RESPONSIBLE WOOL STRATEGY
A review of wool life cycle impacts and farming practices

Prepared by Trucost
SEPTEMBER 2016
CREDITS

Caroline Bartlett Consultant Corporate Services
Anni Georgieva Senior Research Analyst
Beth Burks Research Analyst
Tom Barnett Account Manager
Jacqueline Jackson Account Manager
James Richens Editor

ABOUT TRUCOST

Trucost helps companies and investors to achieve success by understanding environmental issues in business terms. Our data-driven insights enable organizations to manage risks and identify opportunities for growth.

We are the world’s leading experts in quantifying and valuing the environmental impacts of operations, supply chains, products and financial assets. By putting a monetary value on pollution and resource use, we integrate natural capital into business and investment decisions.

With offices in Europe, the US and Asia, Trucost works with businesses worldwide to increase revenues, improve communications, meet marketplace expectations and comply with regulatory requirements.

CONTACT

E: info@trucost.com
E: northamerica@trucost.com
T: +44(0)20 7160 9800
T: +1 800 402 8774
www.trucost.com

ACKNOWLEDGEMENTS

Trucost has been helping companies, investors, governments, academics and thought leaders to understand the economic consequences of natural capital dependency for over 15 years.
# CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>4</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>6</td>
</tr>
<tr>
<td>Objective</td>
<td>6</td>
</tr>
<tr>
<td>Scope and boundaries</td>
<td>7</td>
</tr>
<tr>
<td>Wool farming overview</td>
<td>7</td>
</tr>
<tr>
<td>Literature review</td>
<td>11</td>
</tr>
<tr>
<td>Animal welfare</td>
<td>11</td>
</tr>
<tr>
<td>Social implications</td>
<td>19</td>
</tr>
<tr>
<td>Environmental impacts</td>
<td>21</td>
</tr>
<tr>
<td>RESULTS</td>
<td>28</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>49</td>
</tr>
<tr>
<td>Summary of findings</td>
<td>49</td>
</tr>
<tr>
<td>Implications for Filippa K.</td>
<td>50</td>
</tr>
<tr>
<td>Potential intervention points</td>
<td>50</td>
</tr>
<tr>
<td>Recommendations</td>
<td>52</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>54</td>
</tr>
<tr>
<td>Methodology</td>
<td>55</td>
</tr>
<tr>
<td>Breakdown of findings</td>
<td>65</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>66</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

This report was commissioned by Filippa K to understand the environmental, social and animal welfare issues that may be apparent within its wool supply chain. The objective of the research was to help Filippa K to enhance the sustainability of its wool sourcing, improving traceability and encouraging responsible practice amongst direct and indirect suppliers of wool products. By commissioning this work, Filippa K is showing industry leadership, taking a proactive stance towards continuous and holistic improvement throughout the wool supply chain. The work aims to provide a useful summary for the apparel sector as a whole, and encourage other brands and retailers to take steps to advance current practices.

The wool industry has recently been criticised publicly for poor animal welfare standards, and previous research has often rated wool as a less preferred fabric in environmental terms, due to impacts such as land use and greenhouse gas emissions. This report identifies how the choice of different practices can influence the positive and negative impacts associated with wool production. The report, based on a comprehensive literature review, engagement with stakeholders, and natural capital accounting of wool production from sheep farming through to fabric production, presents the reasons, means and business value of implementing good practice measures for more sustainable wool sourcing.

The literature review identified a variety of good practice recommendations and, critically, specific interventions through which Filippa K and other apparel brands and retailers, can drive such practice within its supply chain. The Responsible Wool Standard (RWS), developed by Textile Exchange and industry stakeholders, is one such opportunity to help facilitate progress. Engagement with the working group at an early stage of development, along with use of the standard, will help individual companies to use a collective voice, and as such apply greater urgency on the wool farming industry to improve practices. The RWS also further incentivises members of the farming community who are already operating to high animal welfare and environmental standards to create commercial value through demonstrating their own good practice.

Organic and conventional wools were analysed, with the following key findings for organic wool compared to conventional:

- 4% reduction in natural capital cost per kg of wool
- 26% less water consumed
- 13% reduction in human toxicity,
- 6% reduction in freshwater ecotoxicity, and
- 33% reduction in terrestrial ecotoxicity (though from a low baseline).
The natural capital analysis highlighted several challenges to robust accounting for the environmental performance of wool production, often rooted in the limited availability of consistent and comparable data. As such, the natural capital benefit of organic wool in relation to conventional wool reported in this study is likely to be an underrepresentation of actual benefit.

The report found several opportunities for Filippa K to strengthen the sustainability of its wool procurement, building on steps already taken alongside industry activity. Recommendations include:

- **Engage with Textile Exchange and the Responsible Wool Standard (RWS):** The RWS aims to protect animal welfare, preserve land health, improve supply chain traceability and provide clear, trustworthy communication. Filippa K can engage to use it as an industry voice to help encourage the farming sector to adhere to at least the minimum satisfactory levels of animal welfare. This can create business value through increased consumer confidence in products, alongside protection against risk of negative representation through ill conduct carried out within its supply chain.

- **Require tier 1 suppliers to have animal welfare policies:** By encouraging direct suppliers (even though these are unlikely to have animals under their direct control) to embed animal welfare policy into business practice, this further supports improved practice ‘up’ the supply chain. When direct suppliers are prompted to source raw materials with consideration of animal welfare this can drive good practice through the wider, indirect supply chain.

- **Consider improved fibres:** Several initiatives and accreditations already exist that require transparency and animal welfare considerations, such as New Zealand Merino and Zque. The principles enshrined in these initiatives can be adopted by Filippa K to help ensure better practice and further strengthen reputation and consumer confidence. Where appropriate and available, recycled wool also offers significant environmental benefit.

- **Promote internal awareness raising and training with buyers and wider team members:** By educating staff, buyers are likely to be more aware of good practice considerations when selecting fibres and fabrics. This can also improve staff morale and loyalty.

- **Continue to sourcing of mulesing free wool:** Filippa K has already committed to non-mulesed wool, and this should be continued. It is, however, important to encourage the sector to ensure that alternative flystrike treatment is given, and that preventative action is undertaken whenever possible.

- **Engage with customers** to encourage best practice behaviour in maintenance of clothing.
INTRODUCTION

Wool is a multifunctional, durable, natural fibre and is used across a huge variety of products. While it is one of the longest serving fibres, and entirely renewable, it has a complicated reputation. Proponents of wool favour its longevity, biodegradability and recyclability and claim it to be a sustainable fibre, valuable for a circular economy. Conversely, opponents cite high methane emissions (a prevalent and potent greenhouse gas), land use and animal welfare concerns as evidence that wool is less sustainable than alternative fibres, and should not be as widely used.

Filippa K uses wool across much of its apparel range, largely sourced from Australian merino sheep varieties. As a conscientious brand with a core ethos of sustainable production, Filippa K wanted clarity on its own wool sourcing, and to strengthen its sourcing policy for wool to ensure best practice across its supply chain. It considers sustainability to be the guide to growth for fashion.

“Ecosystems and planetary boundaries are our inspiration. We want to be part of the solution rather than add to the problem.” Filippa K mission

To support Filippa K’s movement towards this goal Trucost were commissioned to review the typical animal welfare, social and environmental practices prevalent within sheep farming and throughout the garment lifecycle, and importantly, to understand how these impacts and practices differ across different countries and cultures.

OBJECTIVE

Wool is amongst Filippa K’s most significant raw material inputs. Though popularly considered to be a relatively sustainable textile, recent NGO campaigns have highlighted serious animal welfare issues associated with sheep farming practices. There is also likely to be a wide variation in environmental impact depending on production location, the employment of different farming and processing practices, and the type of wool or wool blend in question. As such Filippa K would like to implement wool sourcing practices that take into account these complexities in order to ensure that the wool it uses for its clothing minimises negative impact on the environment, society and animals while maintaining traditional considerations of cost and quality.

This project has the objective to review and understand the impact on sheep, the environment and people from the wool production process, and understand the further impacts of wool through its use and disposal as garments. Using such information, Trucost will identify opportunities to improve the sourcing policy currently in place, including a review of alternative sources, specific procurement specifications and strategies to ensure that these requirements are being adhered to.
The Textile Exchange has also been engaged to review the analysis, literature review, and the recommendations. Textile Exchange has recently launched the Responsible Wool Standard (RWS). The RWS is designed to be a global standard that will protect animal welfare, influence best practices, ensure traceability, and ultimately give consumers clear and trustworthy information that will allow them to make responsible choices.

Scope and boundaries

The research relates to the social, environmental and animal welfare impacts of production of wool from farm to factory gate – that is the raising and farming of sheep through to the production of a length of woollen fabric. In addition, garment processing and manufacture, consumer use and end-of-life (EOL) is considered in later sections, to assess the implications of these stages of the value chain.

Figure 1: Scope of value chain covered within research

The focus of the research is Australian merino wool, as this is the source of the majority of Filippa K’s wool. For benchmarking purposes, wool production in Argentina, China, South Africa and New Zealand is also reviewed. Natural capital assessment considers the greenhouse gas (GHG) emissions, water use, water, land and air pollution (measured using human, freshwater and terrestrial toxicity), and the land use change (captured through the assessment of ecosystem services).

The evaluation of practices within this report refers to sheep wool only, no consideration of angora, cashmere, mohair or other wool varieties.

WOOL FARMING OVERVIEW

The global wool industry produces around 2.1 million tonnes of greasy wool a year from over 1 billion sheep (IWTO, 2009).
Farming practices differ across different countries, with varying breeds of sheep (of which there are over 200), but the focus of this report is Merino wool production, the predominant wool type used by Filippa K.

Merino sheep are widely considered to have some of the finest wools of any breed. Historically raised for their wool Merinos have distinctive wrinkled skin providing a large wool to animal ratio. Merino fibres typically range from 13-25 microns and break down as follows (Stanford Graduate School of Business, 2011).

- Medium Merino – 21-25 microns
- Fine Merino – 17.5-21 microns
- Superfine Merino – 13-17.5 microns

As a result, Merino has a variety of uses, but is most often made into apparel. Merino sheep are more tolerant to extreme heat than many other breeds, but still require shelter and protection, and are liable to experience stress and production losses if not provided with such (Victoria State Government, 2015), strengthening the business case for improved treatment. Globally, merino wool is produced in several countries, with Australia and South Africa the largest producers with combined total of 88% of all merino wool below 24 microns (ABARE, referenced by New Merino, 2015).
Australia is home to about 71 million sheep, approximately 75% of which are Merino (Woolmark Company, 2015). The Australian Merino is not a single homogenous breed but a number of ‘strains’ of sheep, the four main strains being the following (Australian Association of Stud Merino Breeders, 2015):

- Peppin Merino
- South Australian Merino
- Saxon Merino
- Spanish Merino

Figure 3: Global merino wool production
Sheep are generally shorn once a year, following which the fleece is sent for ‘early’ processing, in which it is scoured to remove dirt and grease, then carded and combed. Finally the wool can be spun into yarns and sent for use in fabrics, knitted garments or hand knitting wool.

**A primer on wool production**

There are many hundreds of breeds of sheep, with the volume of wool produced, fibre length, thickness and quality differing with each. The amount of wool that a sheep produces depends upon its breed, genetics, nutrition, and shearing interval.

Wool farming is typically extensive, meaning that it requires limited input compared to other agricultural systems – with small amounts of agrochemical, labour and capital required per unit of land. The majority of sheep farming is outdoors. Sheep may be housed over winter but otherwise housing is generally reserved for lambing, fattening of some lambs and for milking sheep (Compassion in World Farming, 2015).

Sheep are generally shorn once a year (and need to be mustered (gathered in) and inspected before shearing starts. Wool is typically removed by the shearer using a mechanical hand piece or shearing blades (FAO, 1995). Shearers are often contract labourers who are not employed full time by a sheep farm.

Once removed, the wool is thrown onto the wool table – a slatted wooden table designed to allow short pieces of wool and debris to gather beneath the table away from the fleece itself. Rollers are then passed over the wool to remove the undesirable parts in a process known as ‘skirting’. This is done with as little removal of fleece as possible to leave a uniform, higher quality wool (D’Arcy, 1990). The wool is then folded, and rolled to a loose ball before being appraised for quality by a wool classer. In Australia, wool classers may be registered with AWEX having passed a wool classing/wool preparation certification (AWEX, 2015).

Shorn wool is also known as ‘greasy’ or ‘raw’ wool due to presence of lanolin and oil, and this is cleaned before processing into yarn. This process can be undertaken with detergents and water and is known as scouring. Further to this process, wool can be further bleached with hydrogen peroxide to improve brightness and reduce yellowness of the fibre (McKinnon, 2010). The wool is then prepared and processed through a series of picking, carding and roving before being spun for yarn.
LITERATURE REVIEW

Wool is often considered a sustainable fabric, as it is from a natural, renewable source, and is highly durable. However, recent attention from NGO’s (see PETA, 2014 for an example) to some farming, and in particular, shearing practices has highlighted significant animal welfare concerns. While People for the Ethical Treatment of Animals (PETA) promote the end of wool consumption through its #WoolFreeWinter campaign, others argue the many beneficial properties of wool should not be overlooked and rather than stop using wool, focus should be placed on ensuring the treatment of animals during the farming and wool collection processes is responsible and humane.

Literature reviewed focussed on three distinct yet intertwined aspects of wool production:

- Animal welfare
- Social implications
- Environmental impact

These three themes are discussed in the sections below.

Animal welfare

Animal welfare is an emotive and subjective issue. The World Organisation for Animal Health (OIE) defines animal welfare as the following:

“Animal welfare means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress.” (OIE, Terrestrial Animal Health Code, 2015)

What one individual considers to be ‘good’ animal welfare will differ based on moral, religious and philosophical beliefs (for example, considering animals to be sentient or non-sentient), culture, context and potential trade-offs within a wider scenario of variables. Different countries and governments often create legislation to protect animal welfare within their borders, but the content of these can vary significantly. It is for this reason that individual companies sourcing and using animal products should have a strong animal welfare policy in place to reflect their own position, ensuring that they have traceability up their supply chains, and can prevent mistreatment of the animals that are providing these products. While general guidelines for all animals are a useful starting point, focus should be given to animals which are heavily relied upon for raw materials, or that are identified as being widely mistreated within the industry. For a company such as Filippa K that uses significant wool within its product portfolio, a focussed sheep welfare policy is important.
Animal welfare issues associated with the wool industry

Several practices are identified as being potential animal welfare issues for sheep, though whether they are or not depends on the specific management of the practice. Problems can arise where systems are designed for mass market, producing many thousands of units of wool and as such, handling, transporting and processing large flocks of numerous sheep. For example, the process of shearing is not in itself harmful, however if carried out carelessly, can cause severe pain, injury and even permanent damage to the sheep.

Much of the literature around sheep welfare centres around the ‘Five Freedoms’, used by the Farm Animal Welfare Council (FAWC), Royal Society for Protection against Cruelty to Animals (RSPCA) and the World Organisation for Animal Health (OIE) amongst others. These are five internationally recognised freedoms that represent a compact of rights for animals under human control, including working and farmed animals.

The five freedoms are as described by the FAWC (FAWC, 2009) are:

1. **Freedom from Hunger and Thirst** - by ready access to fresh water and a diet to maintain full health and vigour.
2. **Freedom from Discomfort** - by providing an appropriate environment.
3. **Freedom from Pain, Injury or Disease** - by prevention or rapid diagnosis and treatment.
4. **Freedom to Express Normal Behaviour** - by providing sufficient space, proper facilities and appropriate company of the animal’s own kind.
5. **Freedom from Fear and Distress** - by ensuring conditions and treatment which avoid mental suffering.

Alongside these welfare considerations, the literature identified the following specific animal welfare focusses for sheep:

- Surgical treatments including mulesing, castration, tail docking
- Transportation – in particular live transportation and long distance shipping
- Shearing

These three activities are focussed on in greater detail below.

**Surgical treatments**

Surgical procedures can be a standard part of animal husbandry to maintain appropriate flock numbers, manage behaviour and reduce health risks. For example, wethers (castrated male sheep) are considered to be less prone to fighting, sexual aggression and are easier to handle (Sheep Standards and Guidelines Writing Group, 2013). Though all surgical procedures have potential to create animal welfare issues if carried out incorrectly, most criticism is focussed upon practices
which are not part of a specific treatment of injury or disease, in particular castration, mulesing and tail docking.

Mulesing involves removing a section of a lambs breech to avoid flystrike (see pop out box). It is a common practice in countries in which flystrike is a problem and it is practiced significantly in Australia.

The practice is painful, and rarely carried out with anaesthetic or pre-operation painkiller. Local anaesthetic requires a veterinarian to administer and is considered to make the operation prohibitively expensive (University of Adelaide, 2015). Acute pain is long lasting – between 24- 48 hours (Lee & Fisher, 2007). Australian Wool Innovation Ltd (AWI) has been researching alternatives, and is looking to develop a long term solution the remove the need for mulesing, but also working on short term solutions to improve the welfare of sheep with practical solutions (AWI, 2015).

Flystrike is also a painful condition, and treatment is needed to avoid animal stress and loss of livestock. Flystruck sheep develop painful wounds which, if untreated, can debilitate the animal to the extent that it eventually dies of blood poisoning (RSPCA, 2011). Alternatives to mulesing that are not detrimental to the economic viability of sheep farming have been investigated for many years, with the AWI previously pledging to ban the practice by 2010 (AWI, 2008). However, the ban never came into practice. The most suitable long-term solution is to breed the sheep specifically for traits resistant to fly strike, such as bare breech. According to the RSPCA, trials have shown that, in certain conditions, the bare-breech trait is moderately to highly heritable and does not significantly affect other wool traits such as fibre diameter, staple length and strength (RSPCA, 2011). While other alternatives have been identified, these are either still in development or not as effective as mulesing. Alternatives include clipping, injections, management (such as shearing and dag and worm removal), though these are considered part of an integrated approach and not stand alone (idem).

Short term integrated pest management (IPM) was found to be the best option by researchers Scholtz et al, if mulesing is not used “Since none of the management practices in use on the farms surveyed were sufficient to guarantee complete blowfly control when evaluated on their own, an IPM approach should be considered.” (Scholtz et al, 2011).
Research by the FAWC suggests that all methods of tail docking and castration cause pain and distress:

“Available evidence suggests that all methods of castration and tailing cause pain and distress which may be detected by alterations in behaviour such as posture and activity, and by alterations in cortisol concentrations in the blood.” FAWC, 2008

As such, it recommends that immediate attention is given to improvement in provision of pain relief, with local anaesthetic being the only viable option. Castration and tail docking can be carried out using a number of procedures, either surgically, with use of elastrator rings or with a Burdizzo (Clamp) (NSW Government, 2014). Elastration involves banding the body part (scrotum or tail) to restrict blood flow until the tissue becomes necrotic (dead) and it drops off.

Farmers claim that using elastrator rings creates little animal welfare issue, leaving no open wounds which in turn attracts flies and infestation. Both ewes and rams show few pain responses within 1-2 hours of the procedure. However, it is claimed that the rings cause chronic inflammation, sepsis and pain until the necrotic tissue detaches from the healthy tissue. This is not commonly seen in animals that have rings attached within 1 week of birth, but more likely when applied later in life (illegally in some countries) (Scott, 2006). Anaesthetic can be locally provided to block the immediate pain associated with elastrator rings, but is not necessarily undertaken it takes more time and an additional person to conduct (idem).

Surgical castration and tail docking can be performed (legally) later in the animal’s life, up to 3 months for lamb castration and two months old for tail docking (idem). The procedure for both is relatively quick and requires a scalpel to remove the end of the tail, or cut into the scrotum to remove the testes. While quick, the procedures requires skill, and it is important a competent person carries it out, otherwise complications can arise (Duncanson, 2012). Tails should not be docked too short to prevent issues with rectal prolapse and risk of cancer due to exposure to sunlight. Tails also have a role in removing faeces from the breech area, which can be beneficial in reducing flystrike, and therefore tails should be at the correct length to cover external genitalia and anus (National Woolgrowers Association of South Africa, 2009). Both practices are also recommended to be carried out at the correct time of year, when blowfly are less prevalent. Open wounds are prone to flystrike (idem).
Transportation

Transportation of sheep can be highly stressful, and can result in severe injury and death of the animals if not carried out responsibly. Good transportation is considered to be one of the most important animal welfare issues within the wool sector (National Woolgrowers Association of South Africa, 2009). Sheep may be transported by land or by ship when travelling long distances.

According to Compassion in World Farming (CIWF) Australia exports around four million live sheep every year, mostly to the Middle East every year. Animals are transported up to 50km in lorries, before being put on ships to travel for up to three weeks. CIWF estimate that around 40,000 sheep die per year before reaching their destination (CIWF, 2015). Though these sheep are often exported for meat rather than wool, they are often animals bred and reared on wool farms. A challenge for the wool industry, and identified within the Responsible Wool Standard development (see section 0) is that shipping (and ultimate slaughter) of sheep is generally outside of the wool supply chain, and therefore while an animal welfare concern, when sheep are at the end of their productive lives for wool, farmers often sell them to an auction site, and have no control of where they go after that (RWS, 2015). As such, it is unlikely a brand procuring wool would be able to extend influence over transportation directly, though there may be opportunity to exert some pressure on industry practices in general.

Transport by land may occur within the wool farming process. The pop out box provides recommendations from the South African good practice guidelines.

Transportation recommendations for vehicles

Vehicles transporting sheep should have:

- A suitable non-slip floor, which should not impede the cleaning of the floor of the vehicle.
- Adequate ventilation and light whilst in motion as well as when stationary. A totally enclosed vehicle is unacceptable.
- Adequate protection from exhaust gasses. Exposure to exhaust fumes could interfere with animals’ respiration or cause distress.
- Adequate provision for inspection at floor level of all the animals being transported;
- Sidewalls high enough to prevent animals from escaping or falling out of the vehicle. The sides and partitions, when used in a vehicle to separate animals carried therein, shall be of a height not lower than the shoulder joint of the largest animal being transported. The minimum height shall be 750 mm in the case of any smaller animals.
- In multi-tier vehicles, heights between decks shall be adequate, and in case of sheep not less than 1000mm, to enable the largest animals to stand naturally, freely and fully erect and to allow adequate space for the free flow of air above the animals;
- The density of animals packed into any given space shall be such as to ensure the safety and comfort of the animals during transport. The recommended floor space is 0.4 square meter per sheep.

National Woolgrowers Association of South Africa, 2009
Shearing

In many countries where sheep are handled for wool production, no training or accreditation is required for sheep shearing. In Australia, there are no formal educational requirements needed to become a shearer, but courses are available. According to TAFE South Australia\(^1\), of shearers currently employed in Australia, 17% have TAFE shearing certificate, while 76% have no post school qualifications.

While many shearers may not have qualifications, it is difficult to determine evidence that compares the number and severity of sheep injuries by qualified and non-qualified counterparts. Un-qualified shearers are likely to have undergone many years of practice and informal training of shearing and without further investigation it may not be appropriate to presume that shearers who have not received qualifications are automatically less likely to injure sheep handled. However, it is one means of ensuring that shearers do have the basic skills required to minimise injury to both sheep and shearer.

Shearing is stressful to sheep, and the following guidelines are recommended by the National Woolgrowers Association of South Africa (2009):

- Undue handling of sheep must be avoided.
- Care should be taken not to expose shorn sheep to adverse weather conditions.
- Sheep should be returned to food and water as soon as possible after shearing.
- Where circumstances indicate, shearing cuts should be treated to prevent infection and blowfly strike.
- Care should be taken to limit urine and manure contamination on wool before shearing.

Animal welfare groups have recently campaigned using footage of sheep injured and mishandled during shearing. While poor practice may happen in any industry, in the wool industry it is important to put actions in place to limit any possible opportunity of poor behaviour and animal abuse. For shearers, common practice often involves payment by the tonne of fleece shorn, encouraging fast and efficient work, but potentially incentivising workers to cut corners and mishandle sheep in order to get more output in less time. Paying shearers by the hour reduces the drive to process as many animals as possible in the shortest timeframe.

---

\(^1\) Technical and Further Australia Education, an independent Statutory Corporation of the Government of South Australia, and is Australia’s largest provider of Vocational Education and Training
Apparel companies' approach to animal welfare

When considering animal welfare within the apparel sector, sheep have not always been a focus for sustainable or ethical procurement, however, they are increasingly recognised within company policies. Recent animal welfare organisation campaigns have brought considerable focus onto sheep welfare, in particular the process of mulesing, the surgical removal of a section of a sheep’s hindquarter skin to reduce the incidence of flystrike (see Section 0 for detail).

A review of the top 10 apparel companies by revenue\(^2\) identified that of all the companies with publically available animal welfare policies or commitments, all mentioned sheep or wool specifically. Of these, mulesing was identified as a practice to avoid (either banned or moving to ban) by all, and few specified any other practices, though generic animal welfare responsibilities applied. The one exception with more detailed focus was H&M, with the Responsible Wool Standard identified as a an objective of RWS certified wool for future wool sourcing once the standard is complete (see more detail below).

**Responsible Wool Standard**

In 2014 the Textile Exchange initiated the development of the Responsible Wool Standard (RWS) to help address animal welfare issues identified within the wool supply chain. This is a joint collaboration between animal welfare organisations, apparel companies, trade associations and other stakeholders to the wool industry. Textile Exchange describes the RWS as being:

"**Designed to be a global standard that will protect animal welfare, influence best practices, ensure traceability, and ultimately give consumers clear and trustworthy information that will allow them to make responsible choices**" (Textile Exchange, 2014)

Work on the RWS was initiated after Textile Exchange was contacted by H&M wanting to address its wool supply. The decision was made to involve the full industry, and as a result the development of the standard is being undertaken through the International Working Group. The group comprises animal welfare groups, brands, farmers, supply chain members, industry associations, as well as apparel, home, and carpeting brands. The RWS was launched in June 2016.

The RWS is based around the internationally recognised ‘Five Freedom’s’, and builds upon the IWTO ‘Guidelines for Wool Sheep Welfare’ (IWTO, 2013). The RWS includes 5 modules, which cover the following five themes for animal welfare:

- Management

\(^2\) Bloomberg data based on previous 12 months as of 29/06/2015
• Nutrition
• Infrastructure
• Health
• Behaviour and handling

The standard focuses on recognizing and encouraging best practices, while setting some minimum pass/fail criteria.

The Technical Group will also develop a tool for use by farmers to introduce the concepts of the standard, and to also provide an outline for the Certification Body to follow during the on-site audits (RWS, 2015c).

Good Practice

The majority of animal welfare policies of the largest clothing brands focussed on mulesing, with the exception of H&M. Along with brands such as Stella McCartney, Gap and Esprit, involvement in the RWS development is good practice and is designed to drive good practice into the future. However, these brands own policies were highly varied in level of good practice communicated.

The RSPCA Good Business Awards are designed to recognise businesses in fashion and food that practice or encourage superior animal welfare. ASOS was the 2012 innovation winner, due to its animal welfare policy that covers wool, angora, cashmere, feathers and down; animal testing, as well as endangered species, fur, leather and exotic skins (RSPCA, 2012). The policy promotes good animal husbandry in wool farming, as well as banning wool from mulesed sheep. It also banned the use of karakul (foetal or newborn) lamb pelt3 (ASOS, 2014). Izzy Lane, a small UK company that produces wool from rescued sheep, was the 2012 ‘Small Fashion Company’ award winner. At its core are 500 rare breed sheep which have been rescued from slaughter, and whose fleeces are used in the company’s fashion collections. The company’s owner, Isobel Davies, has been petitioning for an ethical, animal welfare standard for wool, including limiting the transportation distance of live sheep to no more than 120 miles, or 3 hours (Izzy Lane, 2014). While this practice is commended, it is yet to be established on the scale of many Australian sheep farms, and further, the distances between processing sites and farms may be significantly different within Australia.

Other brands focus more towards traceability. The Icebreaker ‘Baacode’ traceability programme lets customers trace the merino wool in purchased garments back to the source of the wool. A customer

---

3 Though not a wool, Karakul lamb pelt is also known as Persian lamb, and differs from carpet wool which is the shorn from the mature Karakul sheep.
can input the garment’s specific code and the tool then shows them the specific site of production, living conditions of the sheep and detail of the farmers that raise them (Icebreaker, 2015).

**Social implications**

Direct impacts on humans of sheep farming and wool production have far less coverage in literature than animal welfare and environmental issues. The literature available relates largely to workers’ conditions rather than implications to communities and wider society.

Agricultural work is one of the most hazardous occupations worldwide, with some countries showing twice the risk of fatal accident at work than the average of all other industries (ILO, 2000). Workers and owners often live within the natural resource that they are managing, and therefore the overlap between environmental and social impacts is more acute, with more direct use and interaction with natural resources (ABC, 2015).

The most significant risks to sheep farm workers identified within literature include:

- Insecticide poisoning from sheep dips
- Zoonosis (disease transferable from animals to humans)
  - Q fever -transmitted to humans via inhalation of aerosols or dusts of contaminated birth products of infected sheep
  - Ovine chlamydiosis, which has the potential to induce miscarriage in pregnant women
- Shearing injury

**Insecticide poisoning**

Sheep dips have been used for many decades, initially introduced to rid animals of scab, a small parasite living under the skin of sheep. In several countries sheep dipping was a legal requirement historically, and the chemicals used within dips have been suggested to have caused human health impacts to farmers who work them (Guardian, 2015b; NRA Expert Panel, 2000). Though management of these chemicals (and exclusion of some toxic chemicals such as organochlorines) has improved, there are still risks to workers exposed to sheep dips in current practice.

Organophosphates (OPs) routinely used in control of ectoparasites in sheep are considered one of the most effective medicinal treatments, but are recognised as dangerous chemicals needing careful handling (National Farmers Union, 2014). The processes of dipping, jetting or back-lining for ectoparasite control often result in skin contamination of sheep handlers (Fragar et al, 2001). Research carried out in 1995 found that farmers exposed to OPs performed significantly worse than controls in tests to assess sustained attention and speed of information processing, as well as a greater vulnerability to psychiatric disorder (Stephens et al, 1995).
Guidance from the UK Government Health and Safety Executive, suggests that the greatest risk of OP contamination to humans is due to absorbing chemicals through skin due to accidental contact such as contaminated clothing or touching recently dipped sheep’s fleece, or from splashes of either concentrate or dilute solution (HSE, 2013). Risks can be minimised with good maintenance of dips themselves, appropriate infrastructure (such as entry slope and race to guide sheep into dip with minimal splashing, draining pens which feed back to the dip, piped water available for clean-up and decontamination) and adequate and effective personal protective equipment (PPE) for all operators (idem).

Shower dips are an alternative means to plunge dips to saturate sheep with insecticide, those these are not recommended as best practice due to risk of operator contamination and slow throughput (MLA, 2013).

**Zoonoses**

There are numerous zoonoses (animal diseases that can be transmitted to humans) related to sheep, and these are a general concern to all farm workers and shearers. The best approach to minimising transference to humans is to ensure good care of animals, and minimising number of infected animals through vaccinations where available, and swift identification and treatment where not. Good general hygiene, care during food preparation, wearing protective clothing and vaccination of people can also help minimise risks involved (Department of Agriculture and Fisheries, 2012). Two zoonoses are focussed upon in the review, Q fever and Ovine chlamydiosis, however other diseases to be aware of include Brucellosis (Bang’s Diseases), Campylobacteriosis (Vibriosis), Johne’s disease (Paratuberculosis) and Toxoplasmosis (FAZD Center, 2011).

Q-fever is a disease caused by an organism named Coxiella burnetii. The clinical signs of this disease in humans range from no noticeable signs, to a severe flu like syndrome that may last for months. It is spread by inhalation of the organism from the placental fluids and urine of sheep, goats, and cattle, amongst others. Shearers and farm workers are at risk, and infected animals show no outward sign of infection so caution should be taken with all animals, particularly during lambing season (Victoria State Government, 2007).

The second significant risk of zoonosis from sheep is Ovine chlamydiosis, a bacterial disease acquired from infected sheep or goats. Most infected humans experience a mild flu-like disease, but in pregnant women it can cause a severe life-threatening disease in the mother and lead to stillbirth or miscarriage of the unborn child (HSE, 2008). Pregnant women should avoid all involvement with lambing ewes and lambs and should not handle contaminated clothing from those working with
these animals. Immunocompromised people should also take great care to avoid contact with potential sources of infection at lambing time (Entrican et al, 2001).

**Shearing injuries**
Shearing requires sheep to be handled multiple times – mustering, yarding, and penning – which is stressful to sheep and can create risk of injury, to both the sheep and the operator. The most common injuries occur due to manual handling, injuries due to machinery, injuries due to slipping or falling and injuries from animals (Worksafe Victoria, 2001).

Research conducted in 2001 determined that in Australia, sheep shearer injury alone accounted for 14.8% of agricultural sector workers compensation claims – representing a cost of between $7 to $19 million per annum – 0.5% of the gross value of wool production in Australia at that period (Fragar et al, 2001). Almost 50% of these claims involved body stressing, with another 40% being associated with the body hitting or being hit by another object – sheep or the shearing equipment. Body parts injured are more commonly the back (20%), and the hand (22%).

Prevention of injury is best addressed through a holistic approach, and injuries often occur due to poor planning, complacency or inadequate management. Sheep handling areas should be checked for hazards frequently, records of injuries kept and recurrent issues targeted, and all operators should be trained sufficiently and competence ensured. Calm and competent handling will lead to less stressed sheep, which in turn results in fewer injuries to both the operators and workers.

**Environmental impacts**
The environmental impacts are a subject of some debate for wool. High profile material indexes, designed to help brands and manufacturers select the most sustainable fabrics for use in their apparel, rate wool as a relatively poor fabric in sustainability terms. For example, wool receives a ‘Class E’ environmental score on the MADE-BY ‘Environmental Benchmark for Fibre’ (MADE-BY, 2013a), the lowest in the range of A-E scoring over the following indicators: GHG emissions, human and eco-toxicity, energy use, water use and land use (see Appendix). Recycled wool is scored as ‘Class A’, however.

Wool also performs relatively poorly in the Sustainable Apparel Coalition (SAC) Higg Index materials tool, scoring 18.8 out of 50, worse than polyester fabric (23.3), linen (22.6) and cotton (20.4, 26.6 and 28.2 for woven, knit or organic fabric respectively). It is considered particularly poor in relation to chemical and energy impacts (see Figure ).

*Figure 4: Woven wool fabric Higg Index base material score*
Both these examples provide indicative scoring, as necessary for top level rating systems, however impacts can be varied depending on farming regimes, region, and location of the farmland (e.g. type of land grazed). When analyses are being undertaken, assumptions and decisions made on certain aspects of the impacts can also have a major influence of findings. LCA reviews and fabric ratings systems show significant range of impact. The Higg Index base materials are scored using the Nike developed Materials Sustainability Index (MSI), and both this and the MADE-BY scorecard were developed by the consultants Brown and Wilmanns Environmental, LLC, so some similarities are likely. Both were developed using published LCA papers and reputable data, and are not considered by the author to be inaccurate, but assessment at this level will always be less preferable than company specific analysis. The MADE-BY methodology report notes that:

“MADE-BY sees the limitations of analysing and ranking the different types of fibres ready to be spun in one environmental benchmark for fibres. However, we accept this limitation since, in order to move forward in using more sustainable fibres, one needs to use a classification system and measure progress.” (MADE-BY, 2013b)

The material environmental impacts identified in literature typically refer to the following indicators:

- **GHG emissions**: from methane associated with enteric fermentation, nitrous oxide from waste and fertiliser use, and energy used to fuel machinery within the farming practices and through the wool value chain
- **Water use**: on farm to provide drinking water for sheep (though this is at least in part returned to the system), in supply chains of feed and fertiliser, and water used to clean and maintain good hygiene on site. Further water is used within the processing of wool, including cleaning, wet processing, and finally the use phase can be water intensive, with significant water used over a garment or product lifetime
• **Land use**: often presented in terms of hectares and not accounting for quality or potential beneficial impact of sheep grazing)

• **Chemical use**: this is a fairly vague term, but can incorporate eco and human toxicity, eutrophication, acidification and other measurements of chemical impact. Chemicals include ingredients present in insecticides, fertilisers, dyes, bleaches and various other processes used for wool processing along the value chain.

The challenge can often arise in trying to calculate a single global view of a fabric. Sheep farming impact differs significantly depending on wool growing region, management practices, type of farm, breed of sheep, type of wool and numerous other variables that have an influence on the total impact of the system. As identified by IWTO (2012) impact assessment using life cycle assessment (LCA) approach can lead to significantly varying outputs, depending on scope, data quality and methodology – in particular allocation of impacts specifically to wool. LCAs can be very valuable tools, but it is important that if using for comparison the same scope, boundaries, assumptions and methodologies are used across all systems. Where misalignment is identified, efforts should be taken to adjust for appropriate inclusions (see methodology section 0 for further discussion of impact assessment approach).

As with any such assessment, it is important to take findings in the context of the wider scenario, to assess the systems holistically. Agricultural LCA systems have been criticised in some circles, as natural systems can be more complex to quantify. Complexities arise due to multiple products from a single system, regional and crop/animal specific management techniques, temporal variations (seasonally and annually) and spatial variations (Caffrey & Veal, 2013). Kviseth iterates the difference between industrial and natural systems;

“**LCA was made for industrial systems, not for natural systems. Nature cannot easily be put into metrics in the same way as activity in an industrial site can be measured, where inputs and outputs are more easily monitored. If the world was according to LCA, cows and sheep would be banned, and battery hens would be the best option, all because the metrics say so.**” Kviseth, K (2011)

However, the LCA framework can bring significant benefit to help identify and compare reduction strategies for agricultural systems and LCA methodologies have evolved and improved to help capture some of the more challenging complexities of these natural systems (PRe Sustainability, 2014).

The natural capital assessment conducted within the research project focusses on pulling best available data from LCA sources, adjusting for the specific scope and boundaries of the report. This is then converted to a monetary unit, incorporating quality factors such as water scarcity of the region, land type and region, and the implications of these impacts in the specific region in which the
biophysical impacts are borne. This may include local populations, ecosystems and water bodies (see section 0 for detail of the monetization approach).

**Initiatives and certification schemes**

“From this ‘whole systems’ perspective, it needs to be clearly stated that there is no such thing as a sustainable or an unsustainable material or product; there are only sustainable material and resource management practices. Product and material sustainability claims therefore need to be viewed carefully, and as part of a journey toward sustainability – one that has many possible pathways.” (The Natural Step, 2010)

**Organic wool certification**

The Oxford English Dictionary definition of organic is “(Of food or farming methods) produced or involving production without the use of chemical fertilizers, pesticides, or other artificial chemicals:” but in reality, organic products are extended far beyond that limited scope. Organic textiles can include a wide array of fibres and fabrics, and can be certified at the fibre level (for example, organic sheep producing organic wool fibre), fabric level (adhering to organic standards through processing to fabric) or the whole product (such as an organic woollen jumper). Specific definitions vary, but the Australian “National Standard for Organic and Bio-Dynamic Produce” (2013) defines it as:

(Organic) means the application of practices that emphasise the:

- Use of renewable resources; and
- Conservation of energy, soil and water; and
- Recognition of livestock welfare needs; and
- Environmental maintenance and enhancement, while producing optimum quantities of produce without the use of artificial fertiliser or synthetic chemicals.

Different organic labels and schemes exist across the globe, with the Global Organic Textile Standard (GOTS) a globally recognised standard for all fibrous textiles. The standard covers the processing, manufacturing, packaging, labelling, trading and distribution of all textiles made from at least 70% certified organic natural fibres. The final products may include, but are not limited to fibre products, yarns, fabrics, garments, fashion textile accessories (carried or worn), textile toys, home textiles, mattresses and bedding products as well as textile personal care products (Soil Association Certification Ltd). The standard sets out stringent criteria, including a list of prohibited chemicals and specific requirements for each of the various spinning, sizing, weaving/knitting, pre-treatment, dyeing, printing, finishing and other wet processing stages of a products life.
The research more specifically focusses on the on-farm aspect of organic wool – that is the rearing of organic sheep. Several accreditations and certifications exist, including national certifications in Australia and New Zealand, and the UK based, but globally recognised Soil Association organic certification.

One of the biggest differences between organic and non-organic sheep farming is the methods used for pest and disease control. According to the Soil Association, organophosphorus (often used in dips as insecticide) is banned in organic sheep certification, and therefore farming techniques may be used to compensate. The practice of double-fencing to prevent scab is one option, to avoid infected sheep passing on scab through scratching on fence posts, although this is not always feasible in some locations. Clean grazing (managing pastures so that sheep are only put into fields that have low or no worm infestation) is another technique used to minimise the need for veterinary treatments with chemicals (Soil Association, 2015). For wool to be considered organic according to the Australian standards, the sheep must have had no restricted veterinary or pest control treatments for 18 months (Australian Organic Ltd., 2013).

Specific requirements exist in relation to health treatments, for example tail docking and castration can be carried out before the lamb is 10 weeks, and mulesing is allowed if pain relief is given and “where verifiable animal welfare concerns exist and shall not occur in the absence of preventative management, including permitted substance use and strategic crutching.” The practice is to be phased out by December 2015 however (idem). As well as not being treated with prohibited chemicals, organic sheep also need to be fed organic nutrition, with most certifications (including Soil Association and both Australian standards) requiring nutrition to meet the requirements of the same standard to be considered organic.

Other accreditation and initiatives
The Zque™ or ZQ accreditation programme is a New Zealand based ethical wool system, by which growers are required to adhere to the five freedoms. Easily traceable, partner farms are audited by third party, qualified inspectors as part of the ZQ Merino auditing programme every 3-5 years. In addition, every year a random selection of farms are audited to help ensure growers continue to provide the standard of practice required. Some of these audits are conducted by a veterinarian focusing specifically on the animal welfare and health components of the programme (ZQ Merino).

While the precise requirements of the audit are not fully clear, the programme promotes each animal is free roaming, is healthy, provided ample appropriate nutrition, and is not under unnecessary stress and pain. While it does not allow for mulesing, other common practices such as tail docking and castration are not mentioned on the website communication.
An additional benefit of ZQ is the traceability. It is acknowledged that there are cases of animal abuse within the sheep industry (as is likely in all animal based systems), but this should not be reflected as a practice of all. The challenge arises where wool is bought through opaque markets, and buyers are unaware of the original growing sources of the fibres.

Another programme available is the Wools of New Zealand Integrity Program. This was established to authenticate what is considered best practices of sheep farming in New Zealand including transparent environmental performance (Wools of New Zealand Ltd, 2013). The Integrity Program incorporates environmental management, animal welfare, chemicals and waste and social responsibility alongside transparent documentation of wool quality also.

**Discussion of practices**

**Traceability and transparency**

A challenge of ensuring good animal husbandry in a supply chain is the limited transparency of wool markets. A recent review of selling systems for wool in Australia has identified that the system is in need of modernisation. Australia sells the majority of its wool through an ‘open cry’ auction system and the review found that electronic selling systems could potentially open up markets to new participants, lower participation costs and provide for easier and faster dissemination of market information creating the potential for greater transparency (AWI, 2015).

Clothing companies can improve transparency up their supply chain through the use of third party assurance schemes and certifications.

**Stocking rates**

Sustainable grazing depends on the pasture dry matter levels on the particular biome that the sheep are farmed upon. The higher the dry matter level (measured in kg per hectare) the more sheep can be grazed on it without the system being damaged, that is, whereby the flora can return once grazing ceases. There are numerous factors that influence the stocking rate that is sustainable, not least the length of time sheep are grazed on the land (there is often rotation of flock, or short term grazing), breed of sheep, number of pregnant ewes, soil fertility and non-domestic herbivore grazing (such as kangaroo or feral goats) (New South Wales Department of Primary Industries, 2005).

As such, it is apparent that the use of ‘number of hectares’ as an indicator for natural capital cost is an ineffective means to assess the impact of sheep farming. Du Toit (2010) iterates that there are several factors to consider for stocking capacities, and if the indicator used is number of animals per hectare, regions of South Africa would be given very low (decimal) numbers as one animal may need
very many hectares. However, in irrigated, cultivated pastures it would be higher. Consideration should be given to more appropriate metric use within impact assessment.

The RWS considers land management as multifactorial, with carrying capacity, soil management, biodiversity, nutrient management and pesticide use all influencing the overarching land management process (RWS, 2015d).
RESULTS

Natural capital cost per tonne

The natural capital costs of three fabric types were calculated, with variation also given for coarse or fine wool production. These are:

- Conventional wool
  - Coarse wool
  - Ultrafine wool
- Organically farmed wool
  - Coarse wool
  - Ultrafine wool
- Wool/cotton blend (based on ultrafine conventional wool and conventional cotton)

LCA data for organic sheep farming was not available, so the conventional wool LCA was adjusted to remove the synthetic chemical inputs and adjusting impacts of maize feed to organic maize. More robust direct LCA assessment of organic wool farming would be recommended for more granular future comparison. Figure 5 shows the natural capital cost of 1 kg of fabric, given by value chain phase. As primary data is used to calculate the impacts of yarn and fabric production for wool, these two stages are the same for all the wool fabrics, and are not adjusted for organic processes.

**Figure 5: Natural capital cost of 1 kg of fabric by value chain**

The raw material production phase is the most impactful across all fabrics and the blended fabric. This is largely linked to the methane emissions associated with enteric fermentation from sheep. Of
all the GHG emissions associated with the farming phase of wool, 78% is on farm, while 22% is from the supply chain, such as the growing and processing of feedstuffs and agrochemical production and supply.

Organic wool showed a 4% reduction in natural capital costs in comparison to the conventional farming systems, however this is potentially undervaluing the benefit due to data limitations. Systems were adjusted within the LCA data to remove synthetic agrochemical inputs, along with adjusting feedstocks for organic varieties where possible, however the variation of on farm impacts (such as implications in changes in diet on enteric fermentation), are not captured. In addition, the valuation does not include important qualitative benefits of organic farming, which are discussed elsewhere in the report. As such, any decision making should consider environmental impacts alongside qualitative information.

Figure 6: Natural capital cost of 1 kg of fabric by impact indicator

A significant benefit of organic sheep farming is the reduction of synthetic chemical use for treating sheep for parasites for example. In LCA data, human and eco-toxicity can be measured in 1,4-dichlorobenzene (1,4-DB) equivalents to standardise the toxicity metric. Through the use of organic farming practices, human toxicity reduced by 13%, terrestrial toxicity (while from a low starting point) by 33%, and freshwater toxicity by 6%. The boundaries of the analysis do not consider the in use toxicity of any chemical residues that remain in the wool, which could potentially further increase benefit.
Furthermore, water consumption reduced by 26%, including a 43% reduction in supply chain impacts due to reduce chemical use.

As discussed in section 0, valuing land use at a top level, without being able to assess the specific ecosystem services in place at the site itself, can create misleading findings. In Australia, sheep farming is located largely within a region named the ‘wheat-sheep’ zone, mostly consisting of grazing modified pastures for sheep farming. This was mapped to individual biomes based on the WWF ‘Wildfinder’ tool. This identified the zone is largely associated with ‘Mediterranean forests, woodlands and scrubs’ with other biomes including ‘temperate grasslands, savanna and shrublands’ and ‘tropical and subtropical grasslands, savannas and shrublands’. The percentage figures in table 1 below represent the percentage of the sheep farming region that is was this particular biome, and as such the ‘average’ of the zone calculated based on the weighting of each biome. The value per hectare is from published literature identifying the ecosystem services provided by a particular biome in Australia – so for example, the value of soil erosion protection, regulation of water, waste assimilation and other such services.
Table 1: Natural capital valuation of different biomes within the wheat sheep zone of Australia

<table>
<thead>
<tr>
<th>Biome</th>
<th>Percentage of zone</th>
<th>Natural capital value per hectare (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperate Grasslands, Savanna and Shrublands</td>
<td>32%</td>
<td>358</td>
</tr>
<tr>
<td>Mediterranean Forests, Woodlands and Scrubs</td>
<td>50%</td>
<td>467</td>
</tr>
<tr>
<td>Tropical and Subtropical Grasslands, Savannas and Shrublands</td>
<td>14%</td>
<td>358</td>
</tr>
<tr>
<td>Temperate Broadleaf and Mixed Forests</td>
<td>4%</td>
<td>467</td>
</tr>
<tr>
<td>Weighted average of Wheat sheep zone</td>
<td></td>
<td>417</td>
</tr>
</tbody>
</table>

Source: Adjusted from Blackwell, 2006

The value of ecosystem services associated with pasture land was determined to be €189/hectare. Using this approach the natural capital cost of lost ecosystem services for each hectare of land used for sheep farming would be €275, however this does not factor into consideration the dry matter level of the grazing land, the grazing management practices and stocking levels or any beneficial ecosystem services that may be associated with sheep grazing. While quantified evidence of this is limited, there are examples such as the decline of Lucerne plants if not strategically grazed (FAO, 2006), and reduction of undesirable weeds (Lodge & Whalley, 1985). The IWTO iterate that grazing land is often land that is not suitable for other production uses and which is left relatively undisturbed where stocking rates are low, therefore it is incorrect to assume that record of land use is proportional to negative impact (IWTO, 2011).

By further adjusting this factor to a value per kg of wool unintentionally infers improved natural capital impact through more intensive grazing, regardless of dry matter level and ability of the particular grassland to maintain such provision of nutrition. While this approach may be suitable for granular, site-specific studies, in which the specific characteristics of an individual biome and ecosystem service can be more accurately measured, the use of this approach at a regional level is not advised.
To provide context, a range of stocking rates were identified in the literature, for the countries analysed within the report. These are given in Table 2 below, with yield per hectare based on an average wool production per sheep of 4.2 kg:

Table 2: Stocking densities for sheep farming, by country

<table>
<thead>
<tr>
<th>Country</th>
<th>Stocking density (number of livestock units (LSUs) per hectare)</th>
<th>Average wool per hectare (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Average</td>
</tr>
<tr>
<td>Argentina</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>China</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.5</td>
<td>4.3</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>1.3</td>
<td>5.1</td>
</tr>
</tbody>
</table>

*Sources: FAO Country Pasture/Forage Resource Profiles and du Toit, 2010*

Stocking density range can be significant depending on whether sheep are held by small family farms, pastoral grazing herds, or large commercial static farms. Topography of the region is also relevant, for example, a farmer may have a small number of sheep grazing over a large mountainside with low quality land which would not be suitable for crop production. To assess appropriately, the specific ecosystem services lost due to land conversion and grazing (and potential positive ecosystem service gains) would need to be calculated at different stocking rates. Using an average biome loss to pasture land, and weighted by average wool yield per hectare, creates many variables that influence results. Using this system, natural capital cost of land use change could be up to €1,000 per kg of wool, however this is misrepresentative as the aforementioned variables would need better incorporation into findings. As such, this is a potential area of further research to improve data availability and create more granular comparison.

Country specific findings

Farming practices in Argentina, China, New Zealand and South Africa were also reviewed for animal welfare practice, social systems and environmental performance. To compare LCA data, it is critical
that comparisons must be ‘like for like’, that is scope and boundaries should be the same (or be adjusted to be such) and methodologies and assumptions made aligned. No appropriate LCA data was retrieved identifying variation in impacts of different countries, however regional valuation was applied to the LCA assessment carried out for Australia, to capture water scarcity impacts and implications of eco and human toxicity on the local air, land and people. Figure 8 displays the natural capital cost of a kilogram of wool for the farming phase only, presenting 10% variation in natural capital cost of conventional, from €2.08 -€2.30 per kg for New Zealand and South Africa respectively.

Figure 8: Natural capital costs of sheep farming for 1kg ultrafine wool, by country

While GHG emissions are the dominant impact across all countries, variation is apparent in the impact of water use and implications of human toxicity of farming (see figure 9). Water use is the most impactful in South Africa, responsible for 8% of the total impact, with greater water scarcity than comparison countries. China, has a more significant impact from human toxicity comparatively, with 6% of impact associated with this indicator. Human toxicity is valued through a number of steps – including calculating the damage factor through change in human population damage due to exposure of a particular chemical (see Appendix for valuation methodology). Exposure route differs due to a number of factors which are country specific, including the population density, and as such, the number of individuals exposed in a given area. This information can help to direct focus for improvement, for example focussing more on the water use in South African farms.
Use phase and End-of-life

Consumer use of clothing includes washing, drying, ironing and any treatments that a garment may require to aid its continued functioning as a garment. When the item is no longer desired by the consumer, it is disposed of, either to waste (‘put in the bin’), or to be recaptured in some manner, through donation to charity, clothing banks, in store take-back or other recycling or repurposing organisations. These two stages are more or less impactful depending on consumer behaviour, for example how frequently an item is washed and how carefully it is looked after.

In a 2010 review of clothing LCAs, use phase was identified as being one of the main contributors to most environmental impacts (Oakdene Hollins, 2010) while BSR identified use phase care as “the single most important factor determining a garment’s life cycle GHG emissions” (BSR, 2009). In addition, WRAP identified that the largest opportunities for reducing the carbon impact of clothing include designing for durability and washing less, alongside general eco-efficiency across the supply chain (WRAP, 2012).

Wool is both highly durable, and requires little use phase maintenance. Compared to other fibres such as cotton, woollen garments can be used longer between washing cycles due to the natural repellence to soiling. Some washing can be replaced by airing, and wash programs have lower washing temperatures and shorter washing cycles (Laitala & Klepp, 2016). In addition, once garments are worn out, wool is highly recyclable, and unlike some other fibre types, the quality of fibre remains high even after mechanical recycling. As such, the opportunity to minimise the overall
impact of a woollen garment is high, with design for longevity and clear consumer engagement offering potential natural capital savings.

The total cradle-to-grave impact of a Filippa K woollen sweater, pair of trousers and jacket was calculated, based on 100% wool composition. This included sheep farming through to fibre and then fabric production, garment manufacture, consumer use and eventual end-of-life management. Data sources for each assumption are given in appendices.

**Figure 10: Natural capital costs of all value chain stages of three woollen garments, per item of clothing**

Figure 10 shows that use phase can be significant, ranging from 8% of total natural capital costs for the jacket, to over 40% of the total impacts for the sweater. To calculate the impact of consumer use, assumptions were required over consumer behaviour. Every person differs and therefore practices will vary from consumer to consumer so ‘standard’ assumptions were made based on literature review. With regards to end-of-life, responsible management of garments offers a twofold benefit. Firstly, negative impacts associated with landfilling or incinerating garments are reduced, but in addition, positive gain can be achieved due to avoidance of virgin material requirements, or generation of energy. EOL is therefore a combination of natural capital costs (i.e. the detrimental impacts of energy use, landfill and others) and the natural capital ‘credits’ (seen on the graph as negative, as a credit can be seen as a negative cost) from these beneficial processes.

Impacts were also calculated per wear – as this is a more appropriate unit to compare like for like garments. This avoids the misleading scenario of life extension (increasing use phase impacts without increasing other stages) making a garment look more impactful, when in fact the opposite is true. It is important to note that average life expectancy estimates are variable in themselves, with
wool garments estimated to conservatively range from one or two years for items such as shirts to four years for suits and coats and 10 years for blankets (Drycleaning Institute of Australia Limited, 2014).

Table 3 shows that if looking only at a garment over its lifetime, the sweater is the most impactful of the garments reviewed, due to the most significant use phase impacts. By normalising to the cost per wear (and assuming a jacket is worn less frequently than a jumper over its lifetime – see table 4 below) the jacket is identified as having the higher natural capital cost.

In addition to standard practice, two further scenarios were identified to reflect the significance of behavioural practices; ‘good practice’ and ‘optimised’. Assumptions taken for each are listed below.

The woollen sweater has the greatest consumer use opportunity. By washing a sweater only 10 times a year – a feasible scenario if air cleaning is used – and sending back to Filippa K at end-of-life – a reduction in natural capital cost of 58% is apparent –less than half of the natural capital cost otherwise associated with the garment (figure 11). This includes both reduction of impacts associated with use phase due to lower energy and water use, but also potential positive impact due to end-of-life benefit, such as diversion of virgin material production and avoidance of landfill.
The results show the importance of holistic life cycle assessment for fabrics. As discussed in the Section ‘Environmental Impacts’, public wool LCAs and impact assessments have often been seen to reflect poorly of the environmental credentials of wool. However, by producing garments from wool, alongside appropriate design for durability and longevity, companies may influence the whole life cycle impact of garments. This can significantly reduce the overall impact by minimising virgin material production for new garments, and reducing energy and water use in maintenance.

As discussed, the environmental implications of wool and garment production only presents one aspect of responsible wool use. The following section discusses animal welfare practices, and reviews variation of codes of practice, legislation and cultural diversity within each of the focus countries.

**Animal welfare**

The Animal Protection Index (API) is a tool to rank countries according to their commitments to protect animals and improve animal welfare in policy and legislation. While it does not assess specific species of animal (such as sheep), it provides a useful indicative tool to highlight sheep producing countries of better or worse top level legislation. The API should not be used as a decision making tool, and does not directly reflect the practices of sheep farmers in the specific countries, however, it can provide some insight into the Government requirements and cultural attitude of animal welfare.
The tool was designed by a working group led by World Animal Protection, but with input from senior members of several prominent animal welfare groups, such as the RSPCA, Compassion in World Farming and the International Fund for Animal Welfare (API, 2015). Each country’s assessment was broken down into 15 unique indicators, grouped into 5 themes. Primarily the presence of legislation or policy addressing each issue was evaluated, followed by an assessment of the strength of that legislation or policy, considering:

1. The extent to which the legislation or policy succeeds in making that particular issue of animal protection a mainstream concern of society;

2. Whether there are barriers to improvement on that particular issue in the country. This includes the availability of resources and the presence of socio-cultural traditions and practices that might affect positively or negatively on animal protection; and

3. Whether the legislation or policy includes a structure of relevant enforcement mechanisms. Although this does not assess the extent to which enforcement activity has taken place in the country, it shows whether the legislation or policy has the potential to be effective.

Countries are scored within seven bands, both for individual indicators and on an overall basis. These bands are A through to G, A representing the highest scoring and G the most room for improvement.

The five countries of interest to Filippa K were reviewed, and the results are given overleaf.
## Responsible wool strategy

<table>
<thead>
<tr>
<th>Total</th>
<th>Recognising animal protection</th>
<th>Formal recognition</th>
<th>Support for the Universal Declaration on Animal Welfare</th>
<th>Protecting animals used in farming</th>
<th>Protecting animals in captivity</th>
<th>Protecting companion animals</th>
<th>Protecting animals used for draught and recreation</th>
<th>Protecting animals used in scientific research</th>
<th>Protecting the welfare of wild animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>D</td>
<td>C</td>
<td>F</td>
<td>C</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>South Africa</td>
<td>D</td>
<td>C</td>
<td>F</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>C</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Australia</td>
<td>C</td>
<td>C</td>
<td>G</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>New Zealand</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>China</td>
<td>E</td>
<td>C</td>
<td>G</td>
<td>D</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Governance structures and systems</td>
<td>Animal welfare standards</td>
<td>Providing humane education</td>
<td>Promoting communication and awareness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------</td>
<td>---------------------------</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government accountability for animal welfare</td>
<td>Engagement with the World Organisation for Animal Health (OIE)</td>
<td>OIE animal welfare standards</td>
<td>Reporting on progress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Education on animal care and protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Consultation with stakeholders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>C</td>
<td>D</td>
<td>C</td>
<td>G</td>
<td>F</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>South Africa</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>F</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>D</td>
<td>D</td>
<td>E</td>
<td>G</td>
<td>E</td>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>
The API is a useful indicative tool to highlight regions that show less stringent legislation, or implementation of animal welfare policies, but these are not necessarily reflective of sheep farming specifically, and suppliers obviously may perform significantly better or worse than the country it operates in.

The following section considers the farming systems in place for sheep within each individual country of focus, and captures a top level review of what legislation is relevant.

Country review

Rearing and processing of sheep and wool differs across countries. Different socioeconomic factors, cultural influences, sheep varieties and regional topography all influence farming systems, and the following section reviews sheep farming within the five focus countries of Australia, Argentina, China, New Zealand and South Africa. Focus is given to farming lifestyle and animal welfare practices and legislation, as well as the variation in natural capital available to each.

Animal welfare practices can be difficult to ascertain, with on-site visits and audits a more reliable method of assessment. However, review is taken of animal welfare legislation in the country along with codes of practice, previous publicly available evaluations and voluntary welfare schemes to provide indicative information.

Australia

There are three major groups of sheep bred in Australia: those which produce wool, those grown for meat and dual-purpose sheep grown for both wool and meat (MLA, 2012). The main sheep breed in Australia is the Australian Merino, accounting for around 75% of all sheep (Woolmark Company, 2015). Approximately 12% are first cross ewes used for producing high quality prime lambs (lambs for meat) by mating the ewes with short wool British meat breed rams. The remainder are merino-derived dual purpose breeds, Comebacks, and British breed sheep (Australian Bureau of Statistics, 2003). Owner-operators account for almost 60.0% of industry participants (IBIS World, 2015).

### Australian wool production overview

- **Head of sheep (2013):** 75,550,000
- **Head of sheep (average 1993-2013):** 101,140,000
- **Tonnes of greasy wool produced (2013):** 360,500
- **Tonnes of sheep meat produced (2013):** 660,400
- **Type of sheep:** Merino dominant, though some crossbred sheep wool and a small amount of carpet wool also produced

*Source (FAOSTAT, 2015; AWEX, 2013)*
The sheep industry in Australia has been suffering from losses for many years until 2010, when returning rain improved pasture feed, reducing the cost of keeping livestock and allowing farmers to expand production. Industry revenue has remained volatile, however, with fluctuations in commodity prices, rainfall and production (IBIS World, 2015). The price of wool varies according to many wool characteristics: the category, fibre diameter (micron), length, strength and amount of vegetable matter are some prime price variables. Table 5 provides some indicative prices of differing thickness wool fleece.

Table 5: Indicative pricing of Australian fleece

<table>
<thead>
<tr>
<th>GRADE OF WOOL</th>
<th>AVERAGE PRICE PER BALE (2013 AUD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.0 micron fleece</td>
<td>1584</td>
</tr>
<tr>
<td>19.0 micron fleece</td>
<td>1452</td>
</tr>
<tr>
<td>21.0 micron fleece</td>
<td>1391</td>
</tr>
<tr>
<td>23.0 micron fleece</td>
<td>1359</td>
</tr>
<tr>
<td>28.0 micron fleece</td>
<td>727</td>
</tr>
</tbody>
</table>

Source: AWEX, 2013

The Australian Government (in collaboration with state and territory governments, industry and the community) developed the Australian Animal Welfare Strategy (AAWS) in 2005, which was later managed by the individual States and Territories (AAWS, 2015). As such, there is no national animal welfare law, rather each individual state territory has individual legislation relating to animal welfare (RSPCA, 2014) (see Appendices for detail of these). Australia is a federation of six states and two territories and, under the Australian Constitution, the states and territories have responsibility for establishing and enforcing animal welfare laws (Australian Government Department of Agriculture, Fisheries and Forestry, 2010).

Australian sheep farming has been criticised for its wide historic practice of mulesing (see Section 0 for detail of the practice), which has been practiced with no pain relief. Figure shows non mulesed (NM), ceased mulesing (CM) and pain relief with mulesing (PRM) adult Merino fleece bales offered for sale as a percentage of total adult Merino fleece bales offered from July 2010 to March 2013. It shows that Australian farmers are increasingly providing pain relief to sheep, but the percentage of non mulesed or ceased mulesed has increased marginally over the three years leading to 2013.
Figure 12: Adult merino fleece bales offered for sale July 2010 to March 2013.

Source: AWEX, as referenced by Moffitts Farm, 2013
Argentina

Sheep may be found everywhere in Argentina though with large differences in density, prevailing breeds and production systems. The most important sheep breeding region is Patagonia with two thirds of the country’s sheep, 75% of which are merino (Cardellino & Mueller, 2014).

Once a booming industry, sheep farming in Patagonia suffered a crash in 1930, causing colonization of grasslands across a wide range of productivity. Alongside varying topography, climate, and natural hazards, sheep farming in Patagonia is considered an ‘uncertain’ activity (Coronato et al, 2011).

Many sheep graze freely in large flocks without shepherds for long periods, only gathered in for shearing/marking and other such processes. While 70% of sheep farms are smaller than 1,000 head of sheep, this is only 13% of the entire sheep population, with 87% of sheep belonging to a smaller number of large farms with over 1,000 sheep (Cardellino & Mueller, 2014). Carrying capacity for Patagonia ranges from 0.18 sheep per hectare per year for the shrub-grass steppes of Central District to 1.2 sheep per hectare per year in the more humid grass steppe of the Magellanic District. Wool is typically fine (associated with Merino sheep), though approximately 40% is medium or coarse wool in volume terms.

Table 6: Wool production in Argentina

<table>
<thead>
<tr>
<th>TYPE OF WOOL</th>
<th>TOTAL GREASY WOOL PRODUCED (MKG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine (&lt;24.5 µm)</td>
<td>31.5</td>
</tr>
<tr>
<td>Medium (24.6-32.5 µm)</td>
<td>19.5</td>
</tr>
<tr>
<td>Coarse and Criollo (&gt;32.5 µm)</td>
<td>2.0</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
</tr>
</tbody>
</table>

*Source: Cardellino & Mueller, 2014*

In past decades, over-grazing in areas of Argentina has led to areas of desertification, especially in its central and eastern parts (with less rainfall), resulting in sheep grazing ceasing in many ranches. Some farms continue with a carrying capacity as low as one sheep for each 8-12 hectares (Coronato et al, 2011).
Cardellino & Mueller (2014) iterate that agriculture is continuing to expand however, and livestock are pushed increasingly towards more marginal areas, creating environmental pressure.

While Argentina has limited legislation regarding animal welfare across the wide context of the topic, animals used in farming are identified as being better protected by policy and legislation. Legislation was drafted by the National Service of Health and Quality of Agricultural Food (SENASA) in 2002 and 2004, to establish the National Commission of Animal Welfare, which predominantly focusses on agricultural animals (API, 2014a).

**China**

Along with Australia, China is one of the largest wool producers in the world, however the markets for the product differ significantly. Though approximately one third of Chinese wool is considered ‘fine’, relatively little wool that could be compared with standard Australian "merino-style" wool (Longworth et al, 2005). According to Longworth et al (2004) while “fine wool” for statistical purposes means wool with a visually assessed mean fibre diameter of 25 micron or less, it includes wool which is graded in China as “fine” and “improved fine”. The latter is a very heterogeneous class of wool which, at best, is better described as “fine crossbred”.

Mutton is an important foodstuff within China, and many sheep farmed in China are for the food market rather than the wool sector. Due to challenging conditions of high winds and sub-zero temperatures, Chinese wool is often considered lower quality than Australian equivalents. Chinese wool is categorised as “shorter, less sound, more heterogeneous and having lower clean yields” than Australian wool (US International Trade Commission, 1999).

Sheep are broadly grown in three farming systems (though these also show significant variation):

- Pastoral localities
- Mixed pastoral/agricultural localities
- Agricultural localities

<table>
<thead>
<tr>
<th>Chinese wool production overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head of sheep (2013): 175,000,000</td>
</tr>
<tr>
<td>Head of sheep (average 1993-2013): 146,680,000</td>
</tr>
<tr>
<td>Tonnes of greasy wool produced (2013): 471,100</td>
</tr>
<tr>
<td>Tonnes of sheep meat produced (2013): 2,081,000</td>
</tr>
<tr>
<td>Type of wool: Approximately equal split between ‘fine wool’, ‘semi-fine wool’ and ‘coarse wool’</td>
</tr>
</tbody>
</table>

*Source (FAOSTAT, 2015)*
Pastoral lands are typically located in the vast expanses of northern and north western China. They suffer from extremes of both heat in summer and cold in winter and much of the traditional rangelands have become degraded, some very seriously (Longworth, et al, 2004). Mixed localities occur in regions in which irrigation is possible (snow fed streams and underground aquifers where rainfall is higher). In these locations, sheep are reared alongside cropping. Sheep are generally shepherded around the irrigation during the different seasons of the year, and due to general availability of forages and by-product from cropping, they are often better fed than pastoral areas (Longworth *idem*).

Agricultural localities involve large numbers of sheep within densely populated regions such as north eastern provinces and in the North China Plain. These provide more moderate climate and consequently feedstuff is more widely available. However, pressure on land means limited pasture for grazing, and households frequently keep small flocks (usually less than 5 head) in yards and sheds near their houses. Sheep husbandry standards are low and the production methods employed are certainly not conducive to the production of good quality fine wool. Most sheep in agricultural areas produce either semi-fine or coarse wool (Longworth *idem*).

Animal welfare in China is generally viewed as less advanced than European standards, with significant criticism from media and animal welfare groups (see The Guardian, 2015a for example).

It is argued that there is no specific animal welfare focussed law in China, though this looks to be potentially introduced in the near future (Animal Asia, 2014). However, there are wider examples of legislation that have relevance to animal welfare, including humane slaughter of hogs, and management of dogs for example (Chinese Animal Protection Network, 2013). The Animal Husbandry Law (2006) by the Ministry of Agriculture has a focus on food quality, but Article 42 provides detail on environmental conditions for livestock and poultry, while Article 53 describes conditions of transportation – namely the essential space, nutrition, and drinking water to be provided (API, 2014b).

No sheep specific legislation or guidance documents were identified for Chinese farms, whether during farming or processing.

**New Zealand**
The Merino was the first sheep breed brought to New Zealand in large numbers, and is still an economically important breed, with New Zealand Romney, Perendale and the Corriedale all also of significance (New Zealand Sheepbreeders Association, 2015).

There are three main types of land on which sheep are grown in New Zealand, based on climate and topography. These are:

- High country
- Hill country
- Lowlands

High country is typically comprised unimproved tussock and adventive grass (not deliberately planted). It is associated with long winters which reach low temperatures and have heavy snowfall. Merino wool, or fine wool from Halfbred sheep is the main income source (Stringleman and Peden, 2012). The most substantial area of pastoral land is hill country, traditionally dominated by Romney sheep on the North Island, and Romneys, halfbred and Corriedale on the South Island (idem).

The plains, river valleys and hills of New Zealand are associated with intensive sheep farming. Lowland farmers generally finish stock bought off the hill and high country on fodder crops and special pasture mixes (idem).

Animal welfare is generally considered advanced within New Zealand, with formal legislation given in the New Zealand Animal Welfare Act (1999). The Animal Welfare Act sets out how people should take care of and act towards animals, based upon the five freedoms. The Ministry for Primary Industry (MPI) and the Royal New Zealand Society for the Prevention of Cruelty to Animals (the RNZSPCA) jointly enforce the Act. In addition, two independent ministerial advisory committees have an important role helping set those policies and laws while representing the New Zealand society’s views on animal welfare. These are the National Animal Welfare Advisory Committee and the National Animal Ethics Advisory Committee (MPI, 2015a).

The Animal Welfare Act provides a general list of principles, but specific requirements are laid out within codes of welfare. Codes are issued under the Act and contain minimum standards and recommended best

### New Zealand wool production overview

<table>
<thead>
<tr>
<th>Description</th>
<th>2013 Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head of sheep</td>
<td>30,790,000</td>
</tr>
<tr>
<td>Head of sheep (average 1993-2013)</td>
<td>40,160,000</td>
</tr>
<tr>
<td>Tonnes of greasy wool produced (2013)</td>
<td>165,000</td>
</tr>
<tr>
<td>Tonnes of sheep meat produced (2013)</td>
<td>450,100</td>
</tr>
<tr>
<td>Types of sheep</td>
<td>Merino, New Zealand Romney and the Corriedale</td>
</tr>
</tbody>
</table>

*Source (FAOSTAT, 2015; New Zealand Sheepbreeders Association, 2015)*
practice. Failure to meet a minimum standard in a code of welfare can be used as evidence to support a prosecution for a crime under the Animal Welfare Act (MPI, 2015b).


South Africa

The majority of wool produced in South Africa is used within the apparel sector, predominantly Merino (74%), but with coarse and coloured type also marketed (Department of Forestry and Fisheries (DAFF), 2011). Sheep are largely concentrated in the drier west and also in the south east and are mostly the Dohne merino, bred mainly for wool production, and the Dorper for meat production (FAO, 2002). Production ranges from intensive to semi-extensive and extensive conditions. The industry employs over 35 000 farm workers across 8,000 commercial and up to 24,000 communal producers⁴ (South African Government, 2015) Sheep farming is concentrated in the Northern and Eastern Cape, Western Cape, Free State and Mpumalanga with more than 50% of the clip produced the Eastern Cape and the Free State provinces (DAFF, 2011).

Communal wool producers have varying levels of sophistication of farms, with facilities varying from old and poor constructions with insufficient equipment, handling facilities and no dipping facilities, to sheds that are well constructed with the entire necessary infrastructure for effective wool harvesting, classing and marketing (National Wool Growers’ Association (NWGA), 2012). The NWGA has a training and development programme improve and upgrade infrastructure and training in communal sites.

The care of animals in South Africa is regulated by two Acts – namely the Animals Protection Act, 1962 (Act 71 of 1962) and the Performing Animals Protection Act, 1935 (Act 24 of 1935), available through the DAFF (last amended 1993). The Animals Protection Act covers all animals, including sheep, and covers offences to

---

⁴ Estimations of communal sheep farmers vary significantly, with DAFF (2011) reporting less than 6,000 in 2010, while the National Wool Growers’ Association reported 17,000 in 2012.
animals including ill-treatment, attention and treatment of disease, unnecessarily denying food or water and causing unnecessary suffering, and wider negligence and offences. According to the API (2014c) a draft animal welfare strategy being discussed by the Government is planned to incorporate international principles of animal welfare, and the current legislation will be updated with a new Animal Welfare and Protection Bill.

No sheep specific legislation was identified, though the NWGA ‘Best Practice reference manual for wool sheep farming in South Africa (2009) provides a robust framework for of best practice concepts in wool farming, including animal welfare, social responsibility and environmental management.

CONCLUSION
Sheep farming practices differ significantly, both across but also within countries. While evidence exists for both better and worse practices, it is important not to consider a material inherently ‘good’ or ‘bad’. A responsible retailer procurement policy should focus on ensuring that the wool sourced for products is of good standard and produced in a manner that minimises environmental, social and animal welfare detriment. Animal welfare groups, media and environmental campaigners have brought attention to some of the less responsible practices within the sector, in particular neglect and abuse of sheep during wool production. In a response to this however, a significant sector drive to improve, and provide evidence for, responsible management has been seen.

Environmental impacts of farming vary, however granular data that can be compared across systems is limited, and future opportunity exists for the sector in developing wider, standardised assessment techniques and allocation methodologies. This will allow a greater understanding to be gained of different practices and regional variation. Most importantly, it is also important to consider impacts holistically and not rely only on quantified data.

SUMMARY OF FINDINGS
Reporting of environmental impacts of wool production is varied, and there is a significant range of impacts, and therefore conflict of information, available to the general public and retailers looking to procure wool for product manufacture. The natural capital assessment identifies that GHG is the dominant impact of sheep farming and wool production, regardless of allocation methodology.

The natural capital cost of organic wool compared to conventional showed a 4% decrease, though this is considered to be an under-representation due to limited data availability. The most significant reductions are apparent in water use (26%), terrestrial ecotoxicity (33%) and human toxicity (13%), while GHG emissions, the most significant impact, was reduced by 4%.
Use phase and end of use impacts of a garment can be significant, associated with over 40% of the total natural capital cost of a woollen sweater for example. However, use phase is highly variable depending on how consumers care for, wash and dry their garments. Optimised practice, such as washing garments less frequently (only as needed, and air cleaning when less soiled, possible due to wool’s self-cleaning characteristics), and taking back for reuse or recycling at the end of its useful life, can reduce impacts by 58%. By assessing garments over their entire lifecycle, and normalising using the natural capital cost per wear of a garment, a more appropriate comparison of true ‘sustainability’ of clothing is apparent. This better reflects longevity and durability, as well as recyclability.

Within literature, a criticism of wool farming is the large land use associated with farming. Much of the wool produced globally is grown extensively, over large areas of land that can be poor quality (limited properties for crop growth for example). The use of ecosystem service valuation of land is valuable, but only in granular assessments where specific characteristics of land are taken into consideration. While this approach can be useful when considering deforestation for example, use for sheep farming land assessment is not recommended unless at a site level. Even when adjusting for land quality by assessing the biomes generally, region valuation is too abstract from the specifics of land management, dry matter levels and farming practice to appropriately assess land use change impact.

Implications for Filippa K
Animal welfare issues are highly emotive, and can present a financial risk to business through reputational risks associated with negative welfare group campaigns, with a strong wool product line representing a substantial proportion of product portfolio. Through engagement with suppliers and improved sourcing policy for wool, Filippa K can help to manage this risk and communicate to its customers the positive steps it has in place to ensure animal welfare within its supply chain is optimised.

Furthermore, should legislation be brought into place, there is potential operational risk associated with supply chain disruption and possible implication for operating costs. By proactively addressing the issues within its wool supply chain, Filippa K has the opportunity to become recognised as a brand leader, and promote its good practice to customers and wider stakeholders.

Animal welfare management can interlink with environmental responsibility, and often certification or improvement schemes have requirements for both animal welfare alongside chemical use, or land management. The following sections consider some of the potential intervention points upon which Filippa K can influence better practice up their supply chain.

Potential intervention points
The following provides a list of potential intervention points that could be implemented to drive improved wool sourcing. This includes options that may be less desirable, though should be considered to understand the wide range of options available.

- **Supplier Code of Conduct**
  
  Filippa K already has in place a supplier code of conduct based upon the Fair Wear Foundation Code of Labour Practices. This is a valuable tool to help ensure suppliers adhere to practices outlined by Filippa K. The code of conduct currently focuses on the social impacts of workers within the suppliers’ direct employment, and could be expanded upon to incorporate animal welfare also. Though the links are less direct, as sheep farmers are not in first tier of the supply chain, and therefore direct pressure is more difficult, by insisting that tier 1 suppliers have critical standards of animal welfare that they then role up the supply chain towards sheep farmers, there is a greater chance of wider industry pressure coming to the farmers’ attention.

- **Alternative fabrics**
  
  Non-animal based yarns
  
  One means of absolute assurance of no welfare issues would be to exclude all animal fibres from products sold. This would be extreme, but is promoted as the best alternative by some animal rights groups. Any replacement would need to be carefully considered and all fibres have impacts, if not on animal welfare directly, then through environmental impacts. Alternatives promoted by PETA include natural cellulosic fibres such as hemp or linen, along with more innovative fibres on the market such as soysilk. Soysilk is produced using a by-product of tofu manufacturing, and is promoted as an ‘eco fibre’, however, limited information is available on the long term durability and quality of the fibre, and impacts are unclear. As with other ‘hybrid’ fibres, soysilk is based on natural plant matter, but converted using chemical input to transform to a fibre for apparel.

  Proponents of wool argue that the natural qualities of wool, such as fire resistance, durability, elasticity and softness make it a unique fibre that cannot be replaced easily.

  Recycled wool
  
  As a less absolute alternative, use of recycled wool minimises both the environmental and potential animal welfare impacts of sheep farming. In addition, by diverting waste from landfill, further benefit can be achieved through reduction of decomposition emissions to air, or pollutants from incineration.

- **Certified Fibres**
  
  The research has identified a range of certification schemes and initiatives such as ZQue, alongside various organic certifications that can be sought depending on the country of origin. By engaging with the procurement team and designers, integration of certified wool can help achieve transparency in the supply chain, and potentially minimise risk of poor practice through third party monitoring of minimum standards of performance. Certification can also bring further confidence to customers, who may not be fully aware of other practices undertaken, but may recognise certification on garment labelling for example.
In addition to the wider initiatives already operating, the Responsible Wool Standard (RWS) has recently developed a standard with industry and wider stakeholder review and consultation.

- **Buyer procurement principles**

  Along with supplier code of conduct, buyers can be engaged with to better educate the challenges and opportunities of the wool they buy. This may provide opportunity to better engage with suppliers and ask more questions of the source and supply chain of purchases. While the apparel sector is highly competitive and price driven generally, there is the potential to stand out of the crowd as a market leader, and as such, have slightly higher flexibility in procurement costs.

- **Direct engagement with farmers/farming groups**

  An approach taken by other sectors, particularly grocery retailers, is to engage directly with farmers and farming co-operatives to improve management practices directly. This is a more costly process, and can be more challenging to facilitate, however it can help streamline supply chain complexities, and overcome the concerns associated with wool markets resulting in opaque wool source backgrounds.

**Recommendations**

- **Engage with Textile Exchange and the RWS**

  Though RWS certified wool is not yet available, the Standard aims to protect animal welfare, preserve land health, improve supply chain traceability and provide clear, trustworthy communication. By engaging with the Textile Exchange, Filippa K can differentiate themselves as leaders in animal welfare and responsible procurement. It also provides some protection against any future negative media attention surrounding wool farming practices as a company actively seeking to improve standards.

  A significant benefit of involvement within the RWS is the larger group pressure that can be applied to farmers that are not performing responsibly, and the improved likelihood of influence if speaking from a group platform. The standard was developed with animal welfare groups alongside stakeholders for the farming community, and therefore is well placed to develop a feasible yet beneficial output, that is not outside of the capabilities of farmers to achieve.

  Once RWS certified wool is available, Filippa K can review the standard as to its appropriateness to purpose for its preferences, and potentially introduce certified wool into its range of products.

- **Require tier 1 suppliers to have animal welfare policies**, and encourage roll out up supply chain

  As an immediate step, Filippa K can incorporate a policy whereby suppliers are required to have an appropriate animal welfare policy. The suppliers reviewed for data collection did not have overarching welfare policies (though 1 supplier provided animal welfare policy based upon individual request). These suppliers should then also be encouraged to roll out their policies to their own suppliers, to promote responsible wool procurement at each stage of the value chain.
Policies should be tangible, and avoid vague, generic promises. Where possible, specific practices should be detailed, and targets for improvement set. By prescribing specific requirements of inclusion, Filippa K can also influence wider supplier practices, outside of the direct supply to its own product. This approach has been very successful for social responsibility and could be replicated within animal welfare also.

- **Consider improved fibres**
  - Recycled wool
  - RWS certified wool (when available)
  - Other audit programmes
    - New Zealand Merino
    - ZQue

The previous section discussed some of the opportunities for procurement of recycled, certified or otherwise ‘improved’ wool, and this practice is recommended, though no particular scheme is held as more beneficial than others.

Awareness raising with buyers may be a key first step to help imbed this into practice, as schemes need to be understood by those who will be using them.

- **Continue to sourcing of mulesing free wool**

Filippa K already have in place the commitment to non-mulesed wool. As discussed within the report, this practice can be painful and is often carried out within pain relief. However, flystrike is also a painful infliction, and suitable alternatives should be requested. A potential compromise until a more widely available and accepted alternative exists is to ensure only mulesing with anaesthetic or pre-procedure pain relief is used. This creates practical challenges though, as there is limited transparency currently, even sometimes for mulesed and non-mulesed wool, and ensuring pain relief without the use of a third party standard or audit may prove difficult.
APPENDICES
METHODOLOGY

The natural capital impacts associated with farming through to fabric production were calculated based on primary data collected from Filippa K suppliers and secondary data, largely LCA databases such as Ecoinvent.

A detailed survey, including qualitative and quantitative questions, was circulated to the relevant suppliers, to gather information on resource use, waste arisings and wastewater discharge, in addition to animal welfare, environmental and social policy information.

Quantification of environmental impacts

Primary data collection included engagement with suppliers to provide the following information:

- Production volumes
- Fuel use and type
- Water consumption
- Water discharge (including effluent quality and treatment systems on or offsite)
- Chemical use
- Waste arisings and management
- Any additional relevant data (such as refrigerant use and emission data where applicable or available)

These indicators were then quantified in impact terms, using GHG emissions, water consumption, freshwater and terrestrial ecotoxicity and human toxicity. Waste is considered an intermediate indicator, as it in turn has implications for GHG emissions and pollution (captured within the toxicity measurement). Where possible and relevant, regionalisation of impacts (such as specific grid emission factors for energy use) was undertaken within LCA factors.

Farming impacts, and cotton farming and yarn production were calculated from purely secondary data. Average global impacts were used for cotton, while the wool farming was regionalised to Australian specific practices. Assumptions used, and caveats to data are given in below:

- Cotton farming was based upon the Ecoinvent article for cotton production, with average of USA, China and India data
- Cotton yarn production based upon Ecoinvent article ‘textile production, knit cotton yarn, dyed’ with removal of cotton farming impacts
• Sheep farming data based upon EcoInvent article ‘sheep production, for wool, RoW, per kg’ and adjusted for organic farming by removing synthetic chemical agrochemical inputs and replacing maize feed for organic maize feed

• Supplier data was based on primary data collection. Wastewater treatment was assumed to be equivalent to a large wastewater treatment plant (4.7E10 l/year) and based on a global dataset and adjusted for regional electricity factors.

Allocation of farming impacts

LCA allocation methodology is of particular concern for livestock and potentially each animal is producing multiple goods to be sold. Examples of other outputs, or ‘co-products’ include most significantly meat, but also milk, hide, nutrients from waste, breeding seed stock and young. The primary purpose of the sheep will influence the value of other co-products, and in the case of Filippa K, with the majority of wool being Australian merino wool, these sheep are purpose bred for their wool therefore additional co-products may not be as significant in value as they may be for other breeds of sheep. Once the total emissions and other environmental impacts from nurturing a sheep to maturity are calculated it is critical to appropriately determine how much of those impacts are assigned to wool production versus other goods. There are three types of techniques in the literature: economic allocation, system expansion and biological allocation. Selection of allocation methodologies has been a point of contention in previous wool analyses, and no standard, agreed approach is accepted by the scientific and expert communities. For example, PAS2050\(^5\) recommends economic allocation as a default approach, whereas ISO 14044:2006 suggests physical allocation as a preference when possible. The key universal recommendation is consistency and transparency, with assumptions and reasoning for allocation approach clearly defined as a necessity for a robust assessment.

Economic allocation involves splitting the impacts according to the relative price of the goods sold. For wool, it would include the price obtained for the wool sold throughout a sheep’s lifetime and the meat and other co-products it provides at the end. System expansion looks at comparing the environmental impacts of a system that produces all the other goods except the one assessed, to one that produces all the good. For example, a sheep farm that sells lamb meat, sheep meat and milk but not wool compared with a farm that sells lamb meat, sheep meat, milk and wool. The difference between the two would be the environmental impacts attributed to wool.

---

\(^5\) Publically Available Standard 2050 Assessing the life cycle greenhouse gas emissions of goods and services, developed by the British Standards Institute
Finally, biological allocation can take many forms but essentially looks at the protein growth in sheep for each product. So the protein required to produce, or the protein content of, the meat, foetal growth, maintaining cells in the body and growing wool. Biological allocation method is preferred by wool LCA experts for its consistency over time and the causal link with wool production (Wiedemann et al, 2015). For this reason, Trucost has employed the biological allocation method.

**Monetisation of natural capital costs**

The previous section describes how environmental indicators were quantified in physical terms. Monetisation takes this one step further, placing a financial value on the environmental impacts. This step translates the physical impact (m³, tonnes) into a common metric (EUR) expressing natural capital risks and opportunities.

This section details the methodology used to monetize the value of unpriced environmental impact and derive the social environmental costs applied to quantities of each impact. Trucost’s valuation of environmental impacts estimates the value of a natural good or service in the absence of a market price to allow direct comparison with financial performance and appraisal of potential profit at risk. This approach provides insight into exposure to an increase in the private cost of natural capital following internalization. Valuations were derived from academic journals, government studies and established environmental economics techniques. The way in which these are applied depends on the environmental indicator. Greenhouse gases, for example, have the same impact wherever they are emitted. Values for other pollutants and water use depend on local biophysical and human geography, and so require a technique called benefit transfer to apply a value estimated in one location to another. Each valuation is described in more detail below.

**GHG emissions**

The social cost of carbon (SCC), marginal abatement cost (MAC) and the market price of carbon in existing emissions trading schemes are common approaches that can be used to value the marginal cost of each additional tonne of greenhouse gas (GHG) emissions (usually expressed in tonnes of carbon dioxide equivalents (CO₂e)). The three differ significantly in their current estimates of cost, although in theory climate policy in its effort to balance the cost of abating pollution against the cost of pollution damage would set emissions reduction targets that result in a MAC that is equal to the SCC. In perfect market conditions, the price of carbon should also be equal to the SCC.

Trucost uses the SCC, because it reflects the full global cost of the damage generated by GHG emissions over their lifetime, and as such it is typically considered best practice. SCC is also applicable to emissions
globally, which is not the case with neither the market price method nor the MAC. However, SCC valuations are highly contingent on assumptions, in particular the discount rate chosen, emission scenarios and equity weighting.

Over 300 studies attempt to put a price on carbon, valuing the impact of climate change on agricultural productivity, forestry, water resources, coastal zones, energy consumption, air quality, tropical and extratropical storms, property damages from increased flood risk, and human health. However, due to current modelling and data limitations, such as lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research, these estimates do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature (Ackerman and Stanton, 2010; EPA, 2013). As noted by the IPCC Fourth Assessment Report, it is “very likely that [SCC] underestimates” the damages.

To address these material omissions Trucost bases its SCC valuation on the Interagency Working Group on Social Cost of Carbon 2013 values reported at the 95th percentile under a 3% discount rate, which represents higher-than-expected impacts from temperature change further out in the tails of SCC distribution (IWGSCC, 2013).

Use phase and end-of-life assumptions and data sources
<table>
<thead>
<tr>
<th>Garment</th>
<th>Data point</th>
<th>Quantity</th>
<th>Evidence</th>
<th>Justification / comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweater</td>
<td>Life expectancy</td>
<td>3 years</td>
<td>Fair Claims Guide (2015)</td>
<td>Data used to compensate if garments are damaged in dry cleaning. While Filippa K clothing may last longer than this time frame, evidence from various sources (including Defra 2009) suggests that people rarely wear clothing to the point of destruction, rather would like change/ boredom</td>
</tr>
<tr>
<td>Trousers</td>
<td></td>
<td>4 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacket</td>
<td></td>
<td>4 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweater</td>
<td>Wears per year</td>
<td>52</td>
<td>Trucost estimations</td>
<td>Once a week</td>
</tr>
<tr>
<td>Trousers</td>
<td></td>
<td>52</td>
<td></td>
<td>Once a week</td>
</tr>
<tr>
<td>Jacket</td>
<td></td>
<td>26</td>
<td></td>
<td>Once a week for 6 months of the year only</td>
</tr>
<tr>
<td>Sweater</td>
<td>Washes / year - standard</td>
<td>52</td>
<td>Trucost estimations (informed by literature)</td>
<td>Once a wear</td>
</tr>
<tr>
<td>Trousers</td>
<td></td>
<td>26</td>
<td></td>
<td>Once every 2 wears</td>
</tr>
<tr>
<td>Jacket</td>
<td></td>
<td>6</td>
<td></td>
<td>Once a month</td>
</tr>
<tr>
<td>Sweater</td>
<td>Washes / year – good practice</td>
<td>26</td>
<td>Trucost estimations (informed by FK)</td>
<td>Once every 2 wears</td>
</tr>
<tr>
<td>Trousers</td>
<td></td>
<td>17</td>
<td></td>
<td>Once every 3 wears</td>
</tr>
<tr>
<td>Jacket</td>
<td></td>
<td>3</td>
<td></td>
<td>Once every 2 months</td>
</tr>
<tr>
<td>Sweater</td>
<td>Washes / year – optimised practice</td>
<td>10</td>
<td>Informed by FK and Mistra</td>
<td></td>
</tr>
<tr>
<td>Trousers</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacket</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>Ratio of displacement of new garments</td>
<td>0.6 (100 Second hand garments will prevent purchase of 60 new)</td>
<td>Farrant et al. (2010)</td>
<td>Swedish focus This ratio is used to allocate a ‘credit’ – each garment sent for direct reuse is considered to ‘displace’ 0.6% of its impacts of supply chain (i.e. manufacture).</td>
</tr>
<tr>
<td>All</td>
<td>Exclusion of detergent</td>
<td>0</td>
<td>The impact of detergent is excluded within the use phase as it is outside of scope.</td>
<td>Detergent is discharged to sewers so less material than if discharged directly to water bodies. Supply chain of detergents would require significant research task and considered outside of scope. For detailed discussion refer to page 51 of Defra (2009)</td>
</tr>
<tr>
<td>All</td>
<td>Exclusion of dry cleaning</td>
<td>0</td>
<td>Dry cleaning is considered outside of scope.</td>
<td>Limited LCA data to compare dry cleaning alternatives. Data was difficult to locate for dry cleaning and the other systems identified have only a very limited user base or are emerging technologies, with no independent studies being carried out. Also evidence of a trend away from consumer use of dry cleaning6, including a decrease in the trade of dry cleaning solvents over the past three years. For detailed discussion refer to page 61 of Defra (2009)</td>
</tr>
<tr>
<td>All</td>
<td>Swedish standard EOL</td>
<td>Reuse 20% Recycling 27% Incineration with energy recovery 53% Landfill 0%</td>
<td>Palm, D., (2011)</td>
<td></td>
</tr>
<tr>
<td>Garment</td>
<td>Data point</td>
<td>Quantity</td>
<td>Evidence</td>
<td>Justification / comment</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------</td>
<td>----------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>All</td>
<td>Good practice EOL (Filippa K takeback)</td>
<td>Reuse in-house 60% Reuse in Sweden 18% Reuse export 18% Incineration with energy recovery 4% Landfill 0%</td>
<td>Provided by Filippa K (and textile reuser)</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>Optimised practice EOL (Filippa K takeback)</td>
<td>Reuse in-house 60% Reuse in Sweden 18% Reuse export 18% Mechanical recycling of wool Incineration with energy recovery 1% Landfill 0%</td>
<td>Trucost estimation</td>
<td>As per current practice of takeback, but maximising on wool recycling. There is always expected to be 1% of ‘waste’ wool that is unsuitable for recycling due to heavy soiling or contamination.</td>
</tr>
<tr>
<td>All</td>
<td>Impacts of direct reuse (take back):</td>
<td>Transportation costs only – lorry travelling 300km</td>
<td>Trucost estimation</td>
<td>It is assumed there should be no more than 300km travelled between stores and warehouse, and eventual sale point for reuse. Estimation is based on Swedish use and disposal only, not global sales.</td>
</tr>
<tr>
<td>All</td>
<td>Impacts of overseas reuse (general collection and also remainder export reuse from takeback):</td>
<td>Transportation costs only – lorry travelling 2000km</td>
<td>Trucost estimation based on Henry et al. (2015)</td>
<td>Literature suggests overseas export may be to Eastern Europe, travelling long distance by lorry. Lorry travel to Hungary is used as a proxy, of approximately 2000km.</td>
</tr>
</tbody>
</table>
Water use

Figure 11 summarises the overall approach used to value water consumption.

![Diagram](image)

**Figure 11: General overview of Trucost water valuation process**

Water availability can be affected when the demand for water exceeds the water available in a certain period of time. This situation usually occurs in locations where there is a combination of low rainfall and high population density, or in locations with strong agricultural and industrial operations. An unsustainable rate of water abstraction can affect access to water for the local population, provoke the intrusion of salt water in groundwater sources and in the more extreme situations, can lead to the disappearance of water bodies and wetlands (European Environment Agency, 2015).

The scope of the water valuation methodology includes the impacts of water consumption on both human health and ecosystems. The impacts on human health due to water consumption included in the methodology are limited to those linked to the lack of water for irrigation, which leads to malnutrition. Water scarcity has been considered an explanatory variable for the quantification of impacts on human health due to water consumption. Country-specific water scarcity was determined using GIS data published by the World Resources Institute (WRI, 2013a). In addition, water scarcity was adjusted for inter-annual and seasonal variability using WRI data (WRI 2013b, WRI 2013c).
Impacts of water consumption on ecosystem quality were measured based on Net Primary Productivity (NPP). NPP is the rate at which plants store energy as food matter, excluding the energy dissipated through plant respiration (FAO, 1987). It can be expressed as biomass per unit area (for example g m\(^{-2}\) year\(^{-1}\)). NPP was considered here as a proxy for ecosystem quality, as it is closely related to the vulnerability of vascular plant species biodiversity (Pfister, 2011). In addition, it is assumed that damage to vascular plants is representative of damage to all fauna and flora species in an ecosystem (Delft, 2010).

NPP can be affected by several parameters, such as temperature, radiation and water availability (Nemani et al., 2003). The objective of the biophysical modelling is to determine the fraction of NPP which is limited only by water availability. This was estimated based on the country-specific parameter NPP wat lim defined in Pfister (2011). However, as the effects of water consumption on ecosystem quality depend on local water availability, NPP wat lim was adjusted for water scarcity. Precipitation was used as a proxy for water scarcity, with country-specific precipitation data sourced from Aquastat (FAO, 2014). In that sense, countries with the same NPP wat lim but higher water scarcity (lower precipitation) will result in higher ecosystem damage due to water consumption. Thus, the parameter NPP wat lim adjusted reflects the percentage of 1 m\(^2\) that will be affected by the consumption of 1 m\(^3\) of water in a year (units are m\(^2\) year m\(^{-3}\)).

**Terrestrial and freshwater ecotoxicity**

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

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 of land and 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)

Trucost used the USES-LCA2.0 model (Van Zelm et al, 2009) 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 EDP 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.

\[
\ln (VEDP) = 8.740 + 0.441 \ln(PD) + 1.070 \times \text{FOR} - 0.023 \times \text{RIV} + 0.485 \times \text{COA} - 2.010 \times \Delta \text{EDP} - 0.312 \ln(\text{AREA})
\]

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

\(\Delta \text{EDP}\) = 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).

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

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

Trucost used the USES-LCA2.0 model (Van Zelm et al, 2009). 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, Trucost used the NEEDS project approach (NEEDS, 2007; OECD, 2011). 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, Trucost applied the global median value to value DALYs in different countries.
BREAKDOWN OF FINDINGS

Biophysical impacts of wool and blended wool/cotton are given in the table below.

**Table 4: Summary of biophysical indicators of materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>Water (m³)</th>
<th>GWP (tCO2e)</th>
<th>Human toxicity (kg 1,4 DCB eq)</th>
<th>Freshwater ecotoxicity (kg 1,4 DCB eq)</th>
<th>Terrestrial ecotoxicity (kg 1,4 DCB eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra fine conventional wool</td>
<td>2.1</td>
<td>32.1</td>
<td>3.4</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Ultra fine organic wool</td>
<td>1.6</td>
<td>31.2</td>
<td>3.1</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Coarse conventional wool</td>
<td>2.2</td>
<td>32.5</td>
<td>3.4</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Coarse organic wool</td>
<td>1.7</td>
<td>31.5</td>
<td>3.2</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>50:50 blend</td>
<td>2.2</td>
<td>31.0</td>
<td>5.8</td>
<td>0.7</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Natural capital costs of each value chain phase in Euros.

**Table 5: Summary of natural capital costs of materials, in Euros**

<table>
<thead>
<tr>
<th>Material</th>
<th>Raw material</th>
<th>Yarn</th>
<th>Fabric</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra fine conventional wool</td>
<td>2.19</td>
<td>0.07</td>
<td>0.73</td>
<td>2.99</td>
</tr>
<tr>
<td>Ultra fine organic wool</td>
<td>2.08</td>
<td>0.07</td>
<td>0.73</td>
<td>2.87</td>
</tr>
<tr>
<td>Coarse conventional wool</td>
<td>2.22</td>
<td>0.07</td>
<td>0.73</td>
<td>3.02</td>
</tr>
<tr>
<td>Coarse organic wool</td>
<td>2.10</td>
<td>0.07</td>
<td>0.73</td>
<td>2.90</td>
</tr>
<tr>
<td>50:50 blend</td>
<td>1.30</td>
<td>1.09</td>
<td>0.73</td>
<td>3.11</td>
</tr>
</tbody>
</table>
REFERENCES


API (2014a) Argentine Republic: Animal Protection Index 2014 Ranking D


API (2014c) Republic of South Africa: Animal Protection Index 2014 Ranking D


 Responsible wool strategy


BSR (2009) Apparel industry life cycle carbon mapping


D’Arcy, J.B. (1990) Sheep management and wool technology UNSW Press


Department of Forestry and Fisheries (DAFF) (2011) *A Profile of the South African Wool Market Value Chain*


Duncanson, G (2012) *Veterinary Treatment of Sheep and Goats* UK CABI


FAWC (2009) *Farm Animal Welfare in Great Britain: Past, Present and Future*
Responsible wool strategy


HSE (2015) Sheep dipping: Advice for farmers and others involved in dipping sheep


Longworth, J; Brown, C & Waldron, S (2005) Features of the Wool Industry in China


MLA (Meat and Livestock Association) (2013) A producer’s guide to sheep husbandry practices


New South Wales Department of Primary Industries (2005) Best management practices for extensive grazing enterprises


Pfister, S. (2011). Environmental evaluation of freshwater consumption within the framework of life cycle assessment. DISS. ETH NO. 19490. ETH ZURICH


RSPCA (2011) Prevention and control of blowfly strike in sheep Research paper


RWS (2015a) The Responsible Wool Standard: Module 3 Handling


RWS (2015d) Land Management Draft


A J Scholtz, S W P Cloete, E du Toit, J B van Wyk, T C de K van der Linde (2011) A survey of the prevalence of blowfly strike and the control measures used in the Rûens area of the Western Cape Province of South Africa Journal of the South African Veterinary Association vol.82 n.2


Soil Association Certification Ltd licensees (date unclear) Global Organic Textiles Standard (GOTS) Version 4.0


Stanford Graduate School of Business (2011) New Zealand Merino: Pursuing Acceleration through Collaboration


Worksafe Victoria (2001) *Health and Safety in Shearing*


