3rd Edition of the White Paper on Environmental Impact Valuation as base for a Sustainable Fashion Strategy

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1 Objective of the 3rd edition of the environmental impact valuation

The two previous white papers on the topic of environmental impact valuation at HUGO BOSS were published in September 2016 and May 2017.[1] The papers are the result of nine years of research, development as well as verification. They demonstrate the potential to increase transparency and thus comparability offered by the combination of Life Cycle Assessment (LCA) and Natural Capital Protocol (NCP).

The 3rd edition of the HUGO BOSS environmental impact valuation has two clear targets:

1. Completing the natural capital valuation of all major HUGO BOSS product groups[2] by analyzing the product groups wool suits and silk ties.
2. Addressing the root causes of the impact on climate change and based on this to develop design solutions for low carbon fashion products.

In the previous two white papers, we have done extensive analyses of almost all product groups based on actual data. Only the analyses for the product groups wool suits and silk ties had previously been based on estimated values of comparable products. To complete the work HUGO BOSS has analyzed these two product groups and the associated supply chains using actual data. This makes it possible to concretize and refine the previous efforts to evaluate the corporate natural capital of HUGO BOSS. In addition, the Company contributed to the World Apparel & Footwear Life Cycle Assessment Database (WALDB) by providing data on the various environmental impacts of the analyzed textile products.

In the following, we present all the research done until the end of 2017 including a detailed exploration of the climate change impact of our products, the root causes and possible mitigation strategies. All processing steps along the value chain were analyzed from the climate change point of view, and possible solutions were critically reviewed in terms of overall impact and resources required.

[1] The 1st white paper can be downloaded here: http://group.hugoboss.com/files/user_upload/Nachhaltigkeit/Produkt/2016-10-07_White_Paper_EIV.pdf; the 2nd white paper can be downloaded here: http://group.hugoboss.com/files/user_upload/Nachhaltigkeit/Produkt/31_05_2017_2nd_White_Paper_EIV.pdf

[2] Product categories analyzed in the 1st and 2nd edition of the white paper were: T-shirts, shirts, wool knitwear, jeans, leisure trousers, jerseys and leather shoes.

Furthermore, the data collected and the research done for this 3rd edition of the environmental impact valuation of textile and leather products enables HUGO BOSS to publish all information needed to compare the environmental impacts for leather, wool and cotton products according to scientifically recognized methods and high quality data standards throughout the whole supply chain. In order to ensure a correct application and interpretation of the LCA methodology, the white paper was revised by Prof. Dr. Marzia Traverso from the Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen University in Germany.

2 Life Cycle Assessments

2.1 Methodology of Life Cycle Assessments

All product and supply chain analyses were made in compliance with ISO 14044[3]. In total, 153 Life Cycle Inventories (LCIs)[4] were conducted (34 in the leather and 119 in the textiles sector). They provide detailed tracking of all input and output flows of the production processes, including data on raw materials, consumed water and energy by type, as well as the resulting greenhouse gas (GHG) emissions and impacts on air, water and soil. All processes from raw material extraction to the end of life phase were analyzed and the entire range of data of the respective supply chains was recorded. The analyses of the individual processes generated a complete set of a LCI. This was done in accordance with recognized science-based methodologies, such as the International Reference Life Cycle Data System (ILCD). For more details on the applied methodologies, please refer to our first white paper "The Environmental Impact Valuation as Scientific Basis for a Sustainable Apparel Strategy".

The data collection was made in close collaboration with many different partners along the various supply chains for the different products. The collected data and resulting impact values were discussed with the involved experts and partners. As usual, all suppliers involved in the project received a standardized report highlighting findings and explaining possible solutions.

Overall, HUGO BOSS compiled LCAs for the following product categories in recent years:

- T-shirts
- Shirts
- Wool knitwear
- Jeans, leisure trousers
- Jerseys
- Leather shoes

[3] ISO 14044:2006 describes principles and the framework of LCAs. This includes the definition of the goal as well as the scope of the LCA, the Life Cycle Inventory (LCI) analysis phase and the Life Cycle Impact Assessment (LCIA) phase. Furthermore it includes the Life Cycle Interpretation phase, the reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for the use of value choices as well as optional elements.
[4] The Life Cycle Inventory "is the data collection part of LCA. […] It consists of detailed tracking of all the flows in and out of the product system, including raw resources or materials, energy by type, water, and emissions to air, water and land by specific substance." http://www.athenasmi.org/resources/about-lca/whats-the-difference/

- Suits
- Silk ties

The European initiative Product Environmental Footprint (PEF) clearly defined rules for the calculation of LCAs. HUGO BOSS engaged in the analyses of two different supply chains for the production of T-shirts in 2014 and continued to apply the rules of the initiative.

The LCAs of the products wool suits and silk ties are described below. The LCAs of the other products mentioned above can be found in the previous white papers.

2.2 Findings from the Life Cycle Assessments

2.2.1 Wool suits

The great importance of sheep farming for environmental impacts should not be neglected. However, the impacts generated through sheep farming can be attributed to both the textile and the food industries. With regard to the percentage allocation of the impacts, HUGO BOSS follows the considerations of the European Product Environmental Footprint Category Rules (PEFCR) directive. It recommends an allocation factor of 47% to the textile sector. At HUGO BOSS, wool products are mainly found in the product groups suits, knitwear and hosiery.[5]

Due to the three simultaneous production flows, the LCA analysis of wool suits was the most complex LCA work carried out at HUGO BOSS (figure 1). The three production flows – production of main fabric, body lining and pocket lining – merge in the assembly step[6].

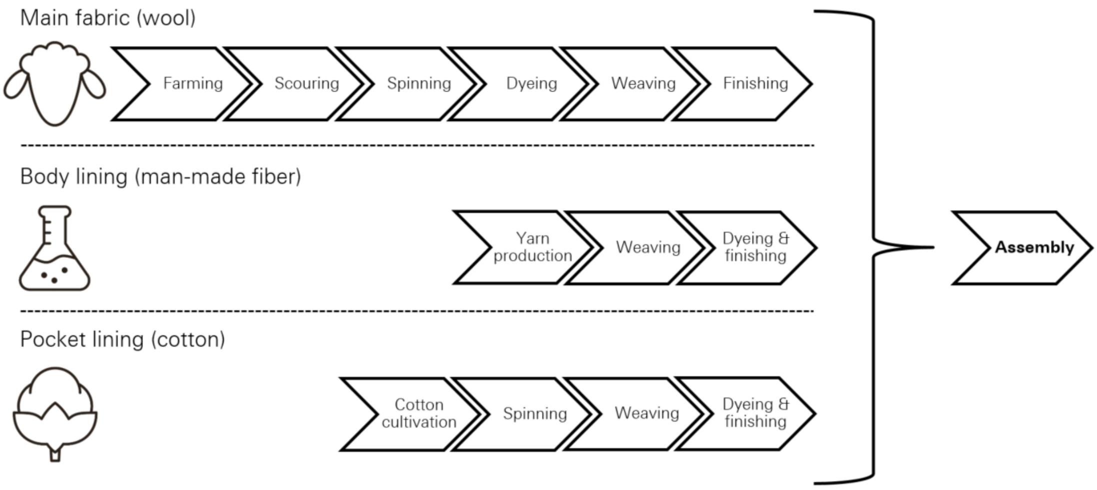

Figure 1: Production flows of the value chain of a wool suit

The suits analyzed in this LCA study are composed of a main fabric made of merino wool, a body lining made of cellulosic fibers and a pocket lining made of cotton, with the addition of many other trimmings (shoulder parts, sleeve head roll, waistband,

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[5] A detailed analysis of knitwear products made of wool has already been published in the 2nd white paper.

[6] The assembly step respectively the process of assembly is comprised by i.a. the following steps: trimming, sewing, ironing, preparation, laying and packaging.

interlinings, ribbons and others) made of additional natural fibers. Since these trimmings are added during the assembly step, their impacts are accounted for in the assembly.

As figure 2 shows, the main environmental hotspots of the wool suit supply chain are sheep farming, assembly and cotton cultivation needed for trimmings. In total, the highest impact has the sheep farming. While cotton-based products' main impacts are on water scarcity and land use, sheep farming generates high impacts also on freshwater ecotoxicity.

A comparison of wool suits with other garments shows that for the former the extraction of raw materials accounts for a large proportion of its total environmental impact. This is due to the high amount of wool used in a suit. In contrast, less wool is used e.g. in knitwear, which is why the finishing process (there) is more important than the extraction of raw materials.

The relevance of the hot spots in the assembly step can be explained with the agricultural origin of many natural fibers used in trimmings (e.g. goat hair and cotton affecting land use, water resource depletion and ecotoxicity). Furthermore, the assembly step has an impact on climate change due to its energy consumption.

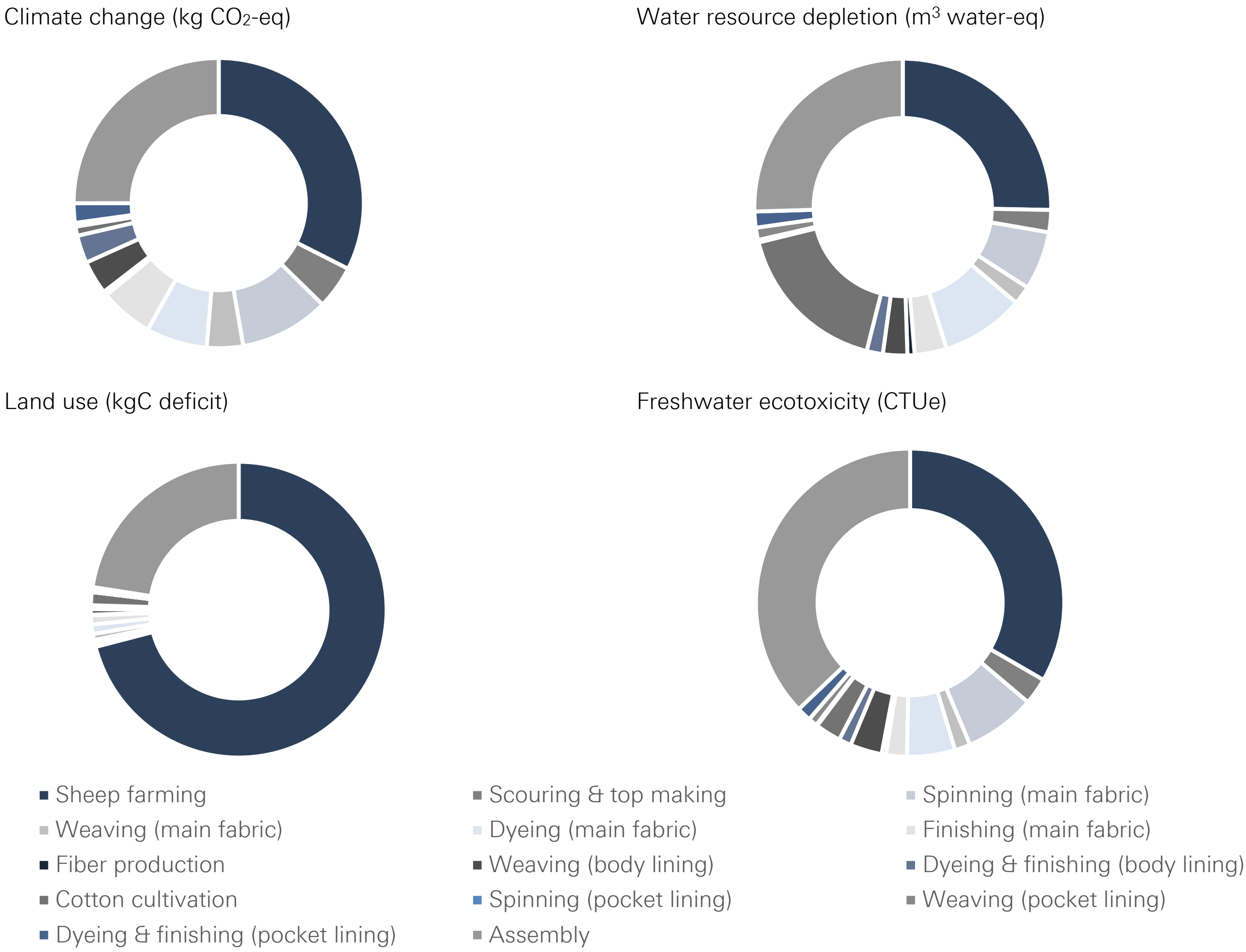

Figure 2: Life cycle stages of a wool suit and their impacts on environmental issues

2.2.2 Silk ties

At HUGO BOSS, silk products are mainly found in the product group neckwear. The proportion of silk in all raw materials used at HUGO BOSS accounts for 0.74% (raw material weight). The LCA of the silk ties was done in collaboration with the WALDB. The silk LCI applied in this analysis is based on a study Quantis made in collaboration with silk producers[7], while the refinement processes are modelled based on the HUGO BOSS supply chain. With regard to the impacts of silk products such as ties, clear trends are emerging. As figure 3 shows, the first impact contributor is silk production. It especially has an impact on water use (depletion and ecotoxicity) and climate change, due to heating energy. In terms of climate change, assembly has the greatest impact due to the energy consumption of machines and building maintenance.

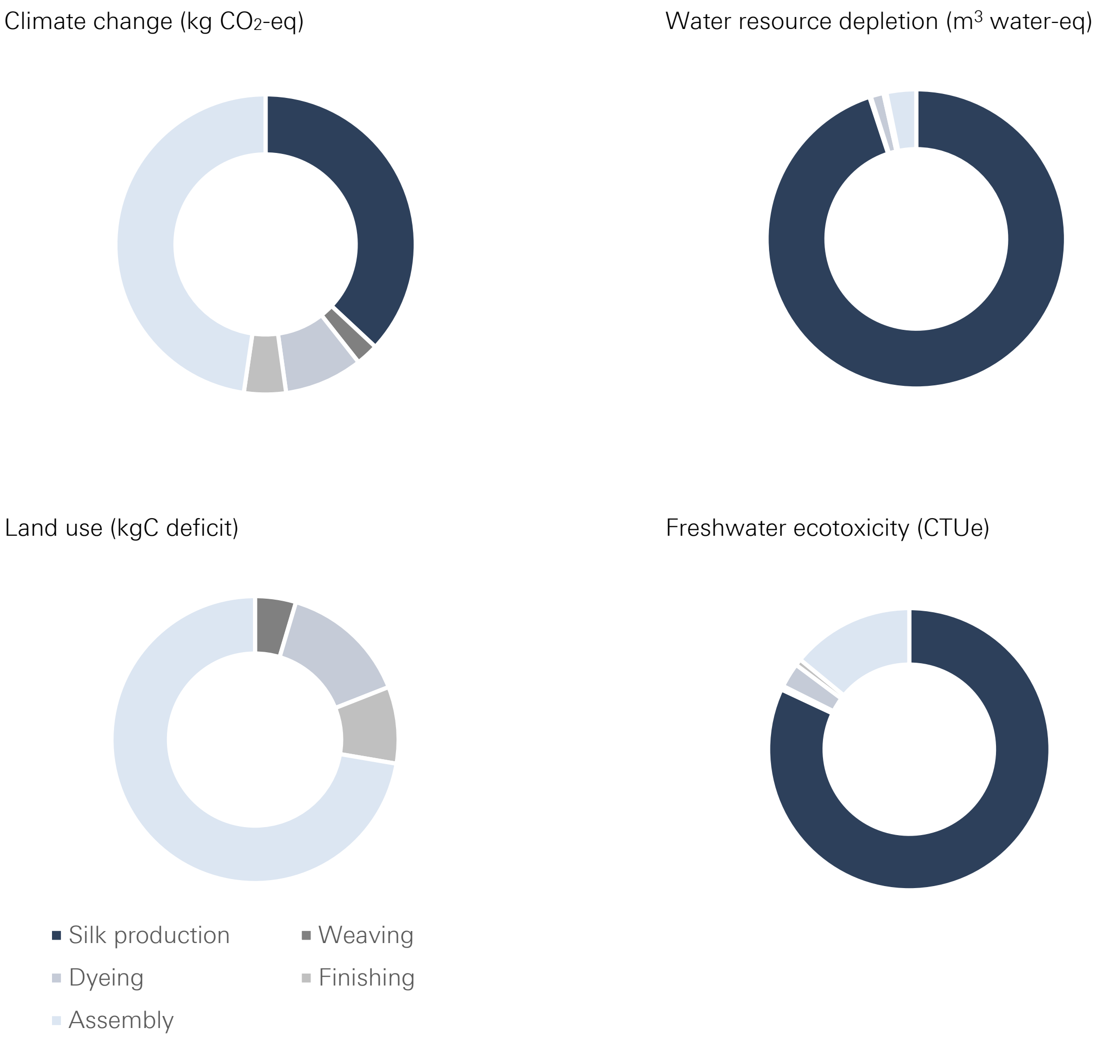

Figure 3: Life cycle stages of silk ties and their impacts on environmental issues

Similar to the assembly of a suit, ties have many trimmings made of natural fibers (e.g. wool and cotton) that are not separately analyzed, but allocated to the assembly step. This leads to a significant footprint of the assembly in terms of land use. Land use is assessed at country level, by analyzing the pattern of the last 20 years and by assessing

[7] The Quantis study was made available through the collaboration within WALDB. For further information, please contact Quantis.

changes in the country's carbon stock accordingly. In principle, the results can be either positive or negative. A positive effect on land use can be observed in the production of silk raw materials and especially in the case of silk caterpillars. This is due to the fact that mulberry cultivation shifts land use from one perennial crop to another. Thus, the mulberry contributes to the expansion of perennial land in the country (e.g. in China, main producer of silk).

3 Natural capital valuation

3.1 Methodology of the natural capital valuation

To compare different impacts resulting from the LCA studies a "normalization step" is required to relate and compare different impact categories, e.g. climate change impacts can be put in relation to other environmental impacts such as water withdrawal or human health. The application of the NCP developed by the Natural Capital Coalition (NCC), a global multi-stakeholder initiative, offers such an approach of harmonization by monetizing eco-system services.

HUGO BOSS was one of the ten selected companies that tested the NCP in a 'Deep Dive' pilot, in cooperation with the NCC in 2015. The NCP defines requirements and provides principles for the monetization of eco-system services[8] (= natural capital).

Figure 4 shows the conversion of low-level process data into midpoint impact categories, damage categories and finally to a single monetized impact score, in accordance to standardized and/or recognized methods.[9]

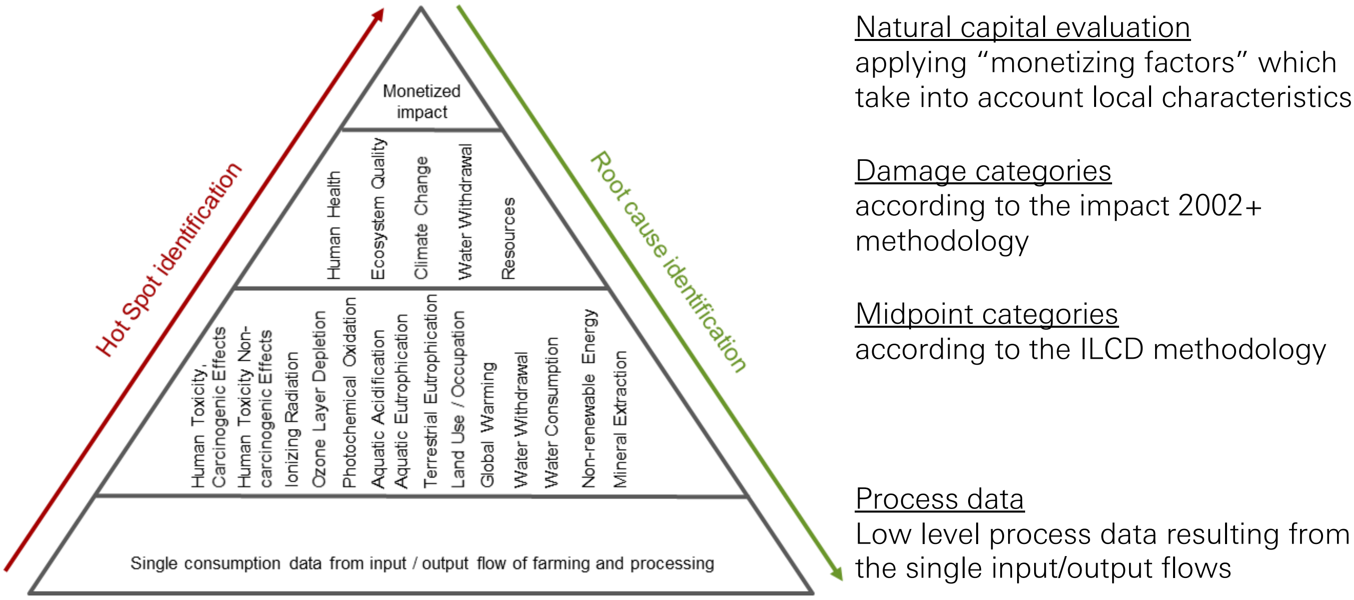

Figure 4: Aggregation levels of the natural capital valuation

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[8] The term ecosystem service describes the value people gain from renewable and non-renewable resources in nature. This includes, for example, food, which would not exist without pollination by insects, or complex services such as the climate impact of the large amounts of CO_2 locked up in forests.

[9] LCI methodology IMPACT 2002+ using Ecoinvent (Ecoinvent is a LCI database that provides process data for a variety of products.)

The detailed description of the applied methodology can be found in our first white paper.

For each manufacturing step, minimum, mean and maximum values were calculated from all corresponding LCIs, in order to obtain an understanding of the statistical variance. For the major hotspots, sensitivity analyses were carried out. This enabled backtracking of the root causes. The sensitivity analyses were then further elaborated by applying different energy sources (fossil versus renewable energy) to a particular manufacturing process, changing modes of transport (airfreight versus sea freight or rail) or comparing different irrigation methods.

LCA midpoint impacts comprise all harmful impacts in the various flows of LCI. Examples include terrestrial ecotoxicity, acidification or eutrophication. These midpoint categories are assigned to damage categories, which reflect the damages to human health, to the environment, to the resources' stock, water withdrawal or climate change. The publicly available monetizing factors were applied to these damage categories in order to transform damages to monetary expenses.[10]

The last step of monetization serves to weight the environmental impacts acknowledging the specific value of ecosystem services (e.g. the value of water in different geographical zones, water scarcity). Since all impacts are harmonized and converted into a monetary value, the hotspot areas found using the classic LCA approach can be compared even better and also discussed with non-LCA experts. However, it should be noted that these are only initial tests. If a sector-independent application is now to be made possible, further studies must be undertaken to define scientifically reliable factors.

The corporate environmental impact valuation published in 2017 on the HUGO BOSS sustainability website[11], depicts the most aggregated level of the Company's natural capital valuation. In addition, it is a fact-based approach of a scientifically based materiality analysis, which shows the most relevant impacts in a simple and understandable way.

[10] To give an example: The human health impact is measured in DALY – Disability-Adjusted Life Years (see http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/) and the monetizing factor used is 90'000 chf/DALY. Hence, the damage is quantified in Swiss Francs.

[11] http://group.hugoboss.com/en/sustainability/products/natural-capital-evaluation/

3.2 Findings from the natural capital valuation

3.2.1 Wool suits

As figure 5 shows, sheep farming has the highest impact (41%) in the production of wool suits across all four categories.[12] This is due to the high wool consumption. The assembly step has the second highest impact. It includes all effects coming from the various trimmings used in a suit (e.g. button, shoulder pad) that are assigned to the assembly phase.

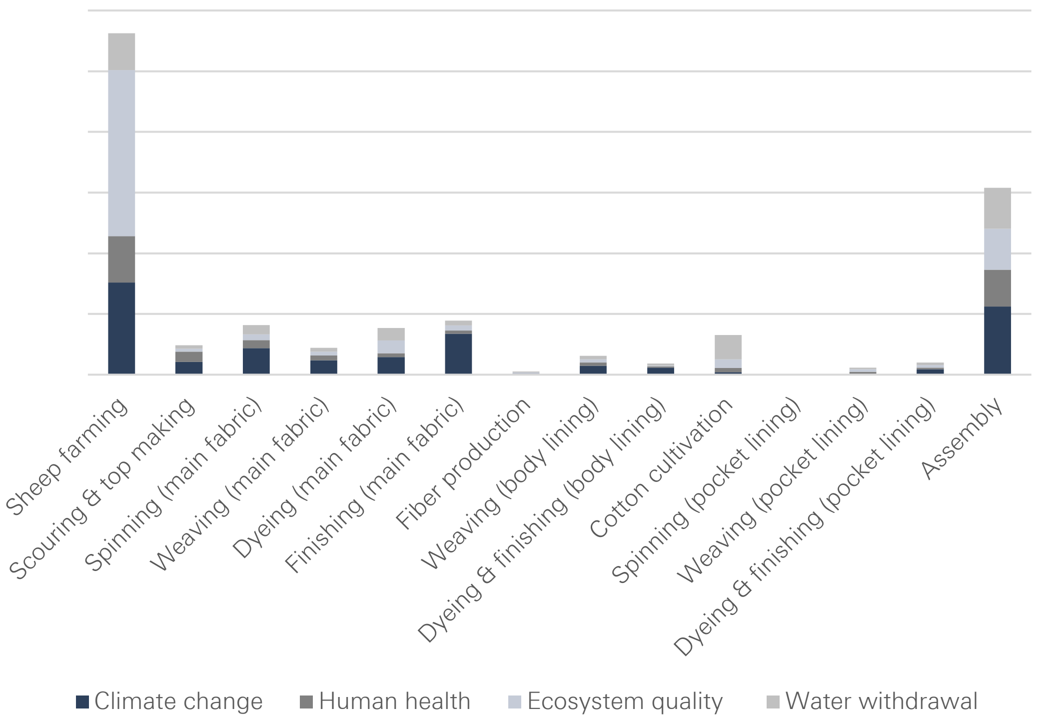

Figure 5: Monetized impacts (in €) of the wool suit's supply chain (cradle to gate)[13]

As figure 6 shows, the impacts added during the use phase (external statistical data) corresponds to about 10% of the impacts that occur during the entire production process. In contrast, the end of life phase accounts for less than 1% of the total life cycle impact of a wool suit. The use phase is of course strongly dependent on customer behavior, but with the high impact of the wool and the supply chain, a long life span (quality) of a suit is a key driver in reducing the impact on ecosystem services.

[12] A fifth category, the resource category, has not yet been included in the natural capital valuation. The reason for this is that no suitable, monetizable factor has yet been identified.

[13] While the monetized impacts were expressed in percentages in the first version, from the second version they were presented in absolute values in order to increase comparability.

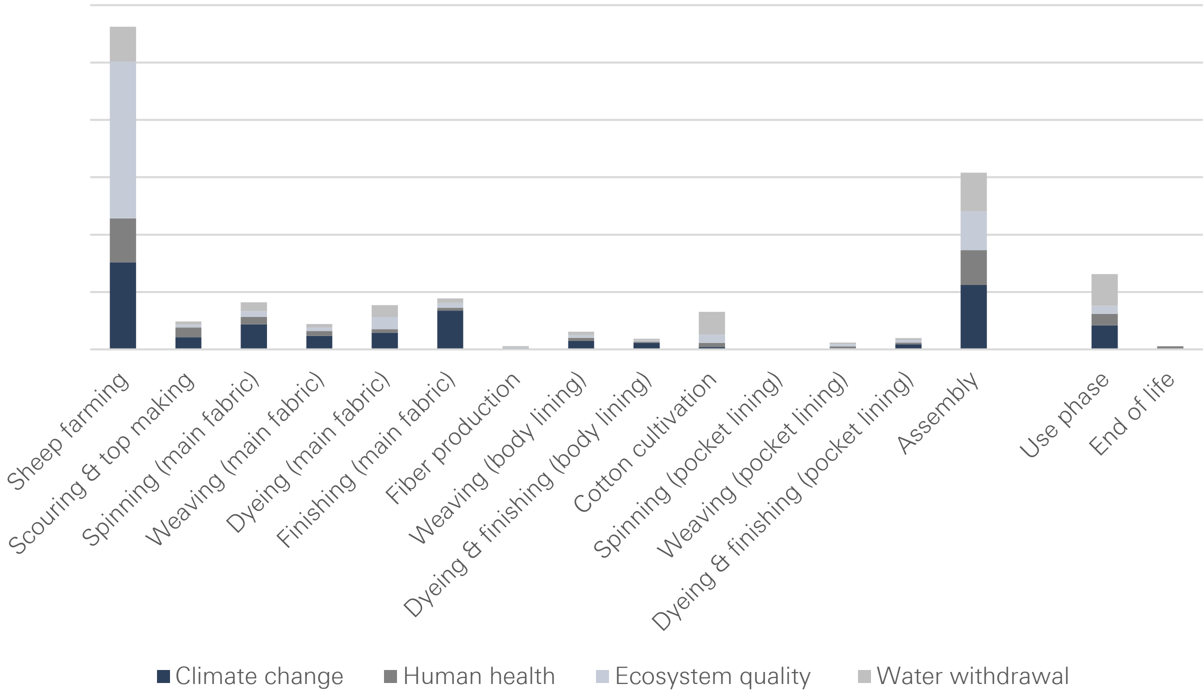

Figure 6: Monetized impacts (in €) of the wool suit's value chain (cradle to cradle)

3.2.2 Silk ties

Silk, which accounts for less than 1% of the total material used at HUGO BOSS, also has a rather low impact as raw material because of its positive impact on land use, as described in the LCA studies. As can be seen (figure 7), the assembly has the highest impact due to the various additional fabrics and materials used in the process. To reduce the impact on climate change, the assembly plant should have a proper environmental system with a focus on energy efficiency and the use of renewable energies.

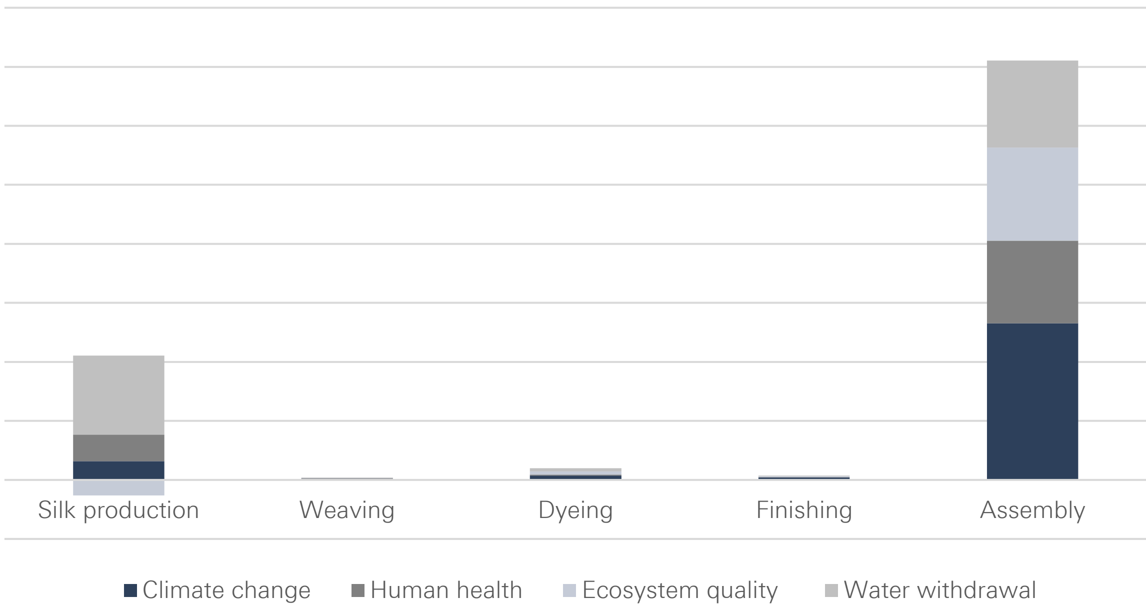

Figure 7: Monetized impacts (in €) of the silk tie's supply chain

3.2.3 Summary

As mentioned at the beginning, HUGO BOSS has completed its natural capital valuation with this third issue of the white paper. For this purpose, data-based analyses were carried out for the product categories for which only estimated values were previously available: wool suits and silk ties.

With regard to silk products, no additional impacts on the valuation of the corporate natural capital could be observed after consideration of the actual data. The reasons for this are the comparatively small number of silk ties produced and their limited environmental impact. However, the impacts of wool products, i.e. suits, increased due to the observed high demand for raw materials. Accordingly, the influence of sheep farming – in terms of raw materials as part of natural capital valuation – increased in comparison to other forms of raw material production. The reasons for this are the consequences of sheep farming on land use and water ecotoxicity, which have a negative impact on ecosystem quality.

Another relevant aspect for the environmental impact of a finished garment is the selection of adequate raw materials for trimmings. The environmental impact of these trimmings show up in the assembly for both product categories, wool suits and silk ties. In regards to the refinement processes, the main impact driver is energy use.

Since the use phase depends very much on the customer's habits, external statistical data was used for the calculation. This makes it possible to calculate the effects of the use as well as the end of life phase and to compare both with the effects of the supply chain (cradle to gate). For HUGO BOSS' high quality garments, the use phase is probably much longer than for fast fashion items, therefore the supply chain impacts are drastically reduced per single wearing occasion.

All the information obtained is shared with the HUGO BOSS' partners and helps to optimize sourcing strategies in order to mitigate environmental impacts throughout the whole supply chain. In addition, the results will be integrated into the updated version of the HUGO BOSS corporate natural capital valuation, which will soon be uploaded on the corporate website.

4 Climate change impact of the HUGO BOSS value chain

HUGO BOSS gives a high priority to environmental and climate protection in particular. The focus is to increase the energy efficiency of its buildings and stores by applying environmental management systems in accordance with ISO 14001 and ISO 50001. Furthermore, the use of renewable energy – purchased or generated with photovoltaic systems on the roof of HUGO BOSS buildings – is part of the strategy to minimize the carbon footprint. The use of environmentally friendly modes of transport is another step towards reducing GHG emissions. The introduction of rail transport from China to Germany and sea shipping from Asia via southern European ports (Italy or Slovenia) reduces environmental impact and at the same time optimizes lead-times.

At the beginning of 2018, the United Nations Framework Convention on Climate Change (UNFCCC) created the platform for fashion and climate action in which HUGO BOSS has been involved in from the very beginning. Total GHG emissions from textile production are estimated at around 1.2 billion tons per year. To combat climate change, the joint initiative of the UNFCCC is crucial, since single actors will only have limited impact. In the following sections, HUGO BOSS shares all the analyses that were made to understand the origin of GHG emissions. They are based on the LCAs made in-house and some recent studies made by other experts.

The corporate climate change impact (figure 8) is based on the LCA studies, the amount of products sold per product category and the data on logistics, administration and retail published in the HUGO BOSS Sustainability Report 2017.

The product groups at HUGO BOSS are divided quantitatively in garments made of cotton (48%), wool (16%), synthetic fibers (15%) and leather (10%) and various special fibers or materials like rubber, silk, alpaca or man-made fibers that sum up (11%) (please see HUGO BOSS Sustainability Report 2017 for more information[14]).

The corporate climate change impact of the HUGO BOSS value chain (figure 8) shows that about half of the impact in the fashion supply chain results from wet processes, such as bleaching, washing, dyeing and tanning. This is due to the energy used for heating water and in general for the chemical refinement processes. Less than one third of the total impact comes from dry processes, such as spinning or assembly. The raw materials extraction and the distribution of finished goods (including the inbound logistics, administration and retail) account for approximately 14% of the corporate climate change impact. Thanks to the high proportion of renewable energies and the implemented energy management systems, the administration and retail buildings of HUGO BOSS account for only 6% of the total corporate climate change impact.

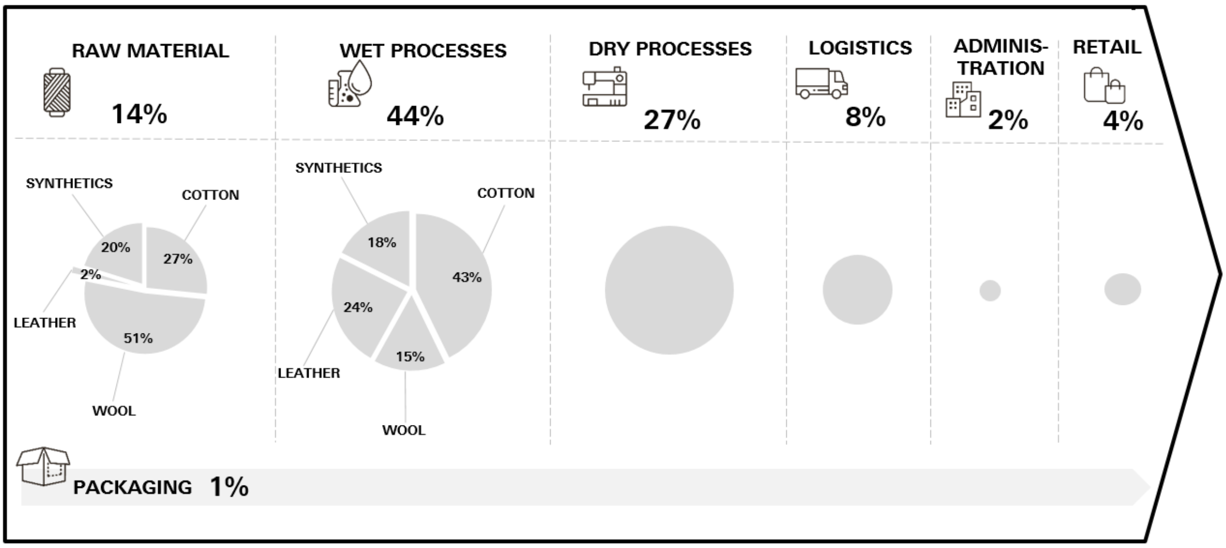

Figure 8: Corporate climate change impact

14 HUGO BOSS Sustainability Report 2017 on page 68: http://group.hugoboss.com/files/user_upload/Nachhaltigkeit/Nachhaltigkeitsbericht/Sustainability_Report_2017.pdf

Detailed analyses were carried out for the individual refinement steps of the value chain in order to understand the causes and to derive suitable mitigation strategies. This is summarized in the following.

4.1 Raw materials

Raw materials have a limited impact on climate change, amounting to 14% of the overall HUGO BOSS value chain. Although synthetic fibers are used in relatively small quantities at HUGO BOSS, they have a rather high carbon footprint, as already reported in the study "Sustainable Apparel Materials", 2015[15] by the Massachusetts Institute of Technology Cambridge. In this report it was outlined that the production of a cotton T-shirt (total impact: 2.1 kg CO_2-eq) emits about 2.5 times less GHG than a T-shirt made of polyester fibers (total impact: 5.5 kg CO_2-eq).

4.1.1 Leather

The low relevance of skins and hides for the corporate climate change derives from the application of the allocation factors recommended in the directive of the PEFCR. They calculate with 12% for the farming and 3.5% for the slaughterhouse, acknowledging the fact that the skins and hides are by-products of the meat and milk industry. Nevertheless, it is important to mention that the livestock sector is estimated to account for approximately 14.5% of global GHG emissions.

4.1.2 Wool

Similar to leather, sheep farming's impacts were allocated to wool fibers using the factor 47%, recommended by the PEFCR. Both types of farming (beef and sheep/lamb, producing mainly for the food industry) have the highest impact within the livestock sector as shown in table 1.

Table 1: Impact of farming on CO_2 emissions[16]

1 kg of meat from	Produces kg CO_2
Beef	34.6
Lamb	17.4
Pork	6.35
Chicken	4.57

More detailed work for wool fibers will follow within the framework of the planned sustainable wool commitment of HUGO BOSS.

15 The study compiled by Randolph Kirchain, Elsa Olivetti, T Reed Miller and Suzanne Greene was published on October 7, 2015. It can be accessed under: http://msl.mit.edu/publications/SustainableApparelMaterials.pdf
16 Please see "Environmental Impacts on Food Production and Consumption". It can be accessed under: file://hbmess14/e91652$/documents/EV02007_4601_FRP.pdf

4.1.3 Cotton

As figure 9 shows, cotton cultivation has a relatively limited impact on climate change. The figure is based on an average weighted cotton shirt and shows that the climate change impact of cotton cultivation amounts to only 7% of the overall production cycle.

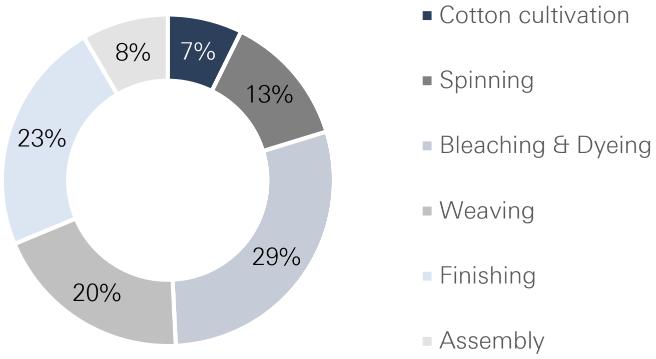

Figure 9: Impact of production of cotton shirt on climate change

For cotton the main root causes of GHG emissions are:

1. Synthetic fertilizers
2. Energy used for irrigation and other mechanical systems in the field
3. Energy used for ginning
4. Organic fertilizers

These main contributors show the importance of training programs for farmers, both to optimize the use of fertilizers (conventional and organic) in combination with optimal irrigation techniques and to maximize yields. HUGO BOSS therefore works with the Better Cotton Initiative (BCI) to provide trainings for farmers and cooperates with members of CottonLEADS that apply the latest farming technology. The use of fuel-based energy for pumping systems and machinery in the cotton sector and in ginning is another reason for the focus on maintenance programs and the switch to renewable energies.

4.1.4 Synthetic fibers

Synthetic fibers have special functionalities, which can be necessary to produce and guarantee certain product properties (e.g. wind and water resistance, good elasticity and breathability typically used for outdoor garments).

Andrew Barber and Glenys Pellow compiled a comprehensive literature review of energy use for a range of textiles (including synthetics and natural fibers).[17] Its most relevant results are shown in table 2.

Table 2: Energy use for different textiles

17 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.553.6556&rep=rep1&type=pdf

Textile fiber	Total energy value in MJ/kg fiber
Nylon	250
Acrylic	175
Polyester	125
Polypropylene	115
Viscose	100
Cotton	55
Wool	63

Similar to the results of the study "Sustainable Apparel Materials", 2015[18] the conclusion of the review is that synthetic fibers have a much higher impact on climate change than natural, renewable ones. Consequently, replacing synthetic fibers with natural ones, whenever possible, could largely reduce the carbon footprint of textiles.

Moreover, synthetic fibers, either virgin or recycled, pollute the aquatic environment with micro-particles that are not biodegradable. Micro-plastics harm the aquatic fauna and enter into the complex food chain, which bio-accumulates up to the top.

4.1.5 Summary

Synthetic fibers have a negative impact on climate change and pollute the aquatic environment. In order to reduce these negative environmental effects, synthetic fibers – insofar as their special functionalities are not required – should be replaced by natural ones. In the course of this, the farmers could be trained in the correct use of technical equipment in agriculture with the aim of optimizing the yield of natural fibers in relation to the resources used.

4.2 Wet process

Wet processes include bleaching, washing, dyeing, tanning and finishing. It is to be noted that most factories execute more than one of the above-mentioned processes within the same structure.

Looking for the root causes of the climate change in the wet processes, the following main drivers were identified:

1. Electricity from coal
2. Heat from natural gas
3. Electricity from a standard grid mix (mainly fossil based)

[18] The study compiled by Randolph Kirchain, Elsa Olivetti, T Reed Miller and Suzanne Greene was published on October 7, 2015. It can be accessed under: http://msl.mit.edu/publications/SustainableApparelMaterials.pdf

These three resources account for over 80% of the climate change impact of the wet refinement processes of textiles and leather. Out of these 80%, about 40 - 50% come from heating and 30% - 40% come from the consumption of electricity. The remaining 20% of climate change impacts can be attributed as follows:

- In the field of textiles: bleaching agents, dyeing chemicals, air emissions of nitrous oxide and wastewater treatment plants
- In the field of leather, where tanneries have by far the biggest impact (85%): sludge from wastewater treatment plants and tanning chemicals (synthetic, chrome or vegetable based)

The root cause analysis shows that GHG emissions depend mainly on the source of energy or electricity, e.g. coal, gas or renewable energy.

4.2.1 Wet process for textiles

Bleaching and dyeing accounts on average for about 30% of textile garments' production climate change impact. For these process steps the main impact driver (over 80%) is the energy used (electricity or heat). Therefore, it is of utmost importance to substitute fossil-based energy through renewable energy whenever possible, be it purchased or produced directly at the factory.

New environmentally low-impacting chemical refinement processes focus on the toxicity reduction (e.g. in the frame of the Zero Discharge of Hazardous Chemicals (ZDHC) program) or water efficiency measures. To effectively decrease GHG emissions in wet processes, heat recovery systems would be an optimal solution to significantly reduce the energy loss. In addition, well-isolated tubes, containers and buildings, as well as a generally higher level of maintenance will further reduce all kinds of energy loss and consequently the GHG emissions at relatively low cost.

Sludge from wastewater treatment plants directly affects the climate change and creates other negative impacts on the ecosystem, if not properly treated. With an efficient and safe incineration plant, heating energy could be recovered and, if made available to the factory, a further reduction of the climate change impact could be achieved.

4.2.2 Tanning of leather

Figure 10 shows that in case of leather products – i.e. mainly shoes – 85% of the climate change impact results from the tanning process, which therefore is the main hotspot. The cut and link phase in which the shoes are assembled and the production of lasts[19] account for 5% each.

[19] The term last refers to a mechanical form, which is shaped like a human foot. Shoemakers use this it in the manufacture and repair of shoes.

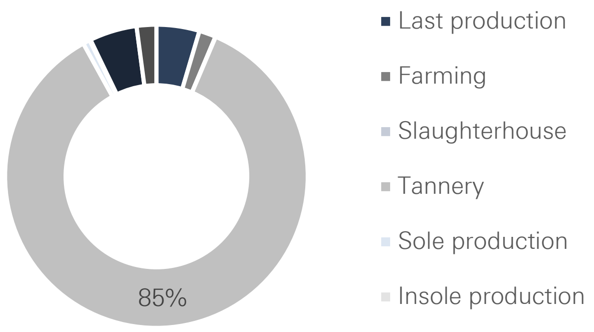

Figure 10: Climate change impacts in leather production

A study by the British Leather Technology Centre (BLC)[20] (figure 11) compares the three most common tanning methods (chrome-, synthetic- (aldehyde) and vegetable tanning) and shows that the chrome-free (aldehyde) tanning method has the greatest impact on climate change and consumes most of the non-renewable energy.

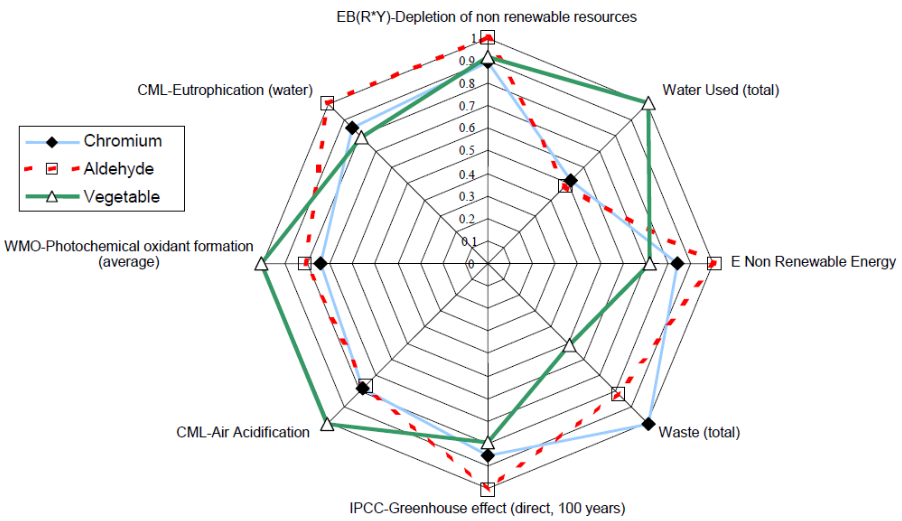

Figure 11: Comparison of chromium, aldehyde and vegetable tanning methods

To mitigate the impact on climate change in the best possible way, a well-controlled chrome tanning with an adequate environmental management system and the use of renewable energy are crucial. Since most of the energy used for tanning comes from heating, heat recovery systems and high-quality insulation can further reduce GHG emissions.

4.2.3 Summary

With regard to wet processes, the greatest mitigating effects on climate change can be achieved by switching from fossil fuels to renewable energies. In addition, also the use

[20] LCA made by ecobilan in 2011 for BLC (see https://echa.europa.eu/documents/10162/8ff2f208-c6a7-4ab8-8573-4100ac8214df on page 84)

of well-controlled chrome tanning with an adequate environmental management system and heat recovery systems can contribute to a smaller carbon footprint.

4.3 Dry process

The dry processes are spinning, weaving, knitting and assembly. These production steps are characterized by the use of different machines at different levels of automation. With the developments that industry 4.0 will bring, especially in the assembly part, the future will bring more automated processes but also the use of robots, self-piloting transport systems and real-time data elaboration. This technology will consume more energy but has the potential to reduce leftovers, production waste and second-choice stock.

To understand the impact of technology improvements compared to the adoption of a more sustainable energy grid mix, two evaluations were conducted: a detailed study on spinning machines and a specific sensitivity analysis comparing coal-based energy and renewable energy to evaluate possible mitigation strategies.

Looking for the root causes of the climate change in the dry processes, the following main impact drivers that account for over 75% to 95% of the climate change impact were identified:

1. Electricity from coal
2. Electricity from a standard grid mix (mainly fossil based)
3. Heat from natural gas

The average ratios of GHG emissions of the consumed electricity or the heating within the specific dry processes are:

Assembly: ~ 65% GHG coming from electricity and 15% GHG coming from heating
Knitting: ~ 65% GHG coming from electricity and 10% GHG coming from heating
Spinning: ~ 85% GHG coming from electricity and 10% GHG coming from heating
Weaving: ~ 73% GHG coming from electricity and 20% GHG coming from heating

Additional climate change impacts are coming from packaging materials, waste going into landfills, transport and trimmings used in assembly (see description in chapter 3.2.1).

4.3.1 Dry process technologies

Different spinning technologies do not only impact the spinning itself, but also other processes along the supply chain such as cotton cultivation due to a different consumption of cotton (figure 12). Among the combed yarns, compact yarn has lower material losses than air-jet, but a higher electricity consumption; among the carded yarns, rotor yarn has the lowest electricity consumption. Both yarn quality (as yarn count) and yarn type (combed or carded) influence the environmental impacts: the production of finer yarns requires more electricity and has higher material losses; combed yarn has higher material losses than carded yarn.

As can be seen (figure 12), carded yarns have on average 15 - 20% lower GHG emissions than combed yarns, but the respective products are also completely different in terms of quality. Even within the same technology (compact or carded), the difference in regards to GHG emissions ranges between 3% and 10%.

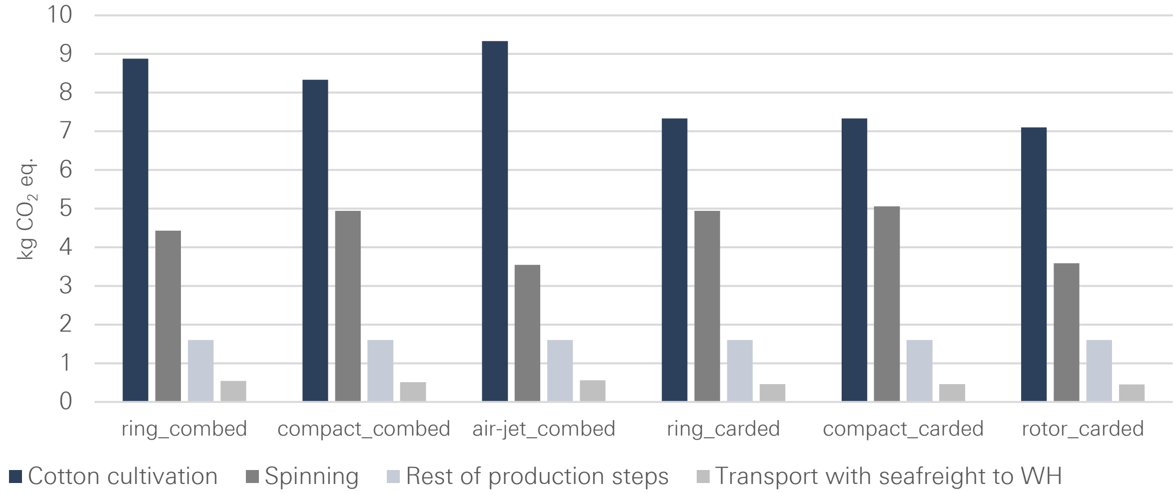

Figure 12: Impact of spinning technology on climate change

4.3.2 Impact of energy sources on climate change and human toxicity

The impact of a particular energy source on climate change is shown in figure 13. Two scenarios are depicted: one is fossil-based and the other one is an electricity mix typical for Switzerland (hydropower and nuclear energy). The evaluation reveals that the impact of energy use on climate change can be greatly reduced if fossil fuels are replaced by renewable energies. Savings from the use usage of renewable energies can exceed 80%, with a further reduction of around 40% in human toxicity impacts (cancer and non-cancer effects).

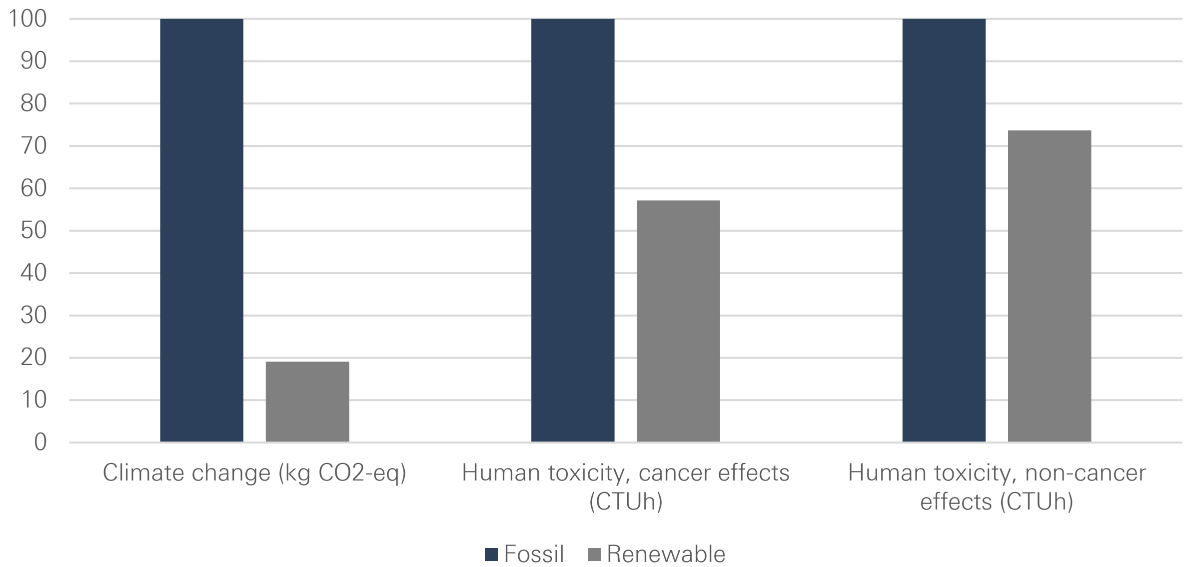

Figure 13: Impact of particular energy sources on climate change in %

Unfortunately, there are certain regions where high levels of smog drastically reduce the efficiency of solar panels while at the same time, renewable energy cannot be purchased and/or legal restrictions do not allow own production of renewable energy. In these cases, other solutions should be found, for example, investments in better technologies could be made or maintenance measures could be improved to reduce climate change.

4.3.3 Maintenance

Maintenance of machines and buildings is crucial for many issues, as it
- Extends the lifespan of machines, hence avoiding the need to produce new ones.
- Keeps the energy consumption of machines at their initial or optimal performance.
- Recovers energy by perfect isolation of buildings and/or correct lightning (nowadays basic standards).
- Keeps safety issues, product quality and many other topics under control, all of which have a direct or indirect impact on the optimal long-term performance of a factory.

For this subchapter of the white paper, unfortunately no own or well-documented literature data was available. Nevertheless, maintenance is definitely a rather low cost investment in order to reduce the overall energy consumption and prevent accidents.

4.3.4 Summary

As with wet processes, the greatest climate protection effects in dry processes can be achieved by switching from fossil fuels to renewable energies. In cases where renewable energies are not available, e.g. due to government or market failures, efforts should be made to achieve energy savings through process and/or technical innovations.

4.4 Logistics – Transport

This chapter deals with the impacts on climate change caused by the various modes of transport. The impacts of the various transport routes – from the finished garment manufacturer to the distribution center – were analyzed in detail and are described below.[21] This is followed by an examination of the different impacts of online and offline shopping on climate change.

4.4.1 Production logistics

In figure 14, the impact coming from an average weighted cotton garment without the final transport is compared to a shipment using sea freight as well as airfreight.[22] The increase of climate change for the shipment with sea freight is “not significant” (amounts to less than 1%), whereas a shipment with airfreight increases the impact on climate change by 20%.

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[21] The delivery routes between the farmers and the various factories are already included in the individual production steps.
[22] The comparison was done for of a typical long-haul transport from Hong Kong to Germany.

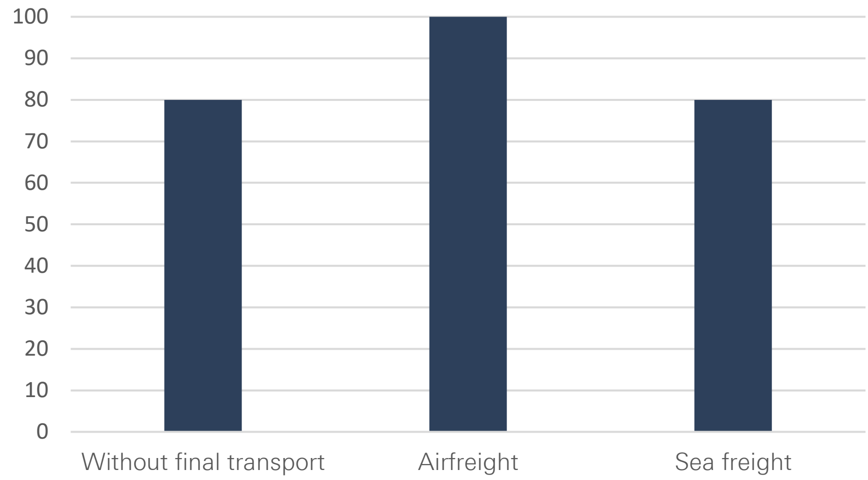

Figure 14: Impact of transport mode on climate change in %

Figure 15 shows a comparison of different modes of transport in terms of lead-times and impacts on climate change for the route from Hong Kong to Germany. Air and sea-air have the biggest impact on climate change (and are by far the most expensive transport modes). By contrast, the various sea freight shipping modes have a rather low impact on climate change (and are the most economic ones). Rail freight is an ideal shipping mode for lead-time critical products. Furthermore, it enables shipping with low environmental impacts (and at reasonable costs).

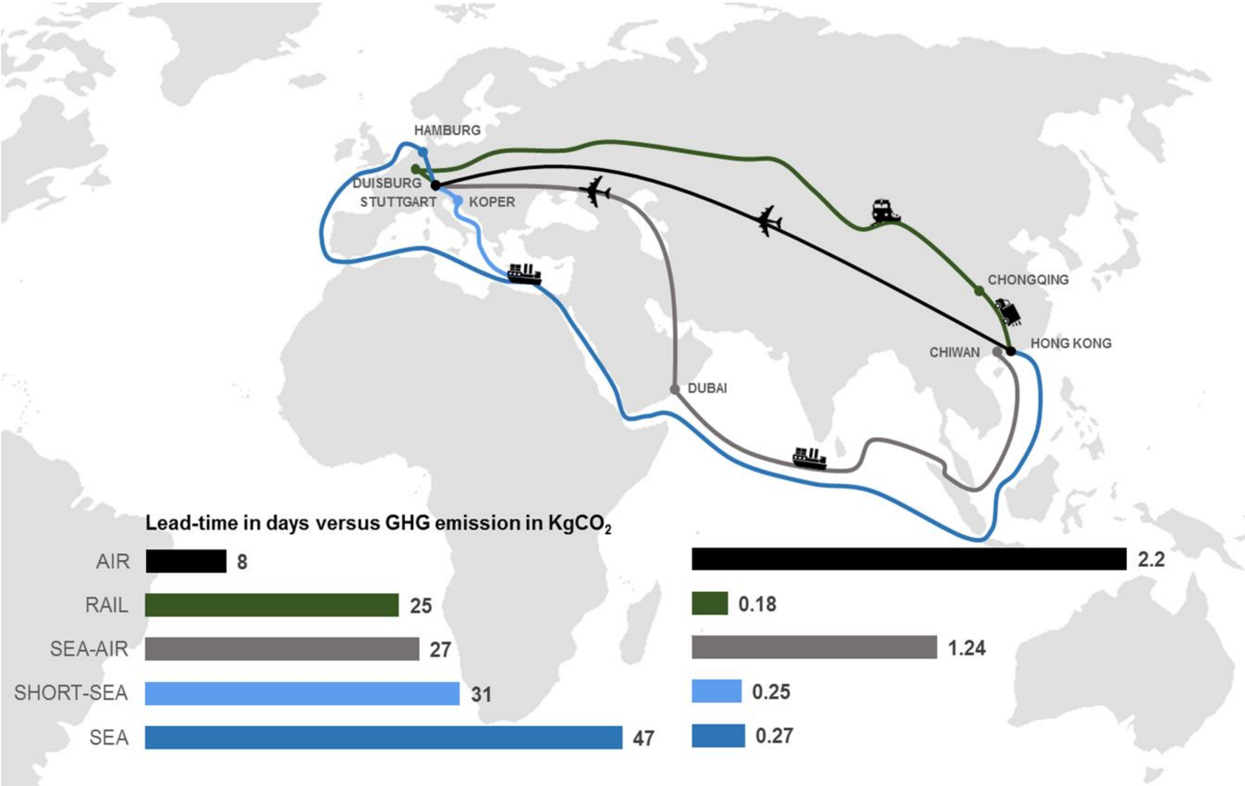

Figure 15: Comparison of different modes of transport in terms of lead-time and GHG emissions

4.4.2 Online vs. offline shopping

From a logistical point of view and in terms of GHG emissions, online sales with direct delivery to the end consumer have advantages over retail purchasing. However, the extent and accuracy of these considerations depends on a variety of variables. The most important of these variables is the return rate, as it affects e.g. the transport and the packaging of the products because of the reshipment. Other relevant variables are e.g. the geographical area (rural vs. urban), the geographical topology ("bicycle-friendly" lowlands vs. mountainous regions), the packaging (eco-friendly bags vs. plastic bags) and the shopping habits of the customer.

4.4.3 Summary

The logistical analysis of the impacts on climate change has shown that airfreight is fast, but particularly damaging to the environment while sea freight and rail transport are quite environmentally friendly but especially sea freight is comparatively slow. In addition, it seems likely that online shopping at low return rates has less of an impact on climate change than offline shopping.

5 Key elements for a low carbon product

As outlined in the previous chapter, the carbon footprint of a product derives mainly from the energy consumed (fossil and renewable energy) in the various production steps. GHG emissions can be reduced by using modern technology, natural fibers, heat recovery systems, energy-efficient maintenance and the absence of airfreight.

To implement the following key elements for low carbon products a close collaboration with all partners along the supply chain is necessary.

5.1 Green energy

Producing a low carbon product depends mainly on the specific energy grid consumed during the various refinement processes. This depends very much on the availability of green energy, the country-specific regulations for the production of green energy, but also on the efficiency of the installations. For example, solar panels do not function properly in areas with high levels of smog and cannot be used cost-effectively there.

5.2 Refinement processes (wet and dry)

To minimize the GHG emissions during the production processes the ideal cost-benefit ratio is achieved by improving energy efficiency through continuous maintenance and investments in energy and heat recovery systems. A good guidance to improve energy efficiency can be obtained by online systems like CPI2[23] or initiatives like the National Cleaner Production Centres (NCPC) [24] supported by United Nations Industrial

[23] CPI2 is a tool that offers companies concrete guidance on how to save energy. After provision off energy self-assessments, improvement measures are suggested.
[24] The NCPC aims to prevent the generation of industrial waste and emissions and thus to reduce the need to recycle, recover and treat wastes.

Development Organization (UNIDO) and United Nations Environmental Programme (UNEP) which provide on-site support.

In addition, innovations in wet processes are already available. However, they often necessitate system changes that require a major rebuild of production plants. Only in this way, the implementation can be economically successful, the complexity be mastered and the old, non-climate friendly processes be eliminated.

5.3 Materials

The production of natural, renewable fibers causes relatively low levels of GHG emissions. Furthermore, these fibers are biodegradable and therefore have a clear advantage over synthetic fibers in the production of low-carbon products. As a result, their higher water and land use is offset by protecting the oceans and the flora and fauna from micro-plastic waste. New bio-based fibers, especially coming from recyclable sources, could help in the future when they will be available on a larger scale.

5.4 Transport

In order to avoid a 20% increase in GHG emissions, airfreight should not be introduced at any production stage. For online sales, the focus is to limit the return rate. Packaging can help to further reduce unproductive volume and weight and thus GHG emission during transport.

5.5 Quality – long life span

A long product life span is the most effective way to reduce any kind of environmental impact of a textile or leather product. Good consumer instructions for cleaning will further help to reduce the impact during the use phase. In addition, products designed in accordance with recycling principles further reduce the impact.

5.6 Summary

The main design and procurement principles to define a low carbon product are:

1. Design for the circular economy
2. Use of natural, renewable fibers
3. Production in factories that use green energy and have energy/heat recovery systems in place
4. Use of environmental management system and publication of GHG reduction targets
5. Appliance of low energy refinement processes whenever possible and available
6. No use of airfreight
7. Focus on quality and a long product life span

The decisive factors in the fight against climate change are the type of energy consumption and the degree of energy efficiency. Therefore, the focus should be placed on implementing available technology to recover energy and/or reduce energy losses by getting support from existing initiatives like CPI2, UNIDO, NCPC or other known organizations. To search for disruptive innovations or niche farming methods as requested in current academic and civil society publications, is therefore of less importance.

The main challenge to reduce the impact on climate change is the availability of green energy and the support of the partners in the entire supply chain. For this reason, HUGO BOSS joined the platform for fashion and climate action from the UNFCCC. Through this commitment and the collaborative effort, we want to achieve the best possible effect.

6 Conclusions and next steps

With this 3rd white paper, HUGO BOSS has completed the analysis of its major product categories started in the 1st and 2nd white papers. Overall, HUGO BOSS draws on more than nine years of research in the field of sustainable products and supply chain management in collaboration with various experts. LCAs (including LCIs) remain a key tool for a holistic understanding of impacts on ecosystems caused by a product's value chain, enabling a focused mitigation strategy.

The monetization of ecosystem services is a powerful tool that makes it possible to compare the various impacts on the environment in the best possible way. Hotspots become more visible and communication becomes more effective. HUGO BOSS will further investigate socio-economic impacts and benefits according to existing standards with a similar approach as described in the environmental impact. Furthermore, collaborations on national and international level in cross sectorial working groups have been established to enable a triple bottom line impact valuation focusing on social, environmental and economic impacts and benefits at the same time.

Finally, HUGO BOSS and its partners will further investigate the impact valuation and publish the results to support efficient mitigation strategies along the entire supply chain. HUGO BOSS will continue to promote the approach of the Natural and Social Capital by conducting additional in-depth analyses and is aiming to find ways to efficiently reduce impacts on the society and ecosystem services.

Mai 31, 2018

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7 List of abbreviations

BCI	Better Cotton Initiative
BLC	British Leather Technology Centre
GHG	Greenhouse Gas
ILCD	International Reference Life Cycle Data System
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
NCC	Natural Capital Coalition
NCP	Natural Capital Protocol
NCPC	National Cleaner Production Centres
PEF	European initiative Product Environmental Footprint
PEFCR	European Product Environmental Footprint Category Rules
RWTH	Rheinisch-Westfälische Technische Hochschule
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WALDB	World Apparel & Footwear Life Cycle Assessment Database
ZDHC	Zero Discharge of Hazardous Chemicals

8 Appendix

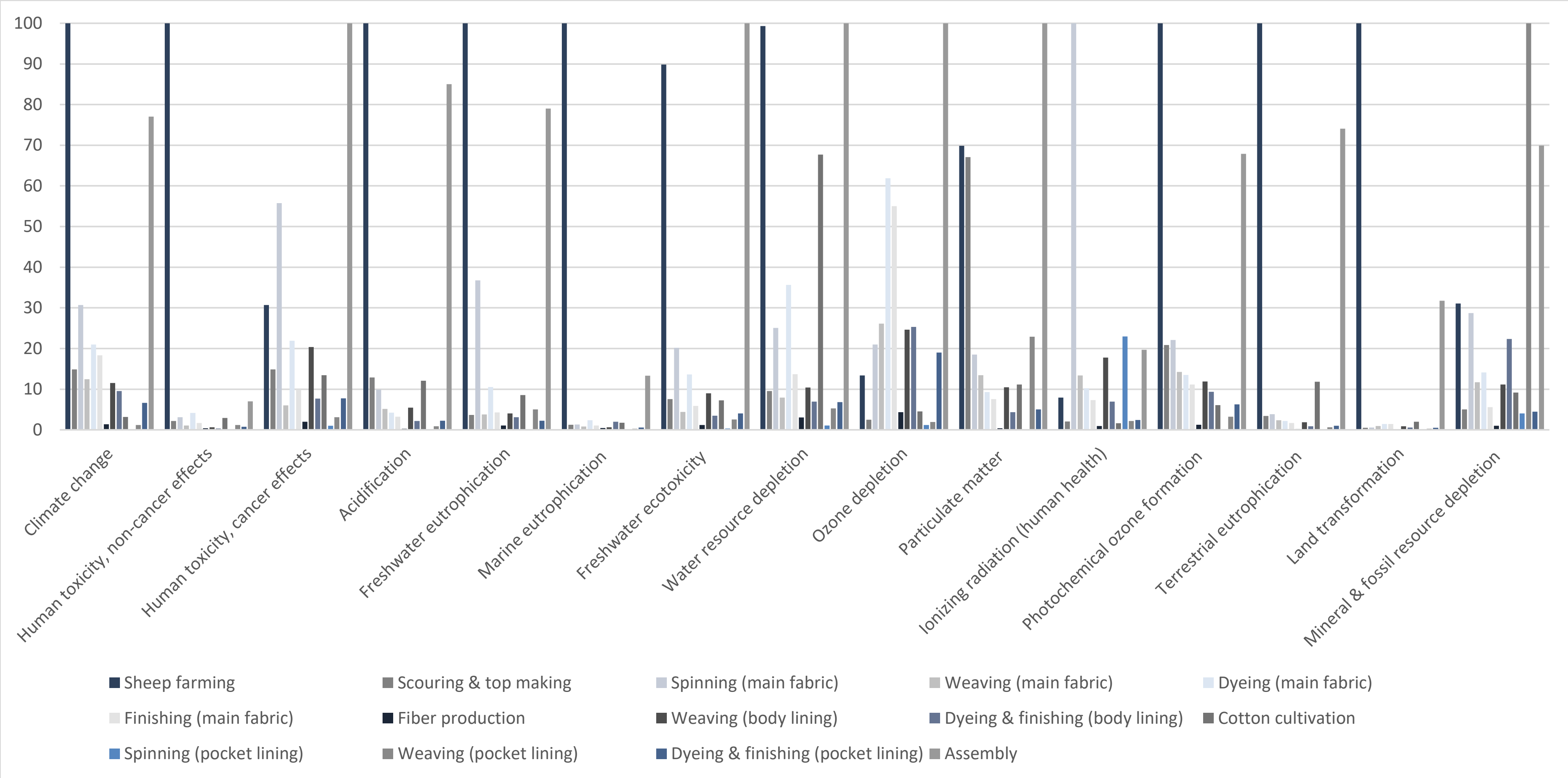

Figure 16: Wool suit median environmental impacts along the supply chain in %

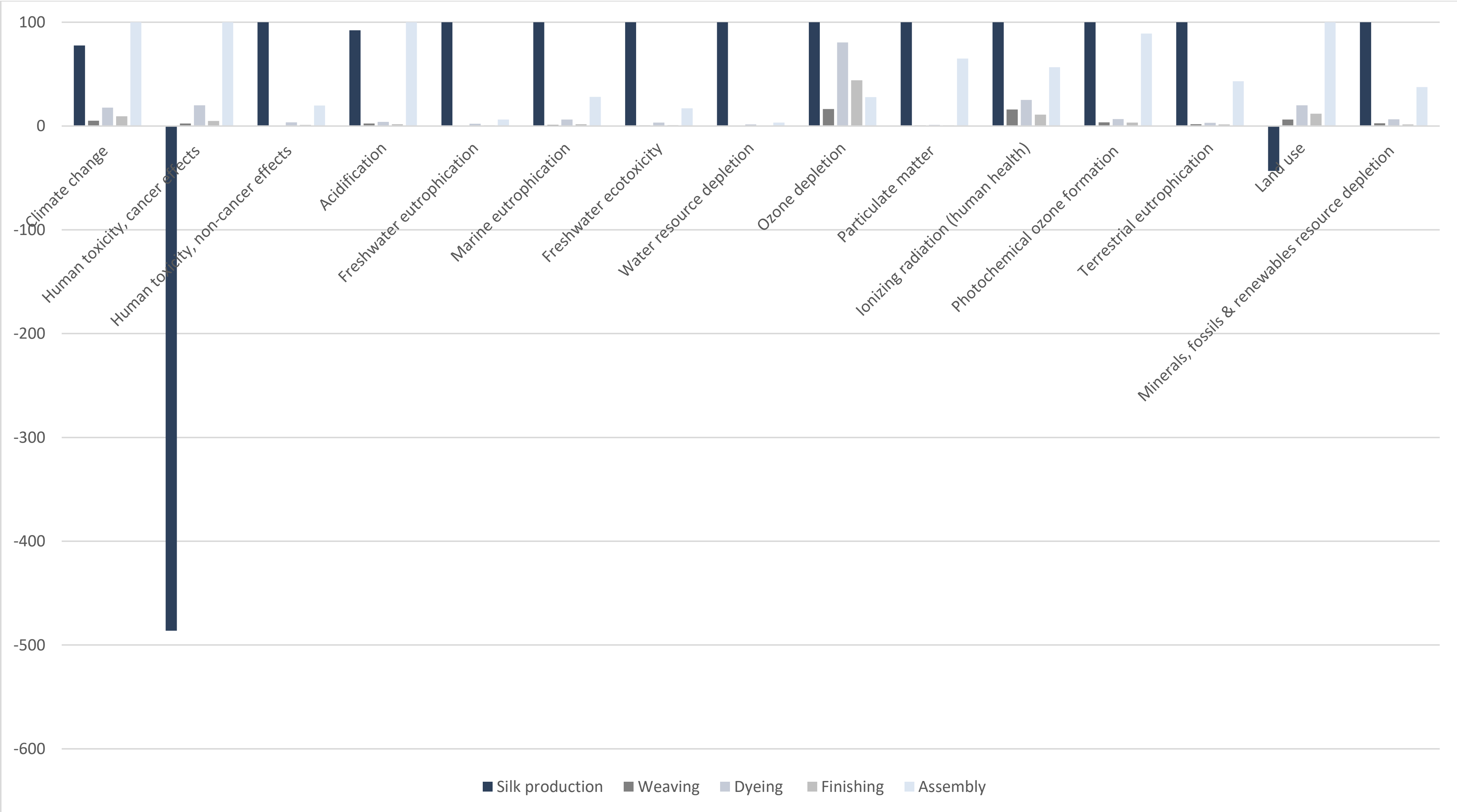

Figure 17: Silk tie median environmental impacts along the supply chain in %