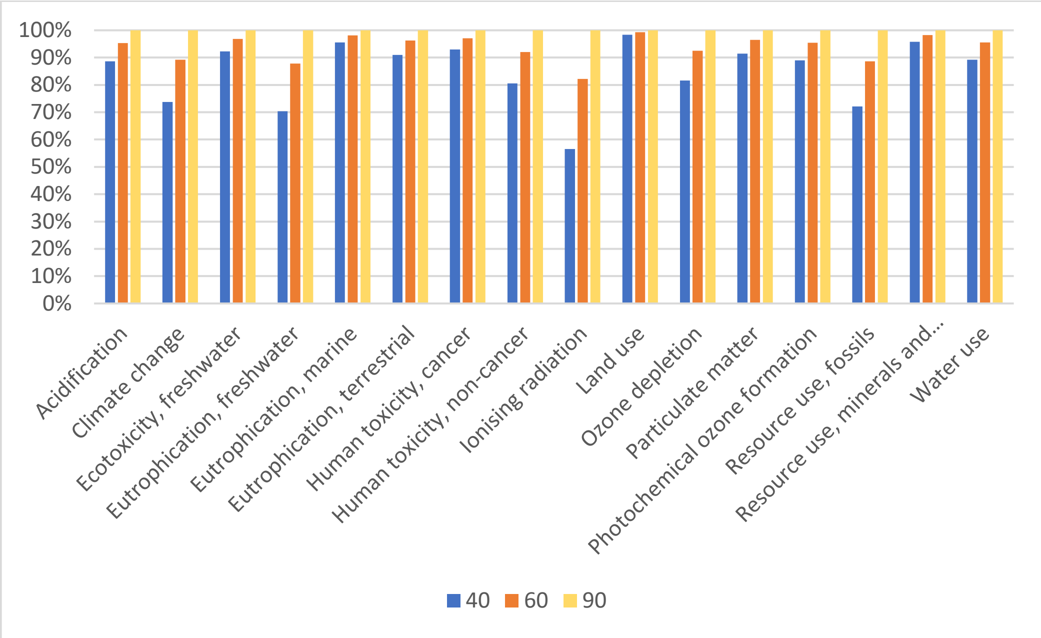

Figure 10: Relative impacts of the product life cycle depending on the temperature of washing

The impacts are proportional to the washing temperature of the program used. It is particularly noticeable for ionising radiation. It is due to the fact that the electricity consumption increases with the washing temperature.

IV. Conclusions and recommendations

Manufacturing, distribution and end of life are low contributors to the overall impacts, whereas the use phase and the raw materials share most of the burdens. The most contributing impact categories are Climate change, eutrophication of freshwater, resource use of fossils and resource use of minerals and metals. Regarding the extraction and pre-processing of raw materials, the processes that contribute the most are the production of seed-cotton and the energy consumption (both electrical and diesel) of batch-dyeing. As for the use phase, the electrical consumption of the washing machine has the greatest influence on the impacts.

The location of manufacturing has very little influence on the whole cycle. On the contrary, the scenarios regarding the use phase showed significant changes of the indicators, including for climate change, eutrophication of freshwater and resource use of fossil fuels. The total impacts vary proportionally with the number of washes and the temperature of the program, as well as whether a tumble-dryer is used. The filling of the washing machine also influences the results as the product bears a greater or lesser share of the environmental impacts depending on this parameter.

Due to the data quality of the background system, no recommendations can be made regarding the raw materials. Further research is needed to allow the manufacturer to choose raw materials with a lower impact. However, recommendations are relevant for the use phase, as it is one of the most contributing stage and under direct control of the user. Adopting the following behaviours can reduce the total impacts:

- Washing the sweater less often,
- Filling the washing machine to its full capacity,
- Avoiding the use of the tumble dryer.

The conclusions and recommendations are given considering the limitations of the study, detailed previously.

References

EC. (2021). *Product Environmental Footprint.*

Eryuruk, S. (2015). *Life cycle assessment method for environmental impact evaluation and certification systems for textiles and clothing*. Retrieved from http://dx.doi.org/10.1016/B978-0-08-100169-1.00007-1

European Parliament. (2019). *Environmental impact of the textile and clothing industry.*

FAO. (2022). *FAOSTAT*. Retrieved from https://www.fao.org/faostat/fr/#data/QCL/visualize

ISO. (2006). *14040:2006, Environmental Management-Life cycle assessment- Principles and framework.*

Jadhav, R. (2022). *Organic cotton production on the rise, led by M.P. and Odisha*. Retrieved from The Business Line: https://www.thehindubusinessline.com/data-stories/data-focus/data-focus-organic-cotton-production-on-the-rise-led-by-mp-and-odisha/article65207630.ece

Maeen Md. Khairul Akter, U. N. (2022). Textile-apparel manufacturing and material waste management in the circular economy: A conceptual model to achieve sustainable development goal (SDG) 12 for Bangladesh.

Rüdenauer, I. G.-O. (2008). *Einsparpotenziale durch automatische Dosierung bei Waschmaschinen*. Retrieved from Öko-Institut e.V: https://www.oeko.de/oekodoc/757/2008-220-de.pdf

S. Rana, S. K. (2015). Life cycle assessment of cotton textiles and clothing. *Woodhead Publishing Series in Textiles*, 195-216.

Sea rates. (2022, 09 08). Retrieved from https://www.searates.com/services/distances-time/

Selectra. (2022, 09 08). Retrieved from https://www.fournisseurs-electricite.com/guides/consommation/lave-linge

Shah, P. B. (2018). Life Cycle Assessment of Organic, BCI and Conventional Cotton: A Comparative Study of Cotton Cultivation Practices in India. *Designing Sustainable Technologies, Products and Policies*, 66-67.

Steinberger, J. F. (2009). A spatially explicit life cycle inventory of the global textile chain. *The International Journal of Life Cycle Assessment,14*, 443-455.

Textile Exchange. (2021). *Organic Cotton Market Report 2021.*

Hooded sweater

Textile Exchange. (2021). *Preferred Fiber and Materials Market Report 2021*.

Annex

Table 6: LCI of manufacturing

HS Manufacturing			
Inputs	**Amount**	**Unit**	**Provider in OpenLCA**
brass	0.02052	kg	market for brass | brass | Cutoff, U - RoW
electricity, medium v	2.472*westgrid	MJ	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U - IN-Western grid
electricity, medium v	2.472*eastgrid	MJ	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U - IN-Eastern grid
metal working	0.02052	kg	market for metal working, average for copper product manufacturing | metal working, average for copper product manufacturing | Cutoff, U - GLO
polyester resin	0.02324	kg	market for polyester resin, unsaturated | polyester resin, unsaturated | Cutoff, U - RoW
textile, knit cotton	0.70624*1.118	kg	textile production, organic cotton, circular knitting | textile, knit cotton | Cutoff, U (copy) - IN
transport, lorry	0.70624*1.118*0.001*50	t*km	market for transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U - RoW
Outputs	**Amount**	**Unit**	
Manufactured HS	1	item	
Waste textile	0.118*0.70624	kg	market for waste yarn and waste textile | waste yarn and waste textile | Cutoff, U - GLO

Table 7: LCI of distribution

HS Distribution			
Inputs	**Amount**	**Unit**	**Provider in OpenLCA**
packaging film	0.1	t.km	market for packaging film, low density polyethylene | packaging film, low density polyethylene | Cutoff, U - GLO
transport, inland w	(8.38+4.93)*0.75*0.001	t.km	market for transport, freight, inland waterways, barge | transport, freight, inland waterways, barge | Cutoff, U - RoW
transport, lorry	0.75	t.km	market for transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U - RoW
transport, sea	11401.18*0.75*0.001	kg	market for transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, U - GLO
Outputs	**Amount**	**Unit**	**Provider in OpenLCA**
Transported HS	1	item	
Waste from packaging	0.1	kg	market for waste polyethylene | waste polyethylene | Cutoff, U - DE

Table 8: LCI of use

HS Use			
Inputs	**Amount**	**Unit**	**Provider in OpenLCA**
electricity (Dryer)	Dryer*0.73	kWh	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U - DE
electricity, medium voltage	0.19*Cons40 +0.32*Cons60 +0.41*Cons90	kWh	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U - DE
non-ionic surfactant	0.011428571	kg	market for non-ionic surfactant | non-ionic surfactant | Cutoff, U - GLO
tap water	13	kg	market for tap water | tap water | Cutoff, U - Europe without Switzerland
Outputs	**Amount**	**Unit**	**Provider in OpenLCA**
Washed clothes	1	kg	
Wateswater	12.48	L	market for wastewater, from residence | wastewater, from residence | Cutoff, U - RoW
Evaporated water	0.52	dm³	

Table 9: LCI of end of life

End of life			
Outputs	**Amount**	**Unit**	**Provider in OpenLCA**
Disposed HS	1	Item(s)	
municipal solid waste	0.75	kg	market for municipal solid waste | municipal solid waste | Cutoff, U - DE

Table 10: LCI of life cycle

Life cycle			
Inputs	**Amount**	**Unit**	**Provider in OpenLCA**
Transported HS	1	item	HS Distribution
Washed clothes	52*6/3,8*0.750	kg	Clothes washing
Manufactured HS	1	item	HS Manufacturing
Disposed HS	1	item	End of Life
Outputs	**Amount**	**Unit**	**Provider in OpenLCA**
Worn out HS	1	item	

Table 11: LCI of yarn production

Textile production, organic cotton, circular knitting			
Inputs	**Amount**	**Unit**	**Provider in OpenLCA**
building, hall	3.85E-05	m2	market for building, hall | building, hall | Cutoff, U - GLO
diesel	0.185937	MJ	market for diesel, burned in diesel-electric generating set, 18.5kW | diesel, burned in diesel-electric generating set, 18.5kW | Cutoff, U - GLO
electricity, low voltage	1.659	kWh	market group for electricity, low voltage | electricity, low voltage | Cutoff, U - IN
lubricating oil	4.90E-04	kg	market for lubricating oil | lubricating oil | Cutoff, U - RoW
yarn, organic cotton	1.025	kg	yarn production, organic cotton, ring spinning | yarn, cotton | Cutoff, U (copy) - IN
batch dyeing	1	kg	batch dyeing, fibre, cotton | batch dyeing, fibre, cotton | Cutoff, U - IN
Outputs	**Amount**	**Unit**	**Provider in OpenLCA**
textile, knit cotton	1	kg	
waste mineral oil	4.90E-04	kg	market for waste mineral oil | waste mineral oil | Cutoff, U - RoW
Waste textile	0.025	kg	market for waste yarn and waste textile | waste yarn and waste textile | Cutoff, U - GLO

Table 12: LCI of textile production

Yarn production, organic cotton, ring spinning			
Inputs	**Amount**	**Unit**	**Provider in OpenLCA**
building, hall	1.61E-05	m2	market for building, hall | building, hall | Cutoff, U - GLO
diesel	0.0637	MJ	market for diesel, burned in diesel-electric generating set, 18.5kW | diesel, burned in diesel-electric generating set, 18.5kW | Cutoff, U - GLO
electricity, low voltage	2.24	kWh	market group for electricity, low voltage | electricity, low voltage | Cutoff, U - IN
fibre, cotton, organic	1.05	kg	market for fibre, cotton, organic | fibre, cotton, organic | Cutoff, U - GLO
lubricating oil	1.73E-04	kg	market for lubricating oil | lubricating oil | Cutoff, U - RoW
Water	1.00E-04	m3	
Outputs	**Amount**	**Unit**	**Provider in OpenLCA**
waste mineral oil	1.73E-04	kg	market for waste mineral oil | waste mineral oil | Cutoff, U - RoW
Waste yarn	0.05	kg	market for waste yarn and waste textile | waste yarn and waste textile | Cutoff, U - GLO
Water	1.00E-04	m3	
yarn, cotton	1	kg	