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Danish apparel sector natural account

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Danish apparel sector natural account

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Sources must be acknowledged.

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1 Foreword: IC Group

IC Group A/S is a Danish listed group formed in 2001 by the merger of Carli Gry International A/S and InWear Group A/S. IC Group A/S runs and develops five strong brands.

With revenues of around DKK 2.6 billion and more than 1,000 employees, IC Group is ranked among the largest clothing companies in the Nordic region. Our brands are sold through nearly 240 retail and franchise stores, through e-commerce and via more than 4,300 distributors in more than 25 countries.

To further our understanding of our value chain and its environmental impact we have participated in the Natural Capital Accounting (NCA) project. The valuation of our natural capital shows us where in the value chain we have the biggest environmental impact. The new insight makes us able to compare our impact on water, CO_2 and air pollution in monetary terms and identify sustainability hot spots. The NCA project also shows us the environmental impact of different choices of materials and hence reinforces the work we do with our designers and buyers in terms of using more sustainable materials.

In general the results complement our work on improving the sustainability of our value chain by being able to focus resources to where we have the biggest impact and identify where we can leverage change.

2 Executive summary

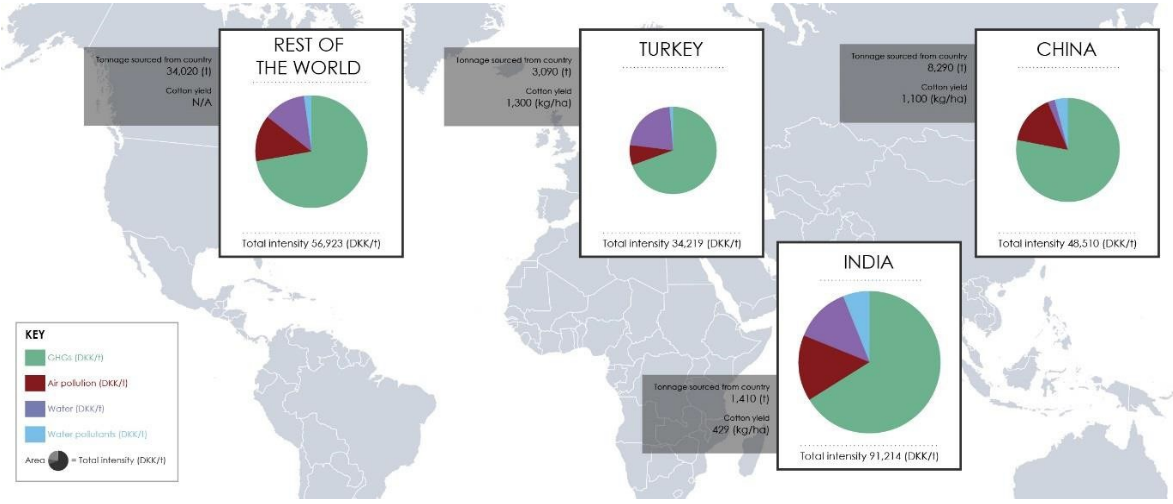
The Danish apparel sector is globally recognised and economically important to the Nordic region. The textile sector for Denmark had an estimated value of DKK 38.6bn in 2012 (DMOGT, 2013), including apparel and other textiles. Like most apparel, it is associated with environmental impacts across supply chains worldwide. The Danish Environmental Protection Agency commissioned Niras, 2.-0 LCA consultants and Trucost to conduct a triple-level natural capital valuation to determine the impacts of apparel production , where they occur and what the significant impacts are in monetary terms. The analysis focuses on three levels of the apparel sector in Denmark. These are:

- National sector-level (including all apparel consumed within Denmark)
- Company-level (including all IC Group core brands)
- Fibre-level (agricultural/raw material production phase of individual fibre types)

This helps stakeholders to understand the natural capital dependencies throughout differing levels of the apparel sector supply chain, allowing better development of sourcing policies and interventions for improvements.

Natural capital accounting in the apparel sector is receiving increased interest, with the 2014 Global Leadership Award in Sustainable Apparel (GLASA) focussing on natural capital advancement in the sector (SFA, 2014). The relevance of natural capital accounting for apparel companies is being driven by factors such as water scarcity, which is threatening crop production as demonstrated by cotton slumps and price hikes following droughts in China and the US, and reputational risk, as witnessed by campaigns over factory working conditions and hazardous chemicals. The study captures greenhouse gas (GHG) emissions, air and water pollution and water consumption, as well as the impact of indirect land use change (ILUC). The study does not capture the direct land use change or other environmental aspects. Including other environmental aspects would alter the results of the analysis and increase the natural capital costs. Also, the use phase of apparel is not captured by the analysis as the focus of the analysis is to show the natural capital cost related to cradle to gate apparel production (raw material production to the finished apparel product). Including the use phase of the fibres would increase the results due to washing and drying requirements of apparel.

Over 80% of Danish apparel is imported as finished product, and most of the environmental impacts are associated with activity outside of the country. The figure shows the distribution of impacts across the three key import countries (Turkey, China and India) for finished apparel, along with impacts associated with the rest of the world (RoW).



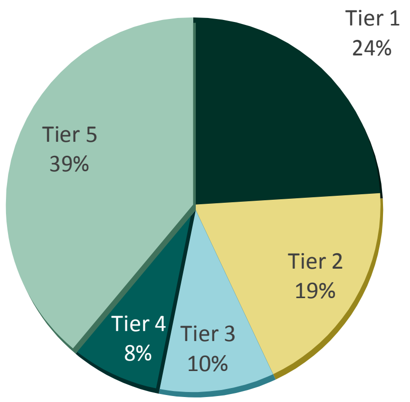
As such, influencing reduction of impacts is more difficult to control, and opportunity exists through supplier engagement and sustainable procurement policies, as well as through consumption measures. Further to this, by using the sector level natural capital account, companies operating in the industry may be able to better understand where to focus their engagement and target improvement.

The results of the sector level natural capital account show that the most material impacts are associated with raw material production in Tier 5, and the final stages of tailoring apparel, Tier 1 (though this phase includes the whole supply chains of accessories and adornments/trims), and Tier 2. Impacts are dominated by GHG emissions, air pollution and water, though water is significantly more material within Tier 5 than other tiers, due to irrigation and farming requirements. Should the sector have to internalise natural capital costs of indirect land use change, water consumption, air and water pollution and GHG emissions, a total cost of DKK 3,390 m would be apparent, equivalent to 11.7% of total revenue for the sector. When considering average profit for the sector in 2012 was less than 6% of revenue (Deloitte, 2014), if the natural capital cost remained constant, this risk would equate to almost twice the profit margin of the year, resulting in a net loss for the sector.

Results for the Danish apparel sector							Results for IC Group
	Air pollutants DKKm	GHG emissions DKKm	Water consumption DKKm	Water pollution DKKm	ILUC DKKm	Total DKKm	Total DKKm
Tier 1 Tailoring of apparel	155	655	3	-	0	**814**	**30**
Tier 2 Wet processing	99	561	5	2.35	0	**667**	**23**
Tier 3 Fabric manufacture	47	299	6	6.36	0	**358**	**13**
Tier 4 Yarn spinning	41	260	7	-	0	**308**	**10**
Tier 5 Raw material production	60	406	340	67.68	39	**912**	**49**
Total	**402**	**2,180**	**361**	**76**	**39**	**3,058**	**124**

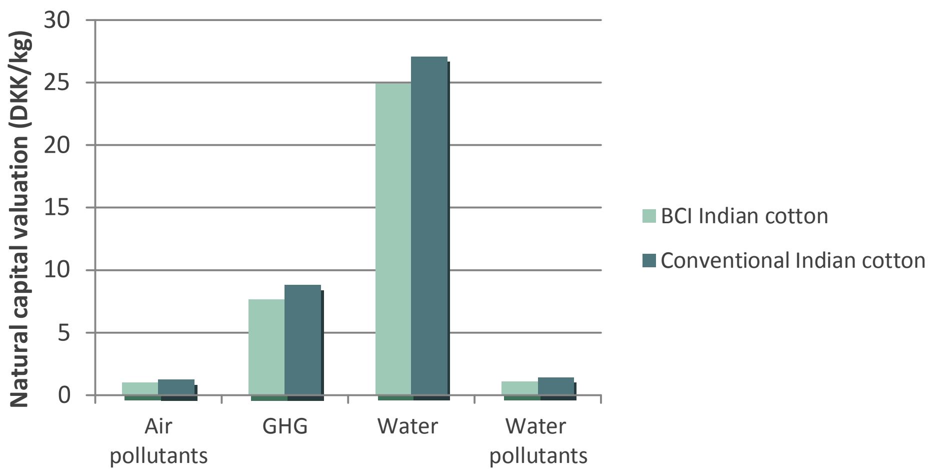
If including leather consumption, the total natural capital cost of the sector is DKK3,393m and DKK129m for IC Group.

The table also shows the natural capital dependency of the IC Group. Analysis of the Group's impacts shows some similarities to the overall sector, with the largest impacts in Tiers 5 and 1, and GHG emissions responsible for the most significant impact. The total natural capital cost of the company's apparel supply chain equates to DKK124m, or DKK129m including leather. However, due to a different ratio of material use and sourcing countries than the sector as a whole, the specific proportions of impacts vary, with Tier 5 more dominant.



Wool has the most impact for the company, with cotton having the second most significant impact. Wool is associated with high GHG emissions at the farming and raw material processing stage, due to several factors including cleaning of fibre in its raw state and methane production from the sheep themselves. Due to higher proportion of wool than the sector average, IC Group average intensity per tonne of apparel is higher than that of the sector, at 63,265 DKK/t compared to 54,221 DKK/t. Cotton cultivation has a greater impact from water consumption due to irrigation requirements, but also has associated agrochemical use and processing resulting in significant GHG emissions also.

IC Group is a member of the Better Cotton Initiative (BCI), an initiative requiring improved water, soil and chemical management of cotton farmland, as well as other environmental and social considerations for production. IC Group will be sourcing a portion of its cotton from farms under the BCI scheme in 2015. BCI cotton from India was compared to conventional Indian cotton. BCI cotton has a 10% lower total natural capital cost compared to conventional cotton, with significant natural capital savings across GHG emissions, water use, and air and water pollution.



By specifying BCI or other sustainable cotton in procurement policies, companies are able to influence supply chain environmental impacts directly, an issue otherwise difficult to improve due to limited control.

The report also focuses on a fibre-level analysis across the sector, highlighting the variation of impacts related to the sourcing location. Production processes in different countries are associated with varying levels of input requirements, different sources of fuel for energy generation, and different levels of water availability.

The report should help individual companies and sector stakeholders to better understand the risk associated with natural capital dependency of apparel supply. This will help the sector to better focus reduction strategies and engage with suppliers to help improve the environmental costs of production and supply of apparel to the Danish market.

3 Introduction

3.1 Background

Home to the world's largest sustainable fashion conference, the Copenhagen Fashion Summit, Denmark is known for its advancements in the world of apparel. Though manufacturing within the country is limited, apparel is an important economic sector comprising well-known brands operating both domestically and overseas.

Danish consumption of apparel in 2000 was nearly 65,000t, of which 83% were imported as finished product (DK & EU IO-database, 2000). This had an estimated revenue of DKK 29bn[1]. Denmark does not produce textiles as raw material (such as cotton farming or polyester production), but it does have apparel cut and sew factories, and finishing plants. As such, it is reliant on a complex and wide reaching network of suppliers and resources. The sector is dominated by women's clothing, produced from a large range of fibres and fabric types. Figure 1 shows fibre production data for the global textile industry, extracted from Oerlikon Textile GmbH & Co (2010), where only the fibres used for apparels (Beton et al., 2009) are presented.

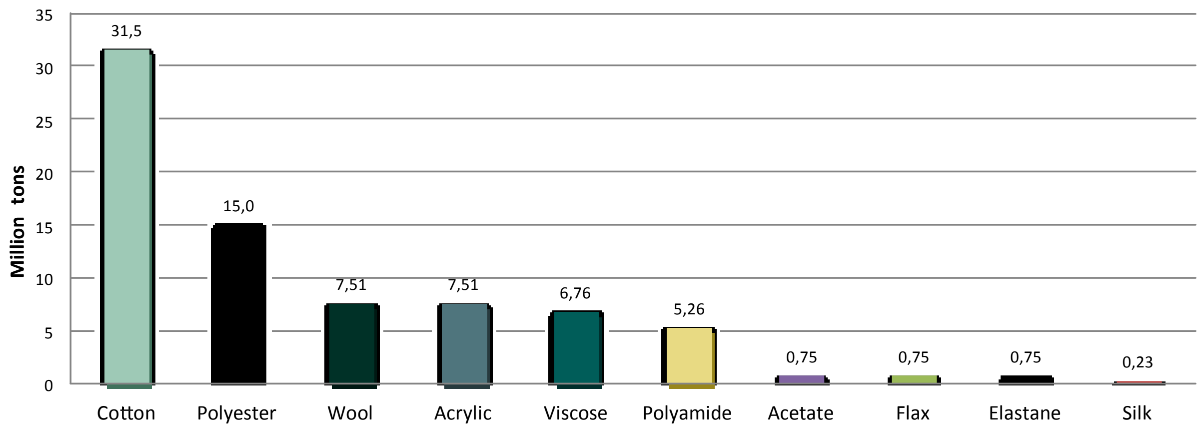


Figure 1 – Global fibre use in textiles

The IMPRO-Tex study and the US industry IO database review further identified cotton harvest and polyester manufacturing as activity hotspots in textile manufacturing (Beton et al., 2009; Suh, 2005). The sector level analysis considers the key fibres and sourcing countries, calculating supply chain impacts for the total sector.

The IC Group is an example of a large national brand operating internationally – currently retailing in 25 countries from over 4,300 distributors. IC Group is responsible for both sportswear and fashion goods, and therefore has a good range of clothing types and materials. The group is the focus of the company level analysis, calculating specific impacts of the supply chain, based on the actual fibre split and sourcing practices of the company based on expenditure.

Different materials and production processes are associated with a wide range of environmentally degrading impacts. Agrochemical use in crop production, chemicals and high-energy processing required in synthetic production and water pollutants which may run off from agricultural land provide some examples of how the apparel supply chain can be intensively damaging.

This triple-level natural capital valuation is designed to highlight these environmental impacts at the level of the sector, companies and raw materials.

[1] Based on Eurostat PRODCOM (2014) Danish production, and calculated using Danmark Statistik (2003) for import sales value.

3.2 What is an industry natural capital valuation?

Natural capital valuation is a means of placing a monetary value on the environmental impacts along the entire value chain of a given organisation, sector, product or other entity.

Since PUMA released the first corporate Environmental Profit and Loss (EP&L) account in 2012, natural capital accounting has become more widely recognised, and more companies such as Novo Nordisk and Yorkshire Water have repeated the exercise on their own value chains. PUMA is a part of the Kering Group that owns brands like Gucci and Stella McCartney. Based on the success of the PUMA project, Kering has decided to roll out an EP&L account for all brands. This study takes the framework set out by these analyses and applies it to three distinct levels by evaluating the apparel sector at a sector level, across the IC Group supply chain and at an individual fibre level.

Natural capital valuation is a method of accounting, in financial terms, for the impacts that business activities have on natural resources and ecosystem services. In the examples of PUMA and Novo Nordisk, the operational impacts of the companies and their supply chains were calculated and monetised based on company expenditure. This report calculates the environmental impacts caused by the Danish apparel sector, thereby capturing the impacts of all apparel consumption within Denmark, both manufactured in the country and imported.

Placing a monetary value on natural capital impacts of apparel allows it to be compared with the revenue of the sector. In the EP&L account, the 'profit' refers to any industry activity that benefits the environment, whereas the 'loss' refers to activities that adversely impact the environment. Almost all sectors will have a deficit on natural capital reflecting the net cost to the environment. These are not actual financial costs to the companies in the industry, and are therefore termed external costs.

The second level of analysis focuses on IC Group, a Danish clothing company responsible for brands such as Tiger of Sweden, By Malene Birger and Peak Performance. At a company level, natural capital valuation can be directly compared to the company's regular financial accounting, which shows the company's net earnings. Adding the external costs to the current financial cost gives an estimate of the true cost of conducting business, and may provide an incentive to reduce not only financial costs, but also environmental impacts. Some costs are already internalised such as fees to local governments for water treatment and waste disposal. Over time, it is expected that more of the external costs will be internalised through taxes and fees, or subject to regulation, so and thus the natural capital account is also a tool for risk management.

Finally, a third level natural capital valuation was is conducted, focussing on fabrics identified in the sector level analysis as highly significant in terms of both environmental and economic relevance to the region. Within this analysis, differing scenarios are given regarding the country of origin for raw materials, and considering the use of Better Cotton Initiative cotton, to understand the effect variation in impact this has on the overall impact of the material.

3.3 How can the apparel industry apply the results?

The sector-level natural capital valuation aims to place a monetary value on the environmental impacts of the apparel sector in Denmark, and the supply of apparel from the production/extraction of raw material through to the completed finished product. The monetary figure aims to reflect the value of natural resources being consumed, such as water, alongside the pollutants emitted to the environment, including both emissions to air and water. Through sector level review, individual organisations operating in the sector can gain an understanding of the impacts that are associated with the products they manufacture or sell. Further to this, the IC Group natural capital account also provides more specific insight into company practices, and shows how an individual company can influence its supply chain impacts. Some of the key opportunities through use of natural capital valuation are given below:

- **Awareness and Transparency Tool:** A natural capital valuation allows greater understanding of environmental impact and dependency on natural capital in a context that is relevant to business. The monetary value of a natural capital account allows for a comparison of the importance of natural capital dependency to other key performance indicators such as economic revenue and profit.

- **Identification of Environmental Hot Spots:** Natural capital valuation allows for prioritisation of environmental key performance indicators (EKPIs) such as global warming and water footprint. Identification of hotspots allows for focus to be placed on the most significant points of the supply chain and within application areas such as functions, product series and business areas.

- **Risk Management:** By being aware of its reliance on natural capital, an organisation can reduce risks to its business. For important EKPIs, the organisation can act to reduce the legal, resource and market-related risks by cutting its impacts.

- **Sustainable Supply Chain Management:** Knowing the distribution of impacts throughout the supply chain allows for an organisation to formulate environmental requirements to suppliers, which can be used to frame supplier engagement and policy.

- **Communication:** Having a singular financial metric to communicate risk and dependency allows for ease of understanding across a wide range of stakeholders, including internal financial officers, investors and customers.

4 Scope and boundaries

The research captures impacts across all the supply chains of apparel consumed within Denmark. A literature review was carried out to determine the types and quantities of apparel sold in the country. The most relevant fabrics and sourcing countries were identified and focussed upon for a robust analysis. Non-apparel textile (such as curtains, bedding and other household linens or textiles) are not included within the report.

4.1 Triple-level analysis

The analysis focuses on three levels of the apparel sector in Denmark. These are:

- National sector-level (including all apparel consumed within Denmark) Section 5.1
- Company-level (including all IC Group brands) Section 5.2
- Fibre-level (agricultural/raw material production phase of individual fibre types) Section 5.3

Figure 2 shows the coverage of each of these analyses.

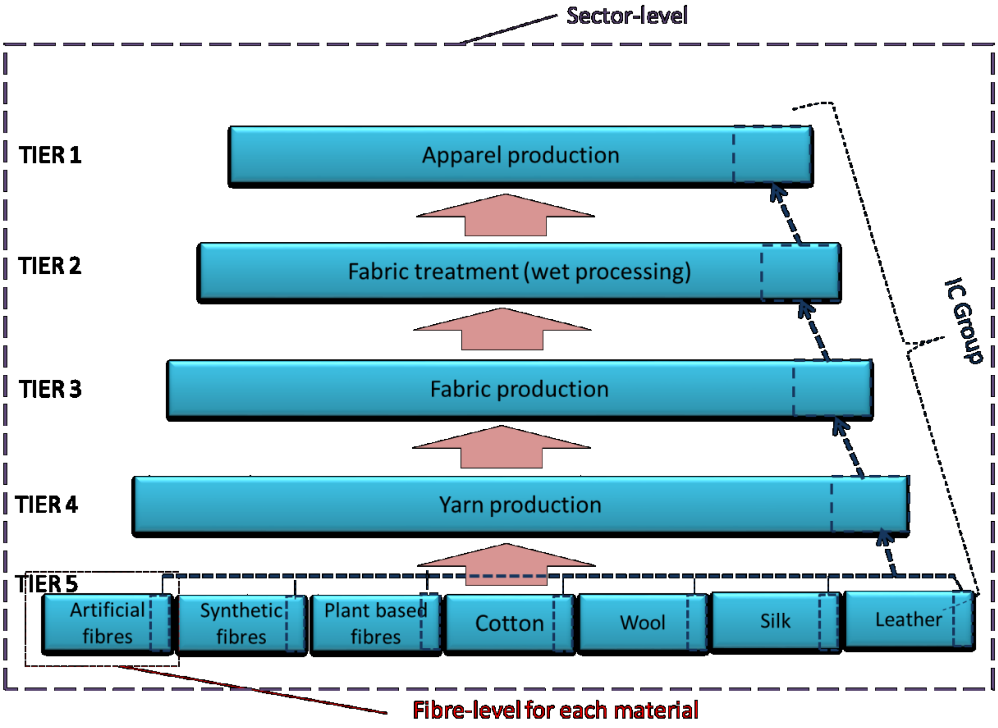


Figure 2 – Scope of the three levels of analysis

For each level, the analysis considers impacts across the value chain from material extraction, through to final manufacture of the product. Section 4 details the complexities of the sector, and how the boundaries are therefore defined specifically for the purposes of this project. Use phase and disposal are often not included within EP&L accounting and are also not included in this study partly due to the limited influence that companies can have on consumer behaviour (though material selection and design have a relevance). Including use and disposal will alter the results of the analysis due to further energy and water requirements for maintenance of clothing (washing, drying and ironing), and disposal into landfill or recovery at end-of-use.

4.2 Environmental key performance indicators (EKPIs) assessed

Environmental key performance indicators (EKPIs) were selected based upon the relevance to the sector and materiality according to current knowledge.

The analysis focuses on the following EKPIs:

- Greenhouse gas emissions (CO_2, CH_4, N_2O)
- Air pollution (including NH_3, SOx, NOx, NMVOCs and PM10)
- Water consumption
- Water pollution
- Indirect land use change (ILUC) – measured through the impact on air pollutants and GHG emissions.

One means to assess biodiversity would be to calculate the ecosystem services associated with the land used in its current and prior state. However, this has a significant overlap with some of the ILUC calculations such as measuring the change in carbon stock in the transition from forest or grassland to arable land, and therefore is not calculated within the study.

Greenhouse gas emissions: Human induced emissions of carbon dioxide and other greenhouse gases are resulting in changes in the global climate. Agricultural emissions related to cotton farming, farming equipment, and the rearing of sheep for wool production are relevant to the sector. In some parts of the world the impacts of climate change are already being felt, including increased flooding and drought, sea level rise, impacts on crop yields, and more frequent storms. Continuing climate change is expected to increase the severity of these impacts with diverse but significant consequences for societies around the world.

Water use: Water plays a critical role in maintaining all natural systems which underpin life. The extraction of water by business (for purposes such as irrigation requirements) from surface watercourses, groundwater, and collection of rainwater for consumption reduces the amount of water available to others and therefore reduces the benefits society derives from water. Specific impacts are highly location dependant but include reduced availability of water for domestic, industrial or agricultural use, loss of habitat for other species, changes to local climate, and impacts on recreation in and around watercourses. Water is required throughout the apparel value chain, including crop irrigation, wet processing, and throughout manufacturing processes at each stage.

Air pollution: Air pollutants include particulates, sulphur dioxide, ammonia, nitrogen oxide, and non-methane volatile organic compounds (NMVOCs) and are emitted principally as a result of the burning of fossil fuels, as well as through the use of nitrogen-based agrochemicals. These emissions can result in smog and acid rain, with associated impacts on health (particularly respiratory conditions), agricultural production, property, and the acidification of waterways and soils.

Water pollution: Discharge from wet processing factories, synthetic fibre production, and the use of agrochemicals (including pesticides and fertilisers) can release pollutants into neighbouring water systems, resulting in negative implications on water quality. The impact of the chemical varies depending on its chemical composition, but for example, fertiliser use can lead to eutrophication of local bodies of water, which can have devastating effects on local flora and fauna within the system.

Accounting for land use change: Increasing demand for productive land creates land use change and deforestation. The indirect land use change (ILUC) model accounts for the land use change that will occur (in a location other than the harvested fields) as a consequence of increasing the crop demand. The model combines two aspects which may be apparent to meet an increase in demand for crop – in this case, cotton;

- Transformation (deforestation): measuring the change in carbon stock in the transition from forest grassland or other land types to arable land. This can be expressed as a carbon figure. This corresponds to an increase of agricultural area.
- Intensification: if the demand for cotton increases, yields could be increased as an alternative to increase of arable land. In this case, the model considers the additional fertiliser input that would be required to meet this growth of yield. Impacts are related to fertiliser production (energy use, etc.) and the increase in emissions from applying fertiliser to agricultural soil such as N_2O, ammonia and nitrates (currently only nitrogen fertilisers are included within the model). This corresponds to an intensification of the farming practices.

Direct land use change and other environmental aspects are not captured within the model. If including more environmental aspects the results will alter. Other environmental aspects could be waste, direct land use change, and land pollution.

5 The Main Findings

This section details the key findings of the triple level natural capital account, showing impacts at a sector, company and material level. As mentioned in chapter 4 the analyses and thus the results covers the environmental aspects GHG emissions, air pollution, water use, water pollution, and indirect land use change (ILUC), and the production apparel from production of fibres to the finalized apparel products. Including more environmental aspects or increasing the scope e.g. by including use and disposal phase will alter the results.

5.1 National sector-level analysis

Of the 65,000t of apparel consumed in Denmark in 2000, over 80% is imported as final product, with the key import countries including China, India and Turkey (International Trade Statistics, 2012). While India only imports 3% of finished product, it has a significant role at earlier stages of the supply chain, for example it is responsible for 25% of the wet treatment of fabric (ITMF, 2011).

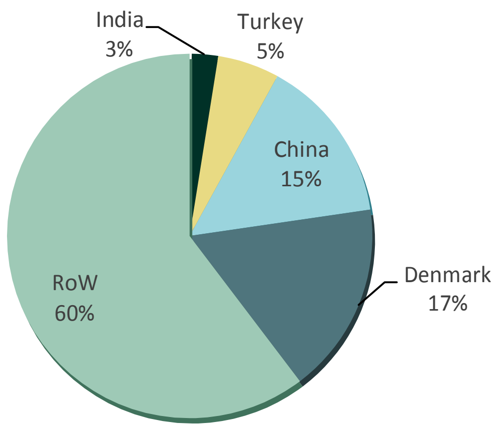


Figure 3 – Sourcing of apparel in Denmark: domestic production and imports

While Denmark does not produce raw material, it does have some factories producing final products from imported fabric and incomplete apparel, which are then finished within the country. The analysis considers the apparel sector only, and does not include textiles used in domestic linens, upholstery and other non-apparel related textiles. These would likely be dissimilar to the apparel sector due to alternative fibre uses, and different processing requirements.

Impacts were quantified and valued at each level of the supply chain, based upon five key industries: raw material production, yarn spinning, fabric manufacturing, wet processing and the tailoring of apparel. Total impact of all apparel in Denmark equates to approximately DKK 3,060m, or over DKK 3,300m including leather. Table 1 shows the full natural capital account with tier level breakdown. The impacts of leather were not a key focus for analysis, and as such are excluded here as the tier breakdown was not determined.

The results of the sector level natural capital account show that the most significant impacts are associated with raw material production in Tier 5 (30% of total), and the final stages of tailoring apparel, Tier 1 (27% of total). Using the allocation of impacts through input-output modelling, Tier 1 includes all supply chain impacts of any additional inputs at this stage, including accessories and adornments/trims such as buttons and zips. This is important to note as these have own individual supply chains, and material impacts may actually be several tiers removed, but the input occurs at the final stage. Tier 2, the wet processing of materials, is also significant with 22% of the total impact of the sector, largely due to GHG emissions.

Impacts are dominated by GHG emissions and air pollution, though water use is significant within Tier 5, due to irrigation and farming requirements. Water pollution is most significant in the raw material extraction phase at Tier 5 also, while Tier 1, tailoring of apparel, has no significant water pollution impact.

Should the sector have to internalise natural capital costs of indirect land use change, water consumption, air and water pollution and GHG emissions, the total cost would be DKK3,390m, equivalent to 11.7% of DKK29bn total revenue for the sector. When considering average profit for the sector in 2012 was less than 6% of revenue (Deloitte, 2014), if the natural capital cost remained constant, this risk would equate to almost twice the profit margin of the year, resulting in a net loss for the sector.

The natural capital account for the sector is detailed below. All figures are given in DKKm, relating to 65,000t of apparel.

	Air pollutants DKKm	GHG emissions DKKm	Water consumption DKKm	Water pollution DKKm	ILUC DKKm	Total DKKm	Percentage of total impact
Tier 1 Tailoring of apparel	155	655	3	<0.1	0	**814**	**27%**
Tier 2 Wet processing	99	561	5	2	0	**667**	**22%**
Tier 3 Fabric manufacture	47	299	6	6	0	**358**	**12%**
Tier 4 Yarn spinning	41	260	7	<0.1	0	**308**	**10%**
Tier 5 Raw material production	60	406	340	68	39	**912**	**30%**
Total	**402**	**2,180**	**361**	**76**	**39**	**3,058**	**100%**

Table 1– Sector level natural capital account for the total Danish apparel industry (excluding leather)

If including leather consumption, the total natural capital cost of the sector is DKK3,390m.

GHG emissions dominated all EKPIs as the most significant impact, with 71% of the total natural capital costs of the sector.

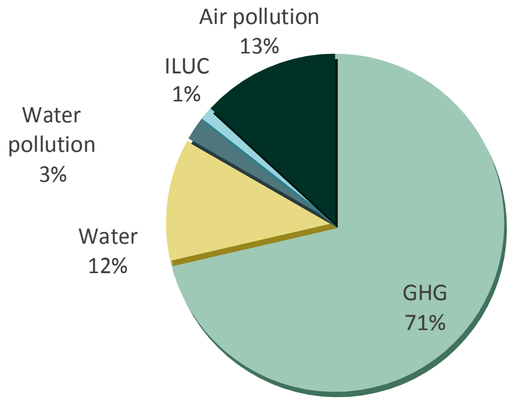


Figure 4 – Total natural capital dependency of the Danish apparel sector by EKPI

GHG emissions are dominant throughout all the tiers of apparel production, associated with fossil fuel for energy use, agrochemicals and many other processes.

The tailoring of apparel phase (Tier 1) is responsible for the greatest GHG emissions, though this captures not just the final stages of apparel production, but the impacts associated with all the additional inputs – such as adornments/trims, buttons and accessories which are not captured within the five focus sectors. The boundary allocation of the IO modelling includes inputs at each particular stage, and differs from the process used for LCA style analysis (discussed further below).

Designers can therefore influence this stage by selecting materials for adornments/trims that have a lower impact, or through designing apparel pieces with simpler styles, and fewer features.

It is worth noting that Tier 5 (production of fibres) obtained the highest ranking in terms of cumulated impacts (see Figure 5). These results are in accordance with previous findings obtained with studies conducted with a process LCA-approach.

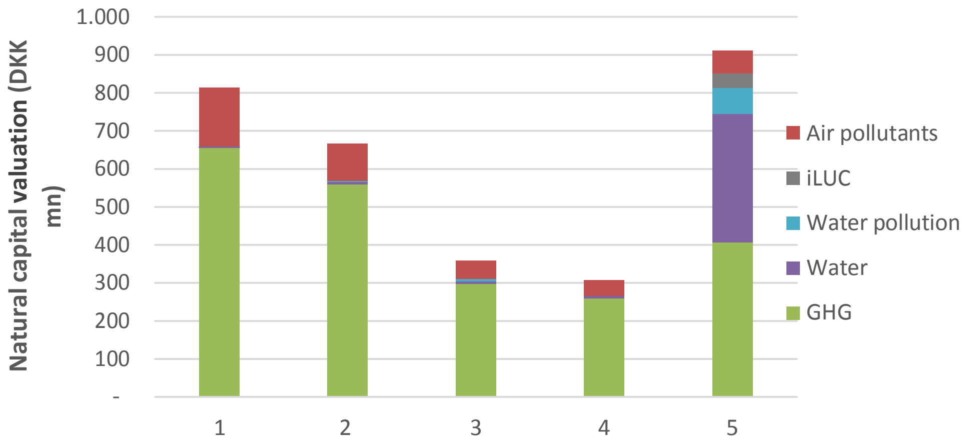


Figure 5 – Danish apparel sector natural capital impacts by tier

Unlike the conventional process LCA approach, the IO-approach considers the whole economy; no industries are left out of the system (e.g. no cut offs are applied). Thus, the IO-approach explains two of the new findings of this study:

- The high contribution of Tier 1 (manufacture of apparel) compared to other tiers. All the industries usually left out from textile process LCA analyses, such as the manufacturing of buttons, are represented in this study within Tier 1. While this does not necessarily mean the impacts are captured at this point, the decisions on inclusion of accessories and adornments/trims here can have significant impact on the overall natural capital dependency of the apparel piece.
- The wet processing industry (Tier 2) reflects more significant impacts than fabric manufacturing (Tier 3) and spinning (Tier 4). The manufacturing of all chemicals, services, and energy consumption are accounted for in the system boundaries for wet processing. In comparison, the water, chemical and requirements at the spinning and fabric manufacturing steps are lower in the chain.

It should also be noted, however, that Tiers 3 and 4 are often captured as 'processing' within the tiers of an LCA and, for example, would both be captured within 'Tier 3' within the PUMA EP&L Account. In order to achieve greater granularity of phases, these are disaggregated within this study.

The largest impacts are associated with apparel from the 'rest of the world' (RoW), also responsible for the greatest total import contribution. However, while India has the lowest individual country of import absolute impact, the intensity per tonne imported is significant. For each tonne of apparel imported from India, the natural capital cost is DKK 91,000 excluding leather.

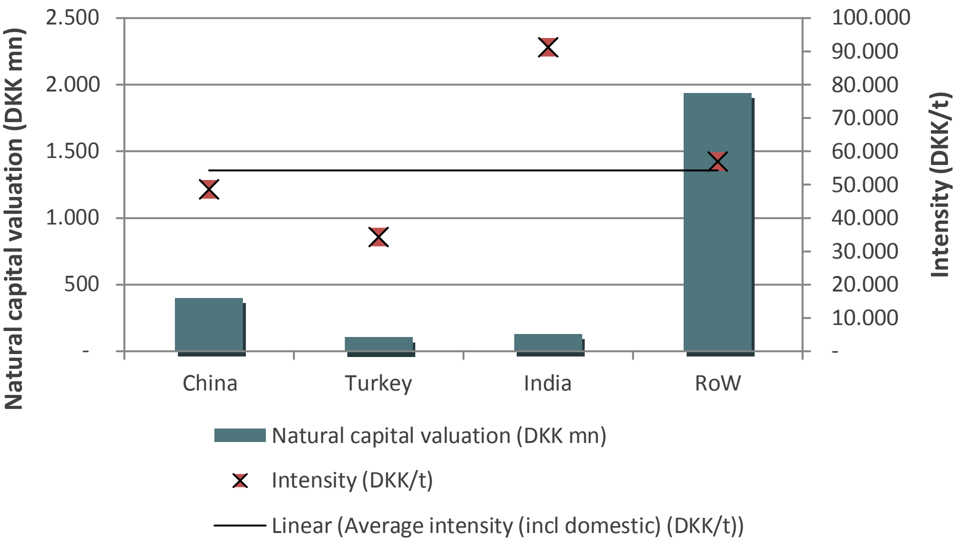


Figure 6 – Impacts and intensity by sourcing country of apparel (all tiers)

While 17% of apparel is considered to be finished in Denmark, the more environmentally damaging processing stages are undertaken elsewhere, and as such it was not considered representative to include alongside countries of production. The linear average shown represents the average of all domestic and imported production, considering the total global supply chain impact, per tonne of apparel consumed within Denmark. Turkey and China are both less intensive, meaning that for every tonne of apparel produced, less negative impacts are apparent than the average tonne of apparel in the country. Figure 7 shows the distribution of these impacts by intensity of natural capital per tonne of material.

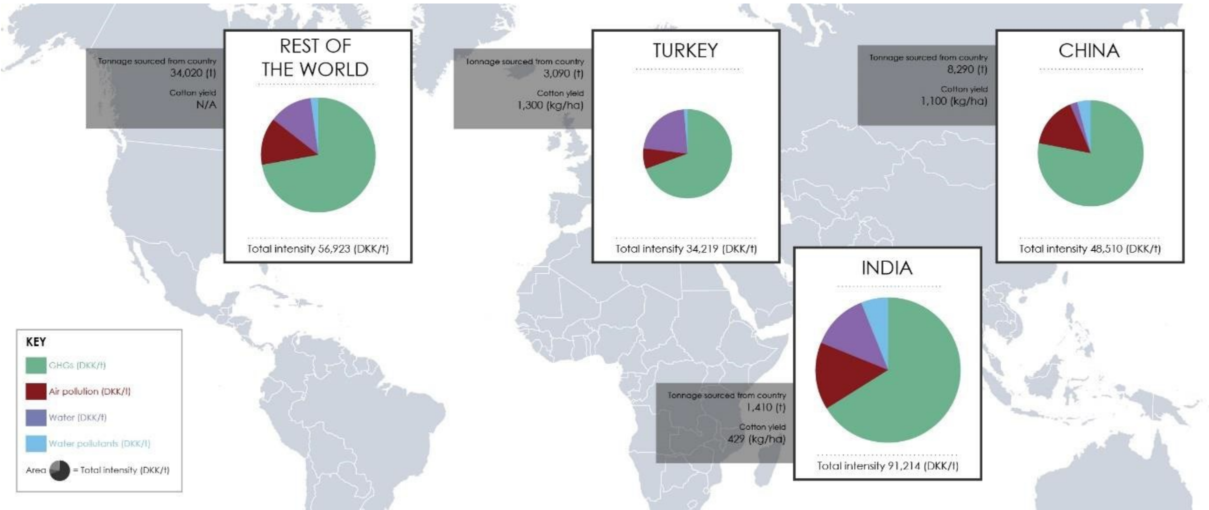


Figure 7 – Impact intensity for all countries of import (all tiers)

Impacts from individual materials are considered in Section 5.3 below.

5.2 Company-level analysis: IC Group

IC Group A/S is a Danish listed company formed in 2001 by the merger of Carli Gry International A/S and InWear Group A/S. The business comprises the three premium brands: Tiger of Sweden, By Malene Birger and Peak Performance and two further brands Designers Remix and Saint Tropez.

The company ranks as one of the largest clothing companies in the Nordic region, with revenues of approximately DKK2.6bn and over 1,000 employees (IC Group, 2012). Brands are sold in over 200 retail and franchise stores.

IC Group provided spend data for 2013, allowing granular evaluation of impact by material. The company consumed 1,960 tonnes of apparel in 2013, with the majority comprised of natural fibres, primarily wool and cotton, accounting for 26% and 40% respectively. While cotton is a larger volume of input, wool is associated with larger natural capital dependency, both in absolute and relative terms. Of all the materials, wool has the highest impact per tonne of material, with DKK61,500 natural capital impact per tonne of material sourced. Synthetic fibres (including polymer based and wholly synthetic materials such as polyester) and artificial fibres (including cellulosic hybrid materials such as viscose) are both associated with low natural capital dependency. GHG emissions associated with both synthetic and artificial fibres can be significant, though this depends on where they are sourced. Section 5.3 highlights the variations associated with these materials in different regions.

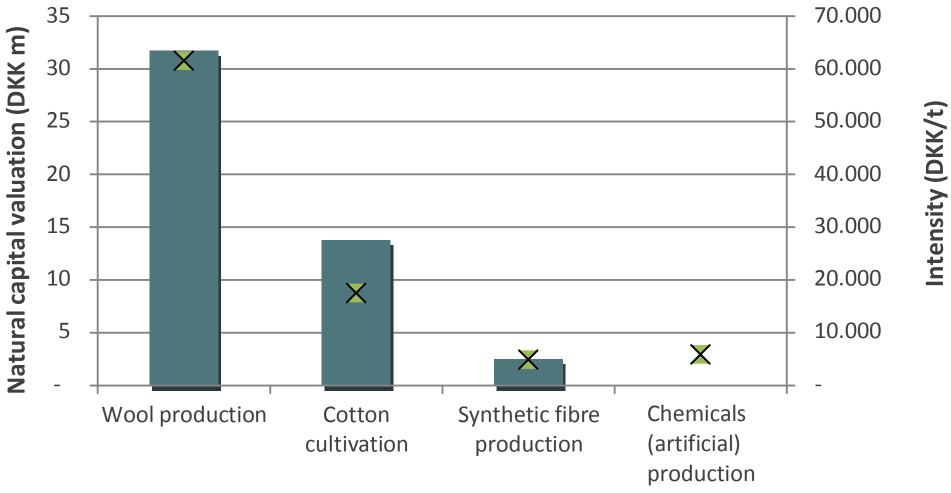


Figure 8 – Natural capital impacts of material (Tier 5 only)

Wool production has significant GHG emission associated with it. Several factors contribute to this issue; firstly, the high cost of wool reflects the cost for manufacturing with much processing required. Wool is also one of the dirtiest fibres in its raw state – so significant chemical input can be required to get the fibres in an appropriate state of readiness for use (this is also true of silk), and this has additional detrimental impacts. Lastly, sheep farming causes methane emissions[2]. GHG emissions are responsible for the significant majority of natural capital dependency for all reviewed fibres, barring cotton, which is heavily dependent on water.

It is important to note, however, that the analysis presented represents only the Tier 5 raw material production phase. The functionality and durability of a fibre and resulting fabric is not considered at this point – and therefore these results should be reviewed with consideration of the end purpose of the apparel piece. For example, a final woollen garment designed to be used and maintained for many years, and recycled at end-of-use, may have an overall lower impact than the several alternative fabric garments which are short lived and cannot be recovered when no longer required.

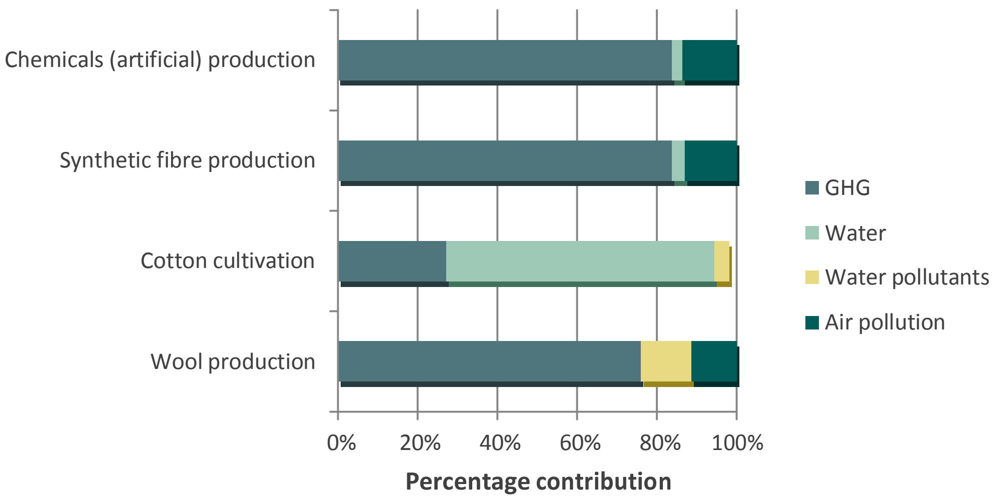


Figure 9 – Ratio of EKPI per material (Tier 5 only)

[2] The emissions caused by sheep farming are allocated between the difference products and co-products (e.g. meet, milk and wool) by economic allocation.

IC Group sources the majority of its wool from Australia, with 64% from this location. GHG emissions vary on location and the chart below shows the variation in intensity (the natural capital cost of GHG emissions associated with 1 tonne of material). Chinese wool has the greatest per tonne impact, with over DKK59,000 of natural capital dependency.

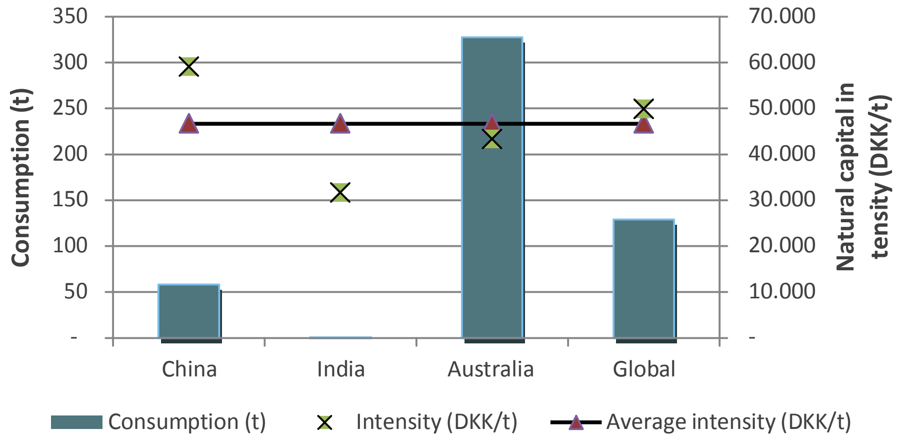


Figure 10 – GHG intensity of wool by sourcing location (Tier 5 only)

Cotton is the cause of IC Group's second greatest natural capital impact, as highlighted in Figure 8. Water consumption can be high, required for irrigation, often in regions with poor water availability.

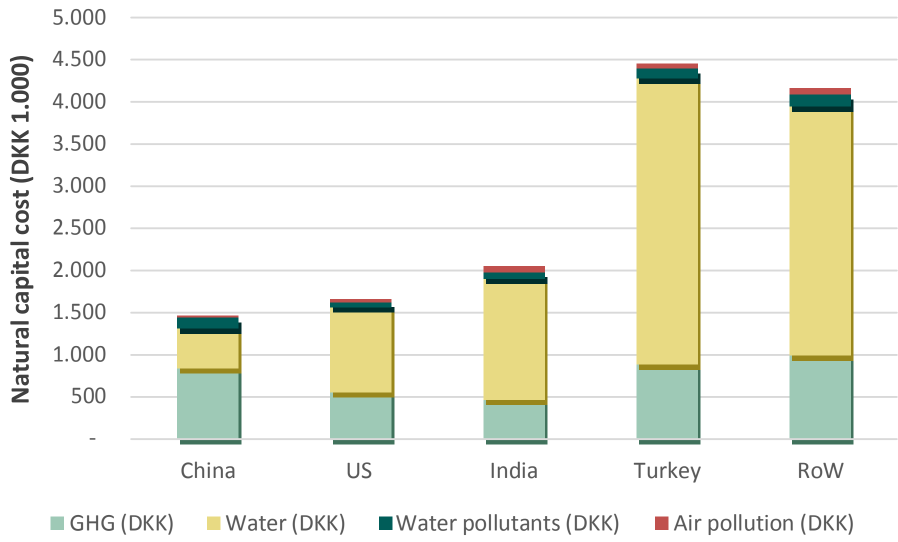


Figure 11 – Total natural capital of all cotton sourced by IC Group, from differing source locations (Tier 5 only)

The natural capital cost of IC Group's use of cotton is DKK13.8m (for Tier 5). The most significant impact associated with cotton production is water consumption, with the exception of China, both due to low water consumption for cotton in the country, and also adequate water supply resulting in lower than global average natural capital valuation. The natural capital valuation of water is increased in regions that water scarcity is high (see Section 7.7), for example, India has high water scarcity, with an associated cost of DKK6.46 per m^3, compared with China with a more ample supply and associated cost of DKK3.76 per m^3.

IC Group is a member of the Better Cotton Initiative (BCI), and as of 2015, will be sourcing some of its cotton from BCI sources with the intention of improving supply chain impacts. BCI cotton is produced using six production principles and criteria, including responsible use of agrochemicals, water, soil management and several other factors that are designed to reduce the impact that cotton harvesting has on land, neighbouring water, ecosystems and humans.

Average cotton yields in India are extremely low compared to the other countries reviewed; 429 kg/ha being the world's lowest average, compared to approximately 1,000 kg/ha for the other countries reviewed (Kooistra, *et. al.* 2006). As such, the impact intensity (natural capital dependency per unit of fibre produced) in tier 5 is significantly higher compared to some other sourcing regions (DKK 38,600 per tonne, compared to the US, which has an intensity of DKK13,200 per tonne, for example). This is due to water scarcity in the region and high intensity of local irrigation requirements.

Due to its high intensity, a case example of Indian cotton was investigated, comparing impacts of conventional cotton sourced by the IC Group, and impacts of BCI cotton from the same region. According to the 2012 BCI Better Cotton Harvest (2013), BCI cotton in India in 2012 used 8% less water and 25% less commercial fertiliser than conventional benchmark cotton in the region. Analysis was carried out using publically available information, and without the input of BCI. Details of modelling assumptions and source information can be found in Appendix 8.3.3.

All EKPIs measured were reduced using BCI version inputs. The total natural capital cost across all EKPI's for BCI cotton is DKK34,700 per tonne for tier 5, a reduction of 10% over convention Indian cotton natural capital impacts per kg of fibre, shown in the figure below.

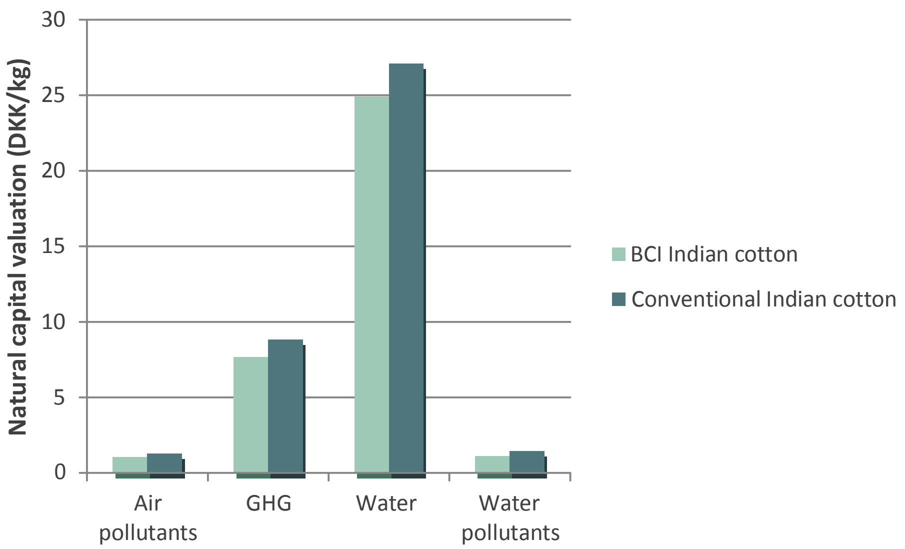


Figure 12 – Natural capital costs of conventional and BCI Indian cotton (tier 5 only)

Through selection of BCI or other sustainable cotton within procurement policies, companies are able to influence the supply chain environmental impacts directly, an issue otherwise difficult to improve due to limited control.

When considering the overall impact of the whole supply chain, IC Group apparel is associated with DKK124m, the majority of which is resultant of Tier 5 activity. As for the sector-level analysis leather is excluded from the tier breakdown. This highlights the importance of sustainable sourcing, as the materials selected and sourcing regions are highly relevant to the overall impact of the company.

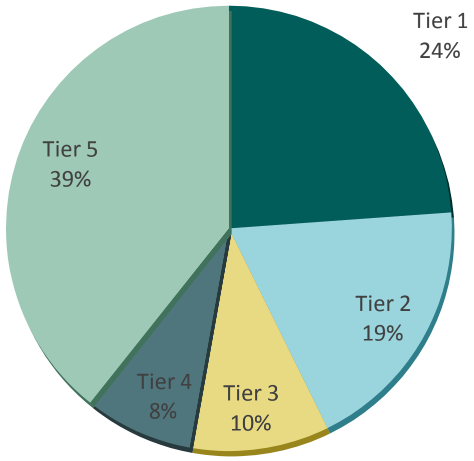


Figure 13 – IC Group natural capital impacts by tier

As with the sector-level evaluation, non-base material inputs (such as buttons and adornments/trims) are included as an input at Tier 1, and therefore this increases the overall impact of all EKPIs.

In comparison to the sector, however, the greatest impacts are resultant of raw materials in Tier 5, in part due to the higher proportion of wool (26% for IC Group) than sector average of 9%.

All tiers are dominated by GHG emissions, largely due to agrochemical use and methane release during raw material extraction, and fossil fuel consumption in energy use during all tiers.

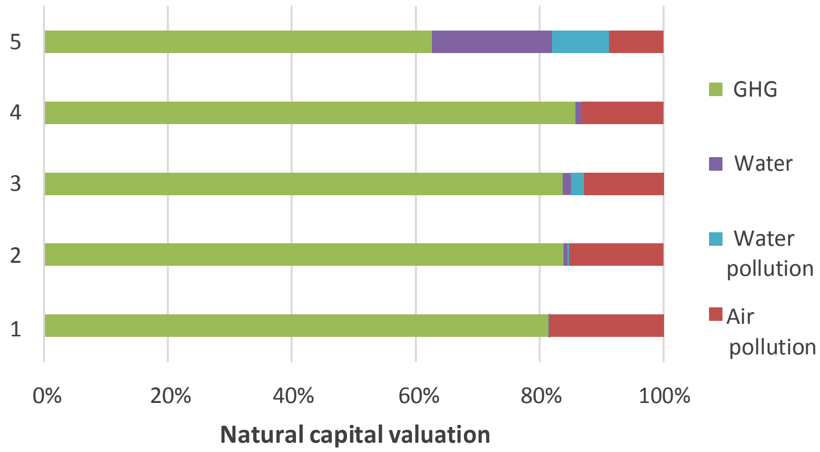


Figure 14 – IC Group natural capital impacts tier breakdown

To place these impacts in context, the natural capital cost of a cotton t-shirt was calculated. The average t-shirt sold by the IC Group is approximately 210g in mass. Based on the IC Group average natural capital costs for cotton production and all processing tiers, a t-shirt has natural capital cost of DKK11.76.

The IC Group natural capital account is given below. All figures are given in DKKm.

	Air pollution DKKm	GHG emissions DKKm	Water consumption DKKm	Water pollution DKKm	ILUC DKKm	Total DKKm	Percentage of total impact
Tier 1 Tailoring of apparel	5.42	24.13	0.07	<0.01	0	**30**	**24%**
Tier 2 Wet processing	3.57	19.62	0.16	0.06	0	**23**	**19%**
Tier 3 Fabric manufacture	1.61	10.51	0.17	0.26	0	**13**	**10%**
Tier 4 Yarn spinning	1.29	8.38	0.09	<0.01	0	**10**	**8%**
Tier 5 Raw material production	4.21	28.65	9.42	4.54	2	**49**	**39%**
Total	**16**	**91**	**10**	**5**	**2**	**124**	**100%**

Table 2– IC Group natural capital account (excluding leather)

If including leather consumption, the total natural capital cost of IC Group is DKK129m.

5.3 Fibre-level analysis

As discussed in the previous sections, the natural capital impacts associated with differing material types can vary significantly. Variation over source location can also have a significant effect, and this section details some of the differences per kg of material across the various countries reviewed.

The figure below shows the average natural capital cost of 1kg of fibre. Both silk and wool have significantly higher natural capital impacts than the alternative materials, at the raw material level (tier 5).

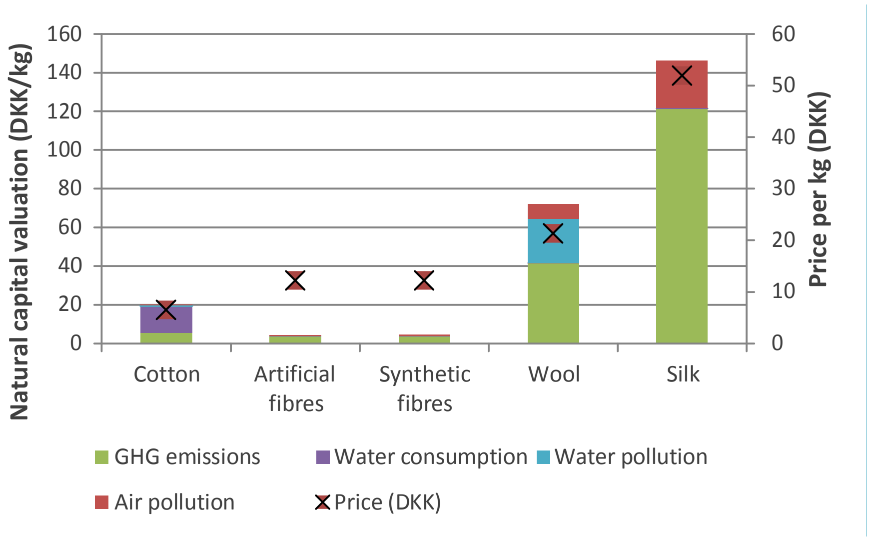


Figure 15 – Average natural capital valuation per kg of fibre (Tier 5 only)

Silk production has substantially higher GHG emissions than wool and the other fibres. This is considered to reflect the high cost of silk but also reflect its high environmental impact. This is in accordance with the process LCA of silk performed by Astudillo *et al* (2014), which shows that silk production can be input intensive and on a mass basis, environmental impacts are above those reported for other natural fibres. The majority of environmental impacts stem from cocoon production, in particular fertilisation.

Artificial and synthetic fibres both have relatively low natural capital costs. These vary depending on sourcing location, as shown in the figure below. This is also because the use of non-renewable resources was not selected among the EKPIs. The synthetic fibre footprint would have been higher.

The results for cotton and synthetic fibres were obtained through hybridisations. However, project limitations prevented the same depth of analysis for wool, silk, and artificial fibres, so the results for these were extrapolated by price scaling of larger industries. Thus, the results obtained for wool, silk and more specifically, for artificial fibres, should be considered with caution. As mentioned previously, this data refers only to Tier 5, so full life analysis (including use and disposal at end-of-use) are not considered. This means that durability and functionality are not included within results and should be considered when making design decisions.

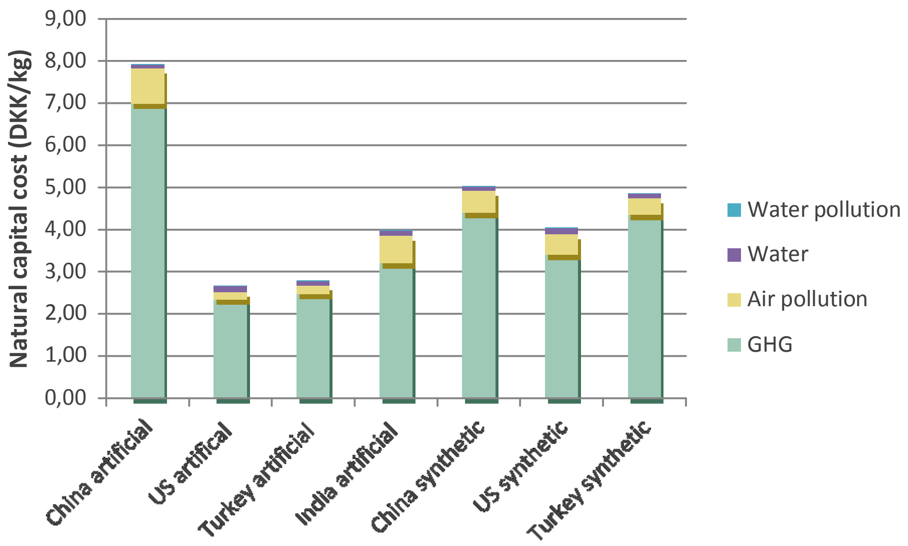


Figure 16 – Natural capital valuation per kg of artificial and synthetic fibre (Tier 5 only)

GHG is responsible for between 80-90% of the environmental impacts associated with both artificial and synthetic fibres. Water consumption has less detrimental environmental impact for these fibres than those from plant or animal sources, and the second most significant impact is due to air pollution. This is likely to be largely due to fossil fuel combustion for energy use when processing the fibres.

Leather has been excluded from many of the discussions and comparisons within this report due to additional hybridisation requirements which were not part of the scope of this study. However, an overarching look at the impacts of leather, across the whole supply chain and without disaggregation of tiers, shows that the most material impacts are due to GHG emissions and air pollution, largely from ammonia. Hybridisation/subdivision of the leather supply chain into different industries would highlight this further and help companies identify the specific points of production that are most material to help mitigate risk associated with natural capital dependency.

GHG emissions are significant due to the high processing costs of the materials and the farming impacts from animals. The production of fibres from animals requires a large number of steps that are unnecessary in the processing of vegetal or synthetic fibres (cleaning is more significant for instance). Ammonia is the second most significant impact, due to emissions from animal waste. Location impacts differ between the two materials, with Indian silk responsible for lower emissions than Chinese silk, yet Indian wool has the greatest impact intensity of all locations.

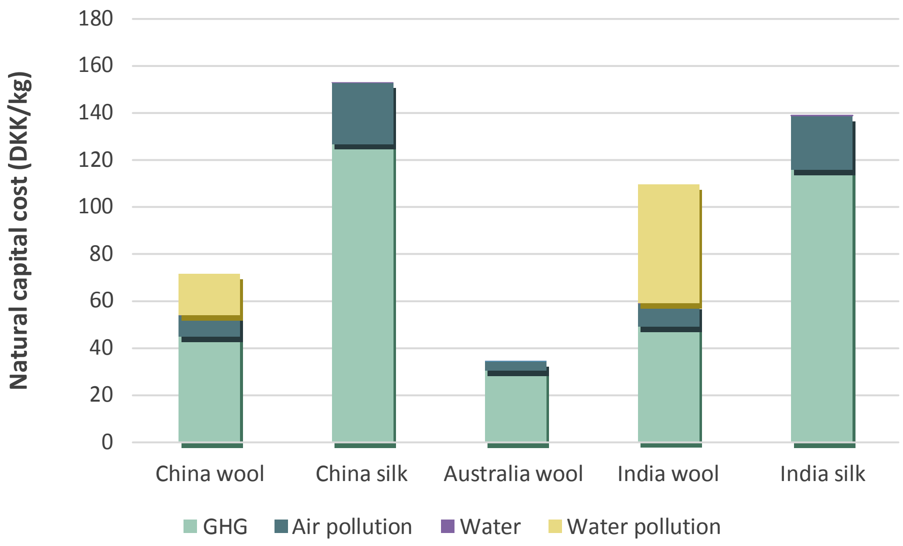


Figure 17 – Natural capital impact of wool and silk per kg (Tier 5 only)

Cotton was considered in Section 5.2, so it is not included here.

5.4 Discussion

The analysis across three levels of the apparel supply chain, focusing on the sector, companies and fibres, show that both material selection and sourcing location are critical in managing environmental impacts, with both aspects showing significant variation. The following sections discuss the key findings across the differing levels of analysis.

5.4.1 Sector-level findings

Water and GHG emissions are the two largest impacts for the sector, with water most significant at the raw material phase, while GHG is dominant throughout all tiers of the supply chain. GHG emissions are largely associated with the use of agrochemicals in crop farming, methane releases from the livestock, and the fossil fuel combustion associated with energy generation. Silk has the highest intensity of impact, but due to low consumption (approximately 100 tonnes per year), silk is only responsible for 1% of the overall impact of the sector.

The use of input-output modelling shows a variation to conventional process based LCAs on the allocation of impacts. This study shows Tier 1 to be the most significant phase for GHG at a sector level, while process based apparel LCAs more often show a higher impact in later tiers, generally reducing by tier as it nears the finished product. This is due to the IO allocation of inputs in the final finishing stages of the product, with impacts associated with adornments/trims, zips, buttons and other accessories included within this stage.

Additionally, the wet processing in Tier 2 is highly significant, and inclusion of all chemical inputs in this stage along with the inherent energy consumption required (for example, due to water heating) has resulted in a greater impact in this tier than Tiers 3 and 4. For Tier 2, data was collected at an industry level, instead of the process level, and is therefore a more accurate representation of the sector.

Finally, Tier 5, the raw material extraction phase, is the most material phase for IC Group, and for the sector as a whole. Water is more significant at this level than elsewhere, and the fibre-level analysis highlights the variations between locations due to water scarcity, particularly apparent for the cotton sector.

5.4.2 Better Cotton Initiative

While cotton is not the most intensive sector, it is the largest mass of import materials, accounting for 36% of total apparel imports to Denmark by weight. As such, the impacts associated with it are significant, with 15% of all the sector-level impacts associated with cotton farming and raw material extraction. This offers significant opportunity for improvement, and the IC Group analysis shows the benefit that can be achieved at the Tier 5 level, through the use of BCI cotton.

BCI cotton was considered as a replacement for Indian cotton. BCI cotton is produced according to six principles including management of water use, agrochemical use, and with consideration of impact to soil, workers and local ecosystems. The total natural capital cost across all EKPI's for BCI cotton in India is 34.7 DKK/kg. This is a reduction of 10% compared to convention Indian cotton which is 38.6 DKK/kg. Indian BCI cotton still has a greater intensity than US or China, due to regional practices, input costs and water scarcity of the region.

BCI's objective is to support cotton farmers everywhere to improve their production practices. While India was the only country selected for comparison within this study, similarly encouraging results have also been obtained in countries such as China and Pakistan where BCI cotton is also produced. BCI has now also expanded in countries such as Australia and the USA, all of which being major global cotton producers.

6 Conclusions and recommendations

Apparel supply chains are typically complex and widely distributed across the globe, and this is true for the Danish sector. Raw materials are often extracted or produced in countries with less stringent environmental regulations than Europe, and with less economic development, meaning workers may also be more vulnerable to impacts.

Due to the complexities of supply chain, control of the impacts in the early stages of production is limited for retailing brands. Selection of material type offers a significant opportunity to manage the impacts associated with a products supply chain, though it is also critical that this does not reduce the functionality and appeal of the garment. Where an alternative material type is not suitable (for example, if it is not appropriate to replace silk with cotton, for a particular piece), then sourcing location could be considered to ensure impacts are reduced.

Where materials are sourced from locations with higher impacts (due to local processes and water scarcity for example), it is recommended that environmentally certified 'improved' fibres/fabrics are used in products. The IC Group's potential use of BCI Indian cotton would show a 10% reduction in natural capital costs in comparison to conventional Indian cotton. Through the use of verified cotton, IC Group can be assured that during the cotton farming process, use of agrochemicals, consumption of water and other environmentally detrimental practices are minimised where possible. Although not calculated within this study, other environmental management certifications/standards are also likely to offer reduced natural capital dependency – providing they ensure lower water consumption, agrochemical use or ecosystem management.

6.1 Summary of recommendations for the sector

Improve transparency and data collection

The apparel sector is challenged by the limited traceability of its material chains due to the complex, global and fragmented nature of the sector. Direct supplier engagement to collect environmental data would offer companies within the sector the chance to better understand the impacts of their supply chains. Tier 1 should be an initial focus, before looking further back down the supply chain, by encouraging Tier 1 suppliers to collect data from their own suppliers, increasing the amount of data for review. Understanding impacts is the critical first step and natural capital accounting and valuation is a powerful tool to assist this process.

Sourcing of sustainable fibres

The most water-intensive phase is Tier 5 - the raw material production and extraction. Through selection of lower impact materials (including BCI cotton), impacts at this difficult to reach tier can be reduced. While not reviewed within this study, recycled materials often offer significant savings over all tiers (depending on the recycling techniques involved and natural capital requirements of collection and processing).

Consider water scarcity of sourcing locations

Fibre production can be water intensive, and as discussed, this is most significant within Tier 5. Through improved transparency of sourcing locations for raw material, companies can better understand the regional impact of the materials they are consuming. Rather than removing these locations from their sourcing portfolios, a better approach would be to engage with cotton and other plant-based fibre farmers, as well as synthetic and artificial fibre producers, to ensure best practice water management is being undertaken. This may include improved irrigation techniques (for cellulosic fibres), water recycling, and prevention of leaks/wastage.

It can be challenging for retailers and brands to engage directly with the Tier 5 suppliers, due to the fragmented and complex supply chain. Therefore, sourcing of sustainable fibres could be focussed on in the regions highlighted within the report (see Figure 7).

Supplier engagement
Danish clothing companies are likely to have reasonable influence on their Tier 1 suppliers, and alongside material selection, this offers great opportunities for brands and retailers to improve the impacts of their products. GHG and water are the two most important impacts of the sector, and companies operating within the industry should focus on these areas to achieve the greatest natural capital savings. Devising and implementing supplier codes of conduct for environmental practices not only offers the opportunity to reduce emissions and water consumption, but may also have the benefit of reducing costs through improved resource efficiency .

6.2 Recommendations for improvement of analysis

Improved data
The robustness of the IC Group analysis could be strengthened through the collection of primary data through engagement with suppliers. There was limited detail available on the actual resource consumption and pollutant emissions of suppliers, and data was mapped based on the companies' expenditure and mapped to the relevant sectors.

BCI data was calculated using the assumption that Indian cotton was 100% BCI certified, as the country of origin of this material was unclear. Through improved transparency, IC Group would be able to better understand its sourcing locations, and impacts would be more comprehensively modelled as a result.

In each country the textile supply chain includes specific industries. India is the only country where silk, wool, cotton and all the industries of the textile supply chain are well represented, with other countries relying on assumptions on data (for example, China relies on Australia for its production of wool).

For this reason, and due to hybridisation limitations (see further detail below), combined results from Tiers 1-5 for the same country were arrived at using the assumption that Tiers 1-4 all occurred in the same country, which is rarely the case in the real market. In the real world, each country-specific tier relies on tiers from the other countries for production of raw materials and intermediate products. Thus, the countries in which all the polluting textile industries are represented end up getting a larger share of the impacts.

Further hybridisation
The hybridisation process is complicated and requires significant time and data. For this reason, for the purposes of this study, not all sectors could be fully hybridised.

In Denmark almost none of the textile supply chain's polluting industries are represented. Tier 1 was not hybridised into different industries, such as manufacturing of buttons, zippers, embroideries, tailoring and wholesale trade. The only industry from Tier 1 largely represented in Denmark is the wholesale trade (by far not the most polluting of all the industries included). European countries have a tendency to outsource most of the polluting and resource-intensive activities to developing countries.

At a sector level, assumptions are made based on country of import material/apparel, and modelled back to the source of material. Inputs within a country are assumed to be from the country (for example, Chinese cotton cultivation is assumed to use Chinese produced fertiliser).

To further strengthen the analysis, the silk, wool and leather sectors, along with Tier 1 sectors, could also be hybridised. This would provide findings with a greater accuracy for the Danish sector activity.

Consistency of quantification
The Exiobase was not used for water pollutant and water consumption quantification due to limitations of data availability. The Trucost EIO model does not have the same level of granularity and mapping is not identical to the processes used within the Exiobase system. Therefore there is some inconsistency over the boundaries of the quantification. Where possible, a single database would be preferable to ensure consistency, though this was not available at the time of report writing.

Increasing scope boundaries
Use phase and disposal are often not included within EP&L accounting. This is partly due to the limited influence that companies can have on consumer behaviour (though material selection and design have a relevance). However, use and disposal phases can have a significant effect on the lifecycle impacts of a product. Understanding this could encourage the sector to make further improvements through take back of material for recycling.

It would also be interesting to review additional EKPIs such as waste and pollution to land.

7 Methodology

7.1 Valuation

Resources from nature are typically undervalued, or not valued at all, due to lack of defined markets, which often leads to overexploitation. It is often difficult to gain a holistic view of the impacts on natural capital and benefits of a particular sector or product, because many metrics are used. For example, it is difficult to combine the consumption of water (measured in m3) and GHG emissions (measured in CO2e). By applying natural capital valuation to each individual impact, a single, monetary figure can be determined. This also enables a direct comparison with financial performance and appraisal of profits at risk.

Valuations can be measured in different ways, reflecting social cost, external cost (social cost net of taxes), or abatement cost. Social costs include the indirect costs of production that are not borne by polluters (such as the release of air pollutants), and therefore not passed on to the end user of the goods produced (International Monetary Fund, 2012). These are often incurred by society at large and other businesses through, for example, lost amenities, health impacts and insurance costs. The external cost of this is the resulting loss which is suffered elsewhere (Coase, 1960). Valuations aim to overcome this form of "market failure" to yield more efficient outcomes overall. Social costs can be used to assess the contribution of ecosystems to human well-being, to inform decision-making, and to evaluate the consequences of alternative actions (UNEP, 2005). In this study we have used the social cost.

Over 1,000 environmental valuations identified in peer-reviewed journals are used, as well as government studies. The way in which these are applied depends on the EKPI. GHG emissions for example, are considered global – even if climate change can be more impactful in some regions than others, the emission of one unit of GHG will globally participate to climate change. Values for other pollutants (air and water) and water use depend on local biophysical and human geography, and require the use of local data whenever possible.

7.2 Determining boundaries

The apparel sector is a complex interwoven web of suppliers and impacts. Impacts are apparent throughout the whole lifecycle – from raw material extraction, through processing, manufacture and also use and end-of-use. The use phase of clothing (which is determined largely through consumer behaviour, and often omitted from EP&L accounting), and the end-of-use, are both excluded from the analysis. Excluding these, the manufacturing of imported textiles is the largest hotspot of the Danish textile industry.

In 2006, outerwear represented 50% of Danish textile imports. The majority of these products mainly came from China (27%), Turkey (14%), Italy (14%) and India (7%) (SRTEPC, 2008). However, this reflects the last manufacturing step of the textiles imported (sewing and assembly of the final product), and does not represent the processing stages and the origin of the raw materials.

Some fibres were excluded from the scope because they are rarely used in the clothing industry e.g. polypropylene, jute, feathers, kenaf, coco, sisal, ramie, hemp, abaca, aramid, carbon, henequen and kapok.

The complexity of the sector is illustrated in the graph below, which provides an overview of the main existing pathways to manufacture textiles in China; though many additional steps and activities could also be added.

The grey boxes in the figure below represent the different steps included within the manufacturing of textiles, and the large blue box represents the textile manufacturing industry as a whole. Notice that the product flows from the grey boxes are converted to IO-categories when crossing the system boundary of the large blue box. The dotted red boxes and arrows are non-apparel-related industries.

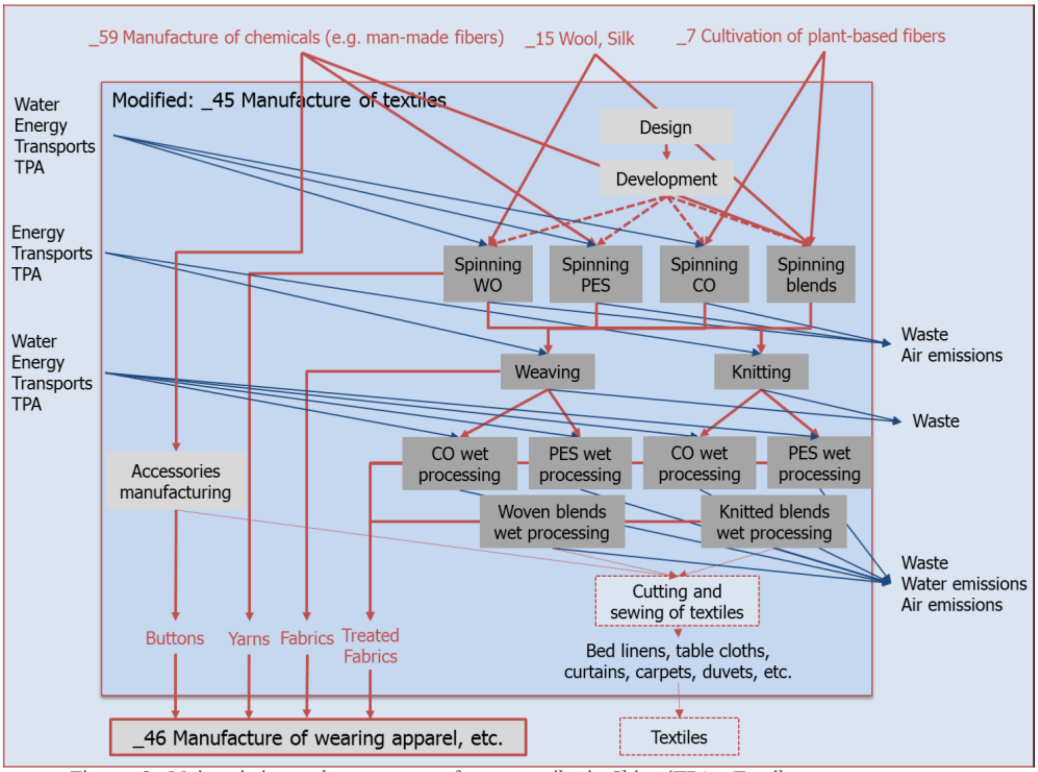


Figure 18 - Main existing pathways to manufacture textiles in China (TPA = Textile Product Auxiliaries)

To simplify matters, all the processes presented in Figure 18 are rearranged into one of the following four main textile industries, also referred to as tiers:

- The spinning industry which includes all kind of spinning and yarn manufacturing processes
- The fabric manufacturing industry which includes all knitting, weaving, crocheting and non- woven manufacturing processes
- The wet processing industry including pre-treatment, dyeing or printing and post treatment processes
- The manufacture of apparel category which includes all the tailoring steps: cutting, sewing and assembly processes involved in clothe making. The design and development industries are also included within this category. The manufacturing of apparel accessories such as press fasteners, buttons, hooks, eyelets, buckles etc. is also included within this category.

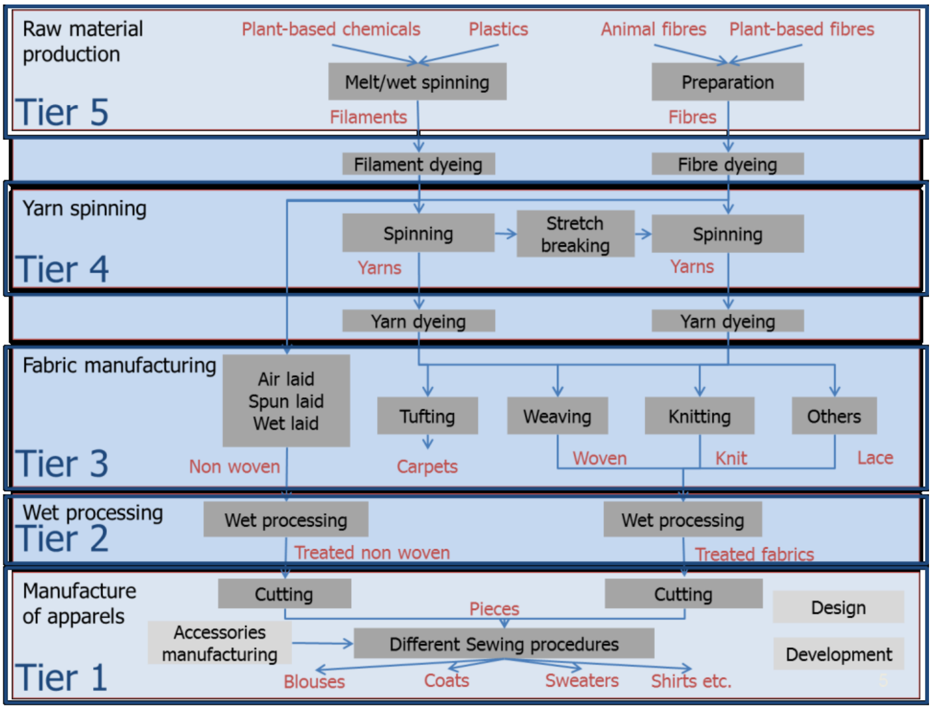


Figure 19 - The textile industry divided in five tiers

As an illustration, the Figure 20 presents a simplified graph for the breaking down of Chinese textile manufacturing into those 4 different industries.

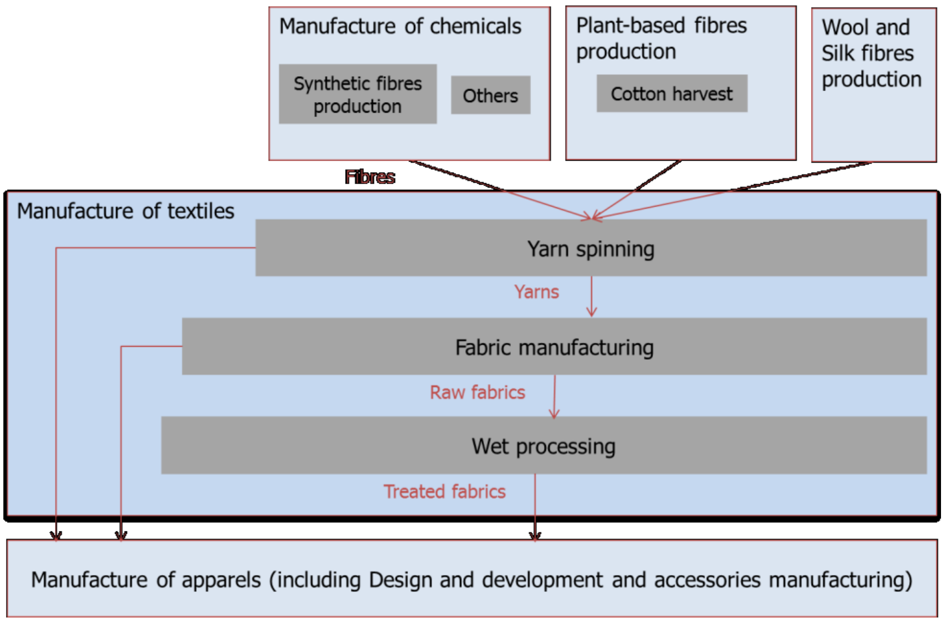


Figure 20 - Simplified textile supply chain for China

This structure has provided the backbone of the tier division of the triple-level natural capital analysis.

7.3 Data gathering and quantification

Data for the analysis was sourced from several locations.

1. Secondary statistical data: Secondary sources were used to identify material consumption for apparel, trade data and to fill data gaps in analysis. LCA databases were used where necessary to find impact data for individual materials and processes.

2. IC Group – IC Group provided spend data on all sub-brands (Peak Performance, Malene Birger, and Tiger of Sweden). Indirect spends were excluded. The main material flows were divided into wool, cotton, leather and man-made fibres.

3. Better Cotton Initiative data was sourced from the organisations public Annual Report, to allocate resource savings to cotton produced under the BCI criteria.

4. GHG emissions and air pollutants, including NH_3, NO_x, VOCs, PM_{10}s and SO_x were quantified using the Exiobase v.1 database, detailed further below.

5. Water consumption was determined using Hoekstra water footprint data where available, typically for the plant based crop production. Water pollution was quantified pulling specific chemical pollutant to water factors from the LCA database EcoInvent (2007). Water consumption within non-agricultural sectors, and water pollution data gaps were determined using Trucost's environmental input-output (EIO) database.

6. **Environmental input- output databases.** This study uses the Exiobase input-output (IO) database, and the Trucost IO database. These are based on national economic and environmental statistics. Using an IO database has the advantage over process-databases that it covers the complete economy, eliminating the need for making cut-offs in the analysis as required in conventional process based LCAs.

The Exiobase v.1 database

The "Exiobase v.1" includes environmental accounts for more than 130 industries in 43 different countries. It was developed to overcome significant limitations in the existing data sources in the field of multiregional environmentally extended Supply and Use tables (MR EE SUTs) and input–output tables (IOT). Trade-linked tables are essential for analysing the effects of sustainability measures taken in one country's economic competitiveness. Exiobase v.1 is in EUR2000 and represents the global economy in year 2000.

Practically, for the textile supply chain, this means Exiobase v.1 provides environmental accounts for the "cultivation of plant-based fibres" and "wool and silk manufacturing" in 43 different countries.

However, the rest of the textile supply chain is broken down into only three industries:

- The manufacturing of textiles, which includes intermediate products (e.g. yarns, fabrics, etc.) and household textiles (e.g. carpets, duvets, etc.)
- The manufacturing of leather products
- The manufacturing of apparels end products

This breaking down of the rest of the textile supply chain into only three industries made it difficult to properly represent the textile manufacturing chain with its variety of manufacturing processes and large number of possible combinations.

Therefore, three textile-industries were hybridised (subdivided) to increase the level of detail of the analysis.

- "Cultivation of plant-based fibres" was hybridised to represent more specifically the cultivation of cotton
- "Manufacture of Textiles" was hybridised into three tiers: Tier 4, 3 and 2 representing respectively spinning, fabric manufacturing, and wet processing
- "Manufacture of chemicals" was hybridised to represent more specifically the manufacturing of synthetic fibres.

Trucost's environmental input-output (EIO) database
The EIO identifies 531 business sectors which have economic interactions (inputs and outputs) with other sectors[3]. Each sector also has a global environmental profile per unit of output which is derived from numerous sources, including the US Toxic Release Inventory, UK Environmental Accounts, Japanese Pollution Release and Transfer Register and Australia's National Pollution Inventory. This creates some inconsistency due to less regional granularity than the Exiobase model.

7.4 Hybridisation

The product categories in the EIO model are generally aggregated. The mapping of 'specific products' to 'aggregated product category' in the model creates some uncertainties.

Selecting high impact spend categories
To select the high impact categories, the Exiobase v.1 EIO model was used. The data are provided for US$1 of activity output.

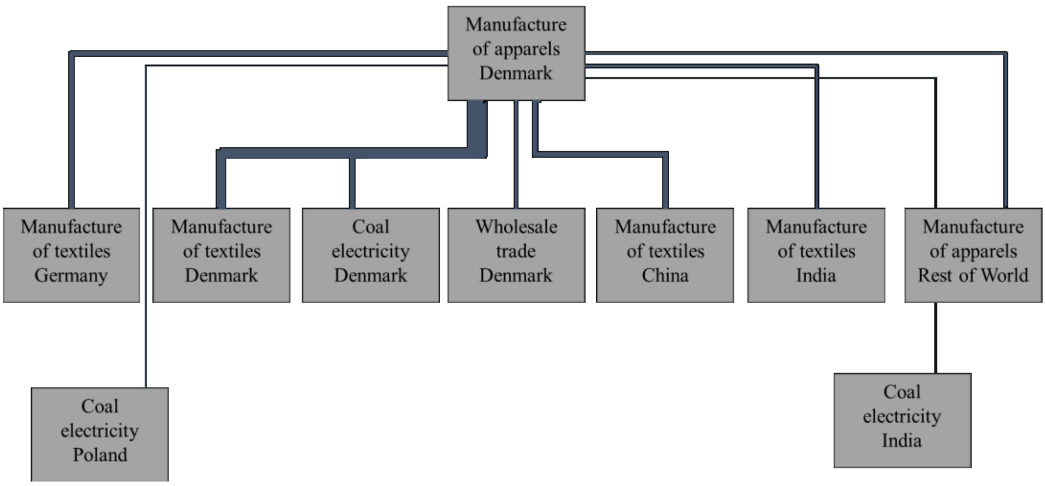


Figure 21 - GHG emissions: process contribution for the Danish apparel industry (Exiobase v.1 database)

Figure 21 highlights some of the key GHG emission contributions for the Danish apparel industry. The full mapping shows numerous additional interactions, with contributions between the various sectors and many additional complexities. For the purposes of the report, however, this is too complex to display in a single figure. The figure should therefore be considered indicative of the simplified mapping only.

The main contributors to the GHG emissions of the Danish apparel industry are:

- Production of electricity by coal (Denmark)
- Manufacturing of textiles (Denmark, China, India and Germany)
- Wholesale trade and commission trade (Denmark)

[3] The baseline for the EIO model is the 2002 US Bureau of Economic Activity matrix. Sector-specific inflation rates have been applied to this baseline to reflect present-day economic interactions.

- Manufacturing of apparel in the rest of the world.

This network presented in Figure 21 also identifies the Cultivation of crops in DK and the Transport via pipelines in Canada as two of the main contributors to the GHG emissions of the Danish apparel industry. However these were excluded as considered not relevant to the sector.

Improving granularity

For the purposes of this study, the apparel manufacturing supply chain is represented with the eleven industries listed below. Industries in red represent specific hybridisations required:

- Cultivation of plant based fibres (except cotton)
- Cultivation of cotton fibres
- Manufacture of chemicals (artificial fibres)
- Manufacture of synthetic fibres
- Wool and silk-worms cocoons (wool)
- Wool and silk-worms cocoons (silk)
- Manufacture of yarns
- Manufacture of fabrics
- Manufacture of treated fabrics
- Tanning and dressing of leather; manufacture of luggage, and footwear
- Manufacture of wearing apparel; dressing and dyeing of fur

The grey boxes in the figure overleaf represent the different LCA process data included within the manufacturing of textiles, and the large blue box represents the created IO-process with its inputs and outputs. Notice that the product flows from the grey boxes are converted to IO-categories when crossing the system boundary of the large blue box.

The sectors for manufacture of plant based fibres, and manufacture of chemicals are hybridised to adjust for cotton and synthetic fibres (polyester, elastane etc.) respectively. However, they are still relevant as non-hybridised sectors to represent other plant based fibres (such as linen, hemp) and artificial fibres (such as tencel, viscose etc.).

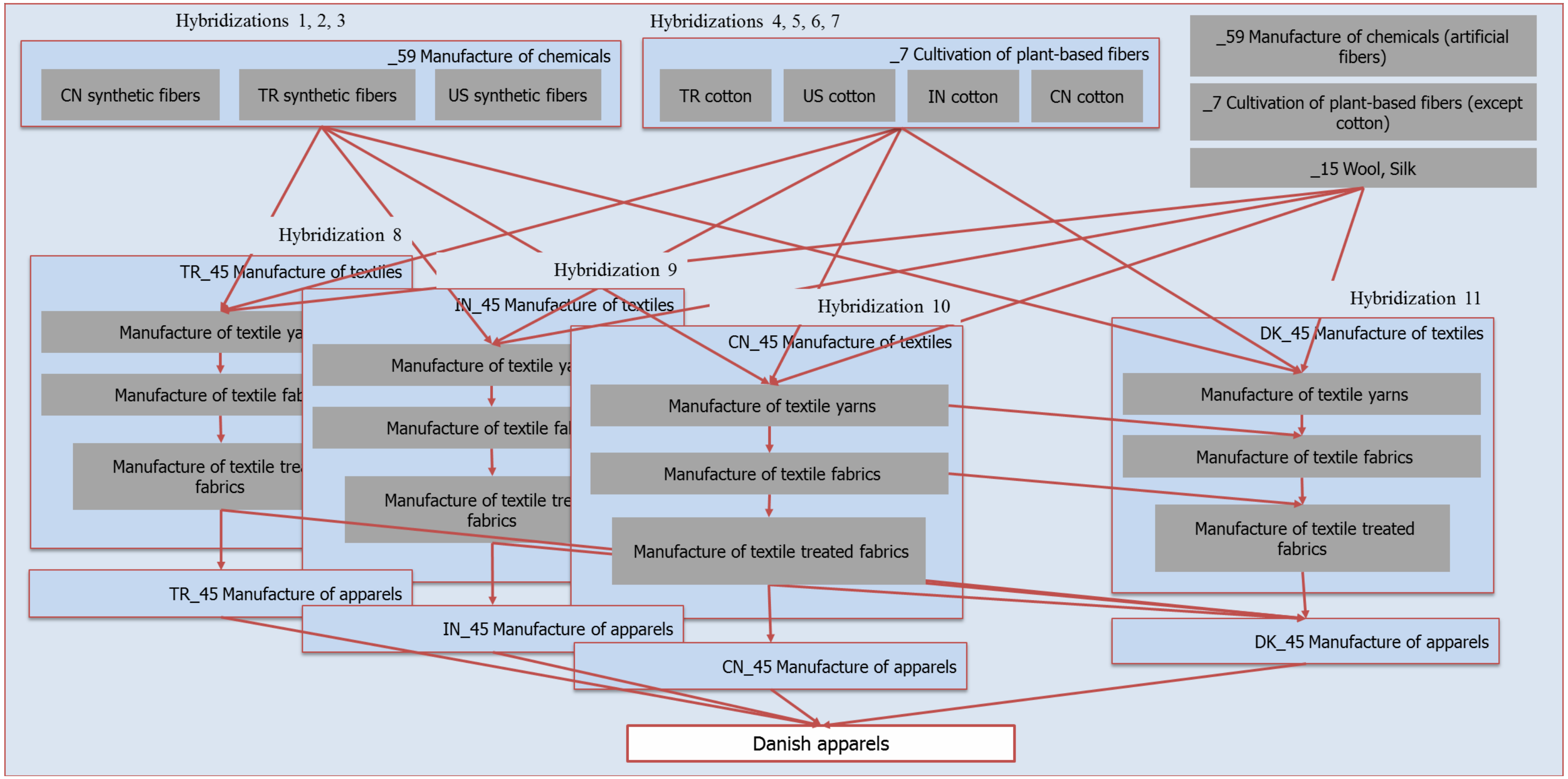


Figure 22 - Hybridisations needed to detail the contributors to the Danish apparel industry

Further details of the specific hybridisations can be found in Appendix 8.2.

Hybridisation creates more robust analysis, relating specifically to the sector in focus. To provide some context of the difference, the figure below displays the fabric treatment phase (Tier 2) with and without hybridisation.

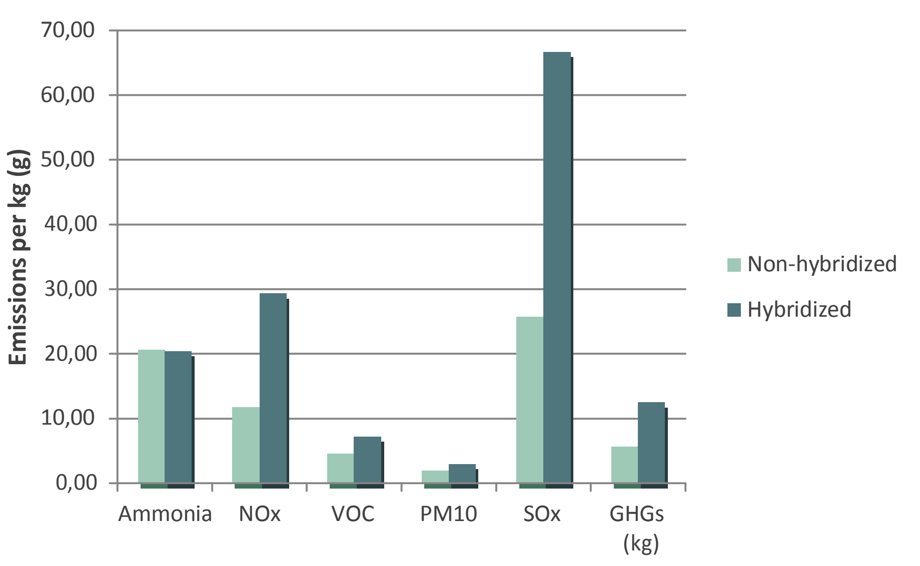


Figure 23 – Comparison of hybridisation and non-hybridisation of fabric treatment (Tier 2).

On average, the hybridised emissions were determined to increase over the non-hybridised findings, though this varied across sectors and EKPIs. The difference between calculations ranged from 0.1-4.2% increase in Tier 2, while in Tier 5, the difference is more pronounced – ranging from a decrease of 140%, to an increase of over 300%, highlighting the importance of hybridisation for accurate results.

7.5 Maintaining a good Geographical coverage

The "Exiobase v.1" includes environmental accounts for 130 industries in 43 different countries. Ideally, the categories hybridised should be hybridised for the full 43 countries, though this is a significant task. For this study, the main producing countries for each tier were identified: China, India, and Turkey (ITC, 2012 – extracted for 2001 data).

Country of sourcing	Percentage of total import
China	17%
India	3%
Turkey	7%
Others	73%

Table 3 – Countries of sourcing for Danish apparel imports

The corresponding categories were hybridised (as shown in Figure 22). An average of the main producing countries was used to represent manufacturing in the Rest of the World (RoW).

Also, to simplify matters, it was assumed that each input modified per individual hybridisation came from only one manufacturing country. As an example, the fertilisers used to grow cotton in China were presumed to be from China.

7.6 Quantifying water and water pollutants

For plant based fibres, including cotton, water consumption data was pulled from Mekonnen & Hoekstra (2010), which details the green, blue and grey water footprint of crops by country. For synthetic fibres and other process steps, water consumption and pollution were modelled based on the Trucost EIO database. To remain consistent with the Exiobase hybridisation, the model was used to calculate direct emission factors for all sectors bar leather. Due to the stand alone nature of the leather sector (calculated separately and without hybridisation), the impacts of the leather sector supply chain were modelled based on both footwear and leather accessories.

Water pollutants were quantified by pulling factors from the EcoInvent database (or other secondary LCA sources if unavailable), considering the emissions to water given in relevant specific fibre related data. Where no data was available through secondary LCA databases, water pollution was modelled through the Trucost EIO - based on over 70 individual chemicals such as heavy metals, nutrients and organic pollutants.

7.7 Applying valuation

Once the EKPIs are quantified in physical terms (tonnes, m^3), a monetary valuation is applied. This section provides an overview of the valuation techniques used.

GHG emissions

Many countries are developing a mix of policy measures, including market-based instruments and legislation, to reduce or abate greenhouse gas (GHG) emissions. Applying a value to carbon provides an understanding of the potential financial implications of emissions. Incorporating carbon pricing into business and investment decisions can be useful to help position companies and portfolios for the transition to a low-carbon economy.

The valuation focuses on the social impacts of carbon. The social cost of carbon (SCC) reflects the global cost of damages resulting from climate change impacts associated with GHG emissions. The valuation is based on the present value of each metric tonne of CO_2e emitted now, taking account of the full global cost of the damage that it imposes during its time in the atmosphere. The SCC includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk.

A social cost of USD115 2013 per metric tonne of CO_2e was used to value GHG emissions, which is the value identified in the UK Government's Stern report (Stern, 2006) as the central, business-as-usual scenario, adjusted for inflation to 2012 prices using a global weighted average consumer price index (CPI). This value was multiplied by the total GHG emissions emitted by each agricultural system to calculate the GHG impacts in monetary terms.

Air pollutants

Air pollutants include sulphur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM), ammonia (NH_3) and volatile organic compounds (VOCs). Each has a set of impacts on human health and/or crop and forest yields.

Each pollutant is associated with different but overlapping types of external costs. Some effects are caused directly by the primary pollutant emitted and some are caused by secondary pollutants formed in the atmosphere from pollutants that acts as precursors. As each pollutant has a unique set of effects, each pollutant is valued using an individual methodology.

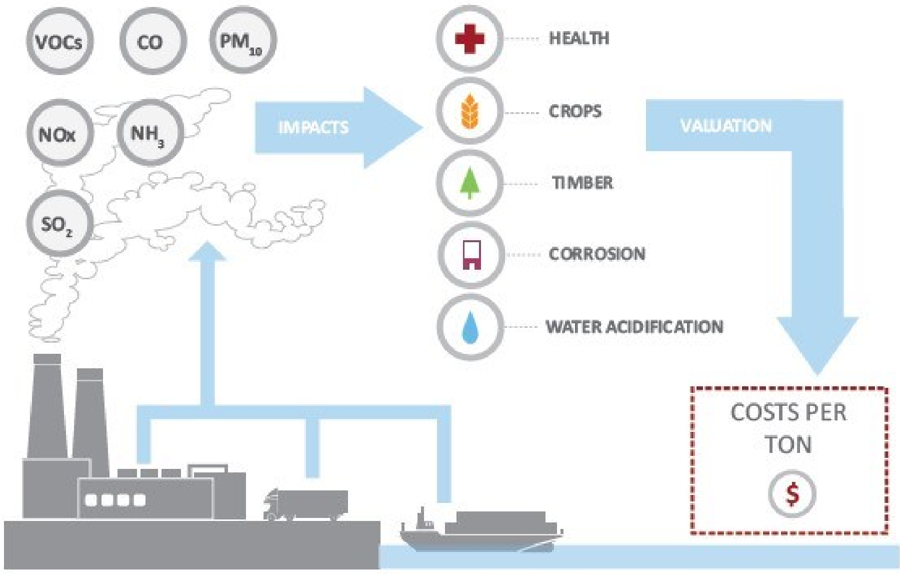


Figure 24 – Impact of air pollutants

Studies into the damage costs of air pollution use the Impact Pathway Approach to follow the identification of burdens to the impact assessment and then valuation in monetary terms. These studies translate exposures to air pollutants into physical effects using dose–response functions (DRFs) which calculate the number of end points (e.g. number of health impacts) to a quantity of air pollutant emissions.

The main impact were identified for each pollutant and built country specific valuations driven by the receptor density (i.e. population density for health, crops cover and crop sensitivity for crops, and forest cover for timber).

Water

Pressures are growing on water resources, with risks from climate change impacts increasing unpredictability about security of supplies. Information on the benefits of water and costs of damages from depleting resources are usually not recognised in market prices nor in risk analysis.

According to the Total Economic Value (TEV) framework (EFTEC, 2010), the value of water can be broken down into "use" values and "non-use" values (see Figure below). Use values can be further broken down into direct use, indirect use, and option values. Within direct use, the values can apply to "consumptive" or "non-consumptive" uses. The valuation of water is based on the opportunity cost of water or the value generated by water when it is not abstracted. Consumptive uses of water have therefore been excluded. Option and non-use values have also been excluded given the difficulty inherent in their valuation. Values for direct non-consumptive uses and indirect uses were identified in academic literature in different geographical locations.

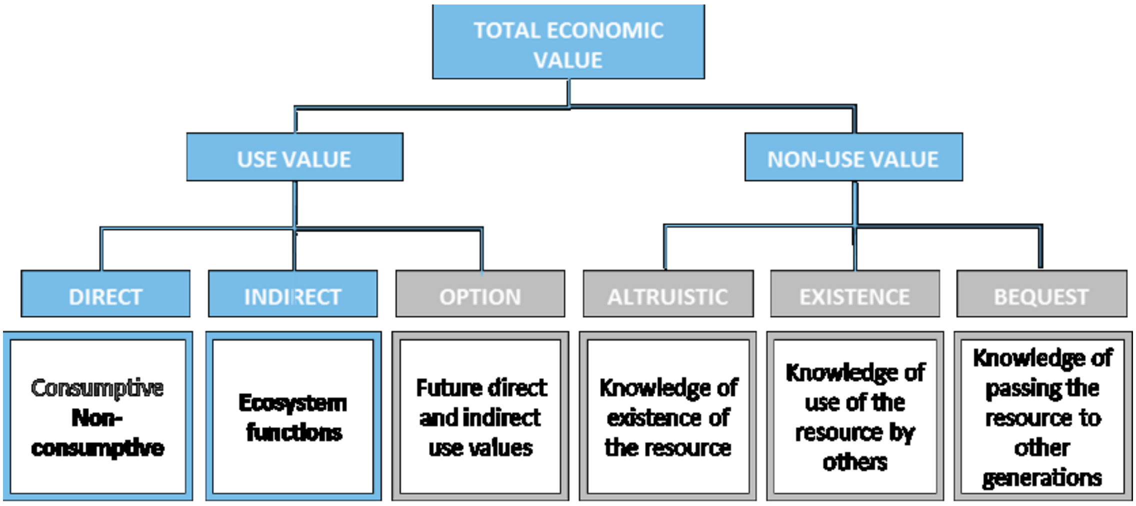


Figure 25 – Total economic value of water

A function of water value (in US$ per m3) relative to water scarcity (% of internal renewable water resource abstracted) was then developed based on the value of the services identified above, in US$ prices.

This function was then used to estimate the environmental cost of water in any location where the scarcity is known, by adjusting the function estimate for purchasing power parity at that location.

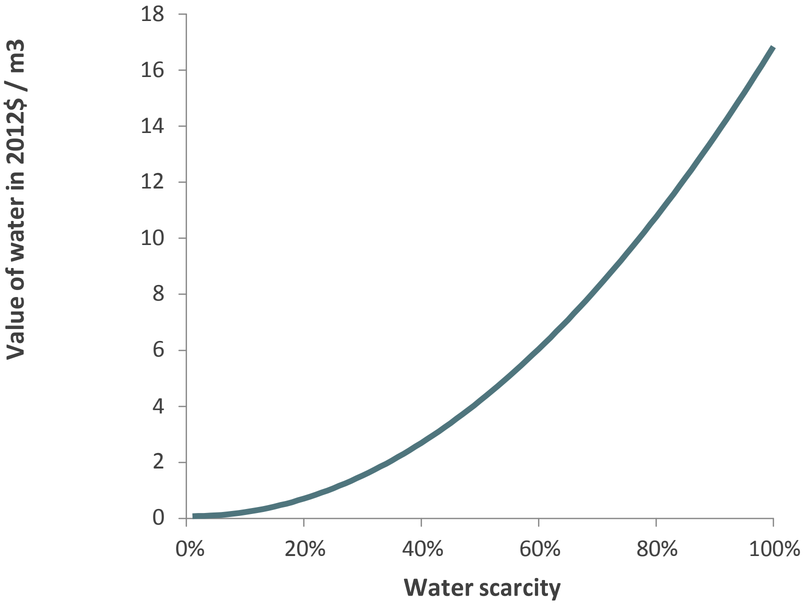


Figure 26 – Water scarcity curve

Water pollution
Chemicals discharged or leaking into water bodies can have a significant impact on local environments. Terrestrial, freshwater and human toxicity is expressed in kg 1,4 Dichlorobenzene (DCB) equivalent in Recipe Midpoint Hierarchist characterization model. To calculate a valuation for different pollutants contained within the EIO database, country specific valuations are required, and determination of willingness to pay to restore a body of freshwater.

Willingness to pay is determined based upon a meta-analysis of 24 studies and 42 value observations across regions and ecosystem types. This is measured using a metric called Ecosystem Damage Potential (EDP), based on species richness. EDP of DCB. An estimate the EDP of 1,4 Dichlorobenzene (DCB) was then calculated, and a function derived to adapt to regional specific valuation using benefit transfer.

The approach requires multiple steps and is detailed in Appendix 8.4.

8 Appendices

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8.2 About the Consultants

8.2.1 NIRAS

NIRAS is a leading European engineering consultancy group focusing on the provision of multidisciplinary consulting services.

Among others areas, NIRAS provides services related to environmentally sustainable production and operations. On a strategic level it delivers corporate environmental and carbon accounts (including EP&L and NCA) providing valuable insights into supply chains. Typically these insights support sustainable strategies, action plans, sustainable supply chain management programmes and corporate reporting schemes. At an operational level, NIRAS provides services related to green procurement, energy audits, risk assessment, waste management and product footprints.

NIRAS has a unique track record in combining these services to address clients' environmental challenges whether they relate to waste streams, or use of energy, resources or water.

8.2.2 Trucost

Trucost has been helping companies, investors, governments, academics and thought leaders to understand the economic consequences of natural capital dependency for over 12 years.

World leading data and insight enables clients to identify natural capital dependency across companies, products, supply chains and investments; manage risk from volatile commodity prices and increasing environmental costs; and ultimately build more sustainable business models and brands. Key to Trucost's approach is that it does not only quantify natural capital dependency, it also puts a price on it, helping clients understand environmental risk in business terms.

8.2.3 2.-0 LCA consultants

2.-0 LCA consultants, founded in 2000, is an internationally oriented research based consultancy company dedicated to providing consultancy and research services to business and authorities. 2.-0 LCA consultants specialises in is doing research and providing decision support within the area of product oriented policies, life cycle assessment, product policy design, and related methods such as input-output modelling and mass flow analysis. Furthermore, 2.-0 LCA consultants contributes to the development of tools and LCA software for the LCA practitioner and provides guidance and critical reviews on how to perform assessments consistent with scientific standards and technical guidelines.

2.-0 LCA consultants also works pro bono for to international organisations such as UNEP, ISO and SETAC and focuses on education and capacity building offering a range of post-graduate education and other courses on demand. 2.-0 LCA consultants has key competences and experience in natural capital accounting. It is one of the main contributors to the development of methods, models and databases used for:

- Development of methods for valuation/monetization of environmental impacts
- Development of input-output databases: Denmark 1999 (Project for Danish EPA), Denmark 2003 (EU FP6 project: FORWAST), Multi-regional world database: Exiobase v2 (EU FP7 project: CREEA)

www.lca-net.com

8.3 Hybridisations

8.3.1 Hybridisation of 'Manufacture of chemicals' into 'Manufacture of synthetic fibres'

The starting point of the disaggregation was to make a copy of the original "_59 Manufacture of chemicals" in the model. If no additional information were available, this would be the best estimate of synthetic fibres production. The manufacturing of man-made fibres includes artificial and synthetic fibres. Most of the artificial fibres are made out of wood pulp e.g. viscose and acetate.

The plastics account for the manufacturing of polyester, polyamide 6.6 and Acrylic (PAN). The Polypropylene and Aramid fibres, rarely used in the apparel industry, were excluded from the scope (see Section 7.2).

All inputs to the created IO-process 'Manufacture of synthetic fibres' were modelled using the existing product flows in the Exiobase v.1 model:

- _60 Manufacture of rubber and plastic products (25)
- _59 Manufacture of chemicals
- _84 Production of electricity by coal
- _85 Production of electricity by gas
- _86 Production of electricity by nuclear
- _87 Production of electricity by hydro
- _88 Production of electricity by wind
- _89 Production of electricity nec]
- Water

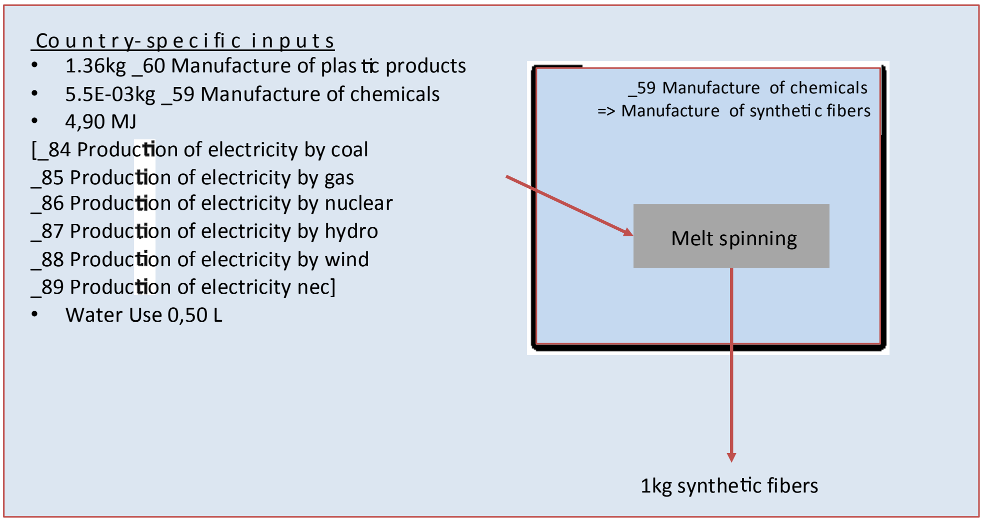

Figure 27 - Detailed LCA-data used to create an input-output process for man-made fibre production that links to the CREEA IO model

8.3.2 Hybridisation of 'Manufacture of textiles' into 'Manufacture of yarns', 'fabrics' and 'treated fabrics'

This section aims at describing how the granularity of the industry 'Manufacture of textiles' can be improved.

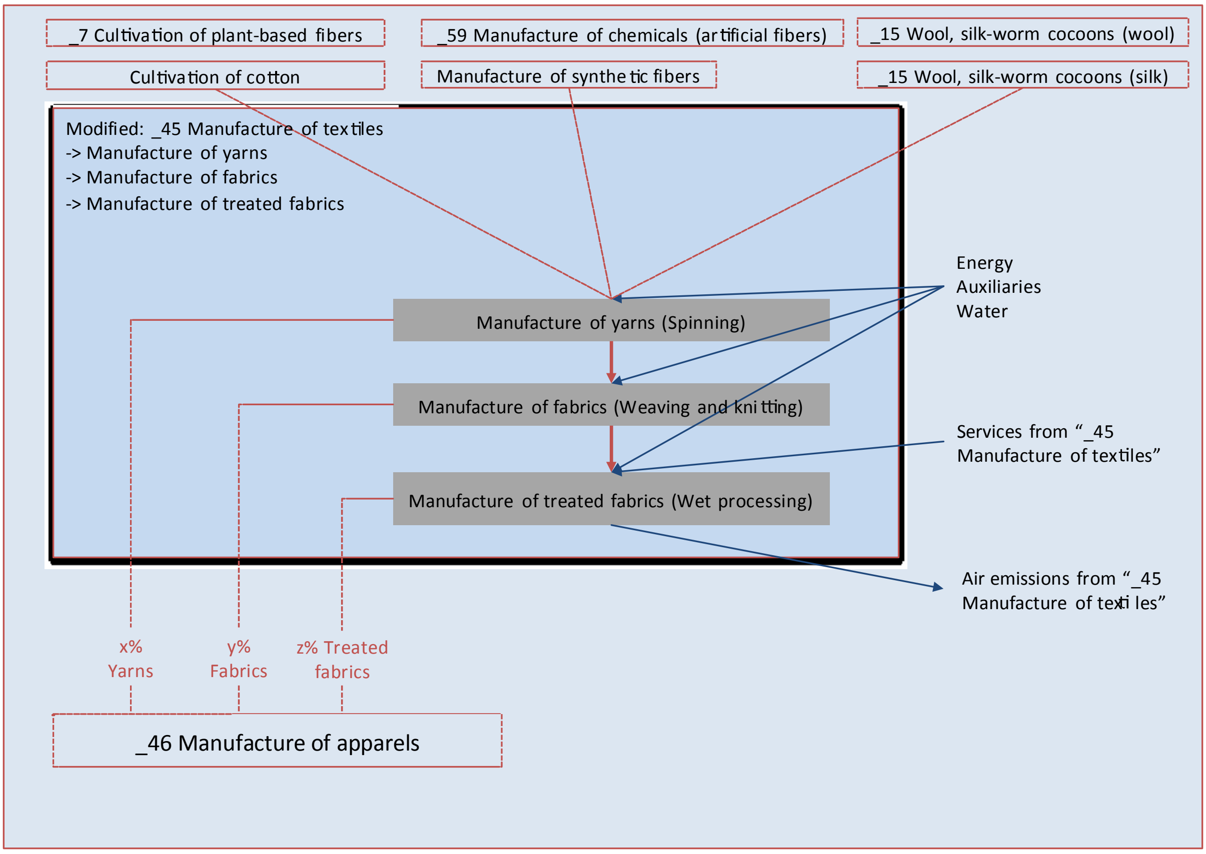

Figure 28 - Breaking down of _Textile manufacturing into three textile industries – inter-linking of the industries

Average yarn spinning and fabric manufacturing processes were used to represent the Manufacture of yarns and fabrics (Saxcé, Rabenasolo, & Perwuelz, 2013). Data collected from 30 wet processing industries were used to represent the manufacturing of treated fabrics (European Commission, 2003; Kalliala & Talevenmaa, 2000).

8.3.3 Modelling BCI cotton inputs

BCI were not involved in the analysis and data has been taken from the BCI Better Cotton Harvest Report 2012.
The following assumptions were made to model the harvesting of better cotton in India:

- For yields, "in 2012, Better Cotton farmers had on average a 17% higher yield than control farmers."
- For water use, "the 2012 data for water use is only based on irrigated projects, and does not include rain fed projects. Better Cotton farmers continued to use less water than the control farmers by 8% in 2012."
- For fertiliser use, "Better Cotton farmers used 5% less organic fertilisers than control farmers in 2012" and "Better Cotton farmers used 25% less commercial fertilisers than control farmers."
- For pesticide use, "in 2012, Better Cotton farmers used on average 17% less chemical pesticides (in volume of active ingredient applied per hectare) than control farmers."(BCI, 2013)

8.4 Valuation of water pollution

Terrestrial, freshwater and human toxicity is expressed in kg 1,4 Dichlorobenzene (DCB) equivalent in Recipe Midpoint Hierarchist characterisation model.

Step 1: Derive a country-specific valuation for Terrestrial and Freshwater ecotoxicity

Toxic substances, here 1,4 Dichlorobenzene, have an impact on terrestrial and freshwater ecosystems through reduced biodiversity. To value biodiversity, a study must define biodiversity, quantify biodiversity losses due to emissions of toxic substances through dispersion and deposition models, and then place a monetary value on these losses. Research projects which have attempted the latter (such as ExternE ("External Cost of Energy") and the NEEDS project ("New Energy Externalities Developments for Sustainability") revolve around calculating the damage cost of pollutants released by energy generation. The ExternE study is the result of more than 20 research projects conducted in the past 10 years, financed by DG Research and the European Commission. The NEEDS project (2006) was run by a consortium of organizations, including 66 partners from the academic, public and private sectors.

The NEEDS (2006) approach developed a formula to estimate the monetary cost per kilogram of toxic substances deposited on terrestrial and freshwater environments in each European country using the three following steps:

1. Calculate the willingness-to-pay to restore an area freshwater

A meta-analysis of 24 studies and 42 value observations across regions and ecosystem types was conducted to calculate the willingness to pay to avoid damage to ecosystems. This is measured using a metric called Ecosystem Damage Potential (EDP), based on species richness.

2. Estimate the EDP of 1,4 Dichlorobenzene (DCB)

The USES-LCA2.0 model (Van Zelm et al, 2009) was used to calculate the EDP of 1,4 DCB at a continental level.

3. Derive of a function to adapt the value to different countries using benefit transfer

Within the NEEDS project, a regression analysis between willingness-to-pay and several variables was performed. The EDP valuation is known to have a positive correlation with population – as more people live close to an area with high biodiversity there will be more people that value biodiversity. The EPD value is known to have a negative correlation with the ecosystem size – if an ecosystem covers a larger area, the value per unit area will be less. Similarly, as biodiversity change increases, the value per unit of biodiversity diminishes. Using these variables, the formula below calculates the value of EDP in different regions.

$$\text{Ln (VEDP)} = 8.740+0.441*\text{In(PD)}+1.070*\text{FOR}-0.023*\text{RIV}+0.485*\text{COA}-2.010*\text{dEDP}-0.312\ \text{In(AREA)}$$

- VEDP= Value of ecological damage potential (willingness-to-pay)
- PD= population density ('000 inhabitants/km2)
- FOR= dummy variable for forest ecosystems
- RIV= dummy variable for river ecosystems
- COA= dummy variable for coastal ecosystems
- dEDP= change in EDP
- AREA= size of ecosystem in hectares

The value of ecosystem damage is a function of the change in biodiversity due to the emission of 1,4 Dichlorobenzene (DCB) and the willingness to pay for biodiversity (adjusted for purchasing power parity).

Step 2: Derive a country-specific valuation for human ecotoxicity

In order to value the health impacts of 1,4 DCB, the first step was to estimate the damage to human population, expressed in Disability Adjusted Life Years (DALYs) and valued DALYs.

Calculate the damage to human population of 1,4 DCB in DALYs

The USES-LCA2.0 model (Van Zelm *et al*, 2009) were used. USES calculates human toxicological effect and damage factors per substance with information related to intake route (inhalation or ingestion) and disease type (cancer and non-cancer) at a continental level.

Damage factors express the change in damage to the human population, expressed in DALYs, as a result of exposure. They consist of a disease specific slope factor, and a chemical-specific potency factor. USES includes cancer specific and non-cancer-specific slope factors. The chemical-specific factors relate to the average toxicity of a chemical towards humans, separately implemented for carcinogenic effects and effects other than cancer. USES's risk assessment is conducted at a continental level and comprises of an exposure, effect and incidence assessment.

Estimate the value of DALYs

In order to put a value on the years of life lost, the NEEDS project approach (NEEDS, 2007; OECD, 2011) was used. The results of this approach are based on a contingent valuation questionnaire applied in nine European countries: France, Spain, UK, Denmark, Germany, Switzerland, Czech Republic, Hungary and Poland. The value was adapted to other countries based on country-specific income levels. To avoid ethical criticisms on the value of life and disease incidence in different countries, the global median value to value DALYs in different countries were applied.

Correct for double counting with the health impact of VOCs

The valuation of VOCs includes impact on human health. VOCs are also included in freshwater, terrestrial and human toxicity calculations. In order to avoid double counting, the VOCs valuation of impact on human health were subtracted from the human toxicity valuation.

8.5 ILUC modelling

The current deforestation and changes in land use are caused by the current demand for productive land. Hence, when a crop for biomass or food requires land, or when land is needed for infrastructure, mines, and housing etc., this affects the overall demand for land. The model used for the calculation of these effects in the current study is the 2.-0 LCA ILUC model (Schmidt et al., 2010; http://www.lca-net.com/projects/ILUCmodel/).

What is land and how can new productive land be created?

Essentially, this model considers land as capacity for biomass production. This is analogous to the capacity a power plant for electricity production. In order to grow biomass, there is also a need for capacity for cultivation, i.e. land. There exists a market for land; called the land tenure market. Since crops can be grown in different parts of the world and are traded on global markets, it is argued that this market for land is global. The 'product' traded on this global market is capacity for biomass production. It should be noted that this capacity can be created in different ways:

1. Expansion of the area of arable land (deforestation)
2. Intensification of land already in use
3. Crop displacement, i.e. a reduction in consumption, e.g. induced by increases in prices, in order to allow others to use the biomass production capacity (social impacts)

The third point above is assumed to be zero because LCA considers long-term effects of changes in demand. Short-term changes will create imbalances between supply and demand, which leads to effects on prices. But in the long term, suppliers will adjust their production to match demand, and unless the production costs are higher, the prices will remain unchanged.

The functions of land to be modelled is the land's ability to produce products, i.e. food, feed, fibre and timber, and the function to provide area for human structures, i.e. buildings, infrastructure and production facilities such as mines. When forests and human structures occupy land suitable for agriculture, it will have similar land-use-related effects as when crops are grown, because it is related to the acquisition of land from the same land-tenure market. Schmidt *et al.* (2010) distinguish five markets for land (all land tenure markets can be used for urban, industrial or infrastructure area):

- Extensive forest land: not fit for more intensive forestry (e.g. clear cutting and reforestation), e.g. because it is too hilly, too remote, or it is growing on very infertile land making intensive forestry uneconomic. Forests grown on extensive forestland are typically harvested after natural regrowth with mixed species.
- Intensive forest land: fit for intensive forestry (e.g. clear cutting, reforestation, species control etc.), but not fit for arable cultivation because the soil cannot be tilled to sustain crops, e.g. because it is too rocky. Forests grown on intensive forestland may be managed as intensive or extensive forestry. Intensive forest land may also be used for other land use, e.g. livestock grazing and extensive forestry.
- Arable land: fit for arable cultivation (annual crops and perennial crops). Arable land may be used for cultivation of annual or perennial crops, for intensive or extensive forestry, and pasture.
- Rangeland: too dry for forestry and arable cultivation. Therefore, when in use, rangeland is most often used for livestock grazing.
- Other land: not fit for biomass production; barren land, deserts, ice caps, high mountains etc.

The capacity for biomass production needs to be measured in an appropriate unit. Activities which include occupation of land clearly need a specified area in a specified period of time. This can be measured in hectare-years (ha yr). An LCA market activity is defined in order to model this. This activity is called 'Market for land tenure'. It is the inputs and outputs of the market for land tenure that consists in the modelling of ILUC. An obvious option for a reference flow of a land-tenure activity would be occupation of land (ha yr.). However, this approach does not take into account that the potential produetion on 1ha yr land in e.g. a dry temperate elimate is very different from the potential in wet tropical climate. This could be overeorne by operating with a kind of productivity-weighted occupation of land. Another option would be the potential Net Primary Produetion (NPPo), measuredin kg carbon. Since the latter provides a simple way to inelude land with different productivities, this option is adopted.

Danish apparel sector natural account

This report is a Natural Capital Account (NCA) of the Danish apparel sector, and the account shows a total of over DKK 1 bn natural capital impact of the sector. The account has a three-level focus: sector-, company- and fibre-level and shows that both material selection and sourcing location are critical in the managing of environmental impacts.

What is NCA

Natural capital accounting is a means of placing a monetary value on the environmental impacts along the entire value chain of a given organization, sector, product or other entity.

Results

GHG emissions are the most material impact for the sector, dominant through all tiers of production. These are largely associated with the use of agrochemicals in crop farming, methane release of livestock, and the fossil fuel combustion associated with energy generation. Water is significant at the raw material phase particularly in regions were water scarcity is high.

Cotton is the largest mass of import materials and as such has 15% of the total sector level impacts associated with the farming phase alone. This offers significant opportunities for improvement, and the company level analysis shows that use of BCI cotton is one means of achieving such improvements.

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