SCAP Footprint Calculator 2.10
Technical Report

Research date: November 2018 – February 2019  
Date: December 2019
WRAP’s vision is a world in which resources are used sustainably.

Our mission is to accelerate the move to a sustainable resource-efficient economy through re-inventing how we design, produce and sell products; re-thinking how we use and consume products; and re-defining what is possible through re-use and recycling.

Find out more at www.wrap.org.uk

Document reference (please use this reference when citing WRAP’s work): [WRAP, 2019, Banbury, SCAP Footprint Calculator 2.10, Prepared by James Joyce and Anton van Santen]

Written by: James Joyce and Anton van Santen

Resource and Waste Solutions LLP (RWSP)
Front cover photography: Machine stitching denim

While we have taken reasonable steps to ensure this report is accurate, WRAP does not accept liability for any loss, damage, cost or expense incurred or arising from reliance on this report. Readers are responsible for assessing the accuracy and conclusions of the content of this report. Quotations and case studies have been drawn from the public domain, with permissions sought where practicable. This report does not represent endorsement of the examples used and has not been endorsed by the organisations and individuals featured within it. This material is subject to copyright. You can copy it free of charge and may use excerpts from it provided they are not used in a misleading context and you must identify the source of the material and acknowledge WRAP's copyright. You must not use this report or material from it to endorse or suggest WRAP has endorsed a commercial product or service. For more details please see WRAP's terms and conditions on our website at www.wrap.org.uk.
Preface

WRAP (the Waste & Resources Action Programme) works in England, Wales and Northern Ireland to help businesses and individuals reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way.

Since 2012, WRAP has led the Sustainable Clothing Action Plan (SCAP)\(^1\) with the ambition to improve the sustainability of clothing across its life cycle, focusing particularly on reductions in carbon, water and waste. As part of this, WRAP worked with SCAP signatories to specify and develop a footprint calculator (as a Microsoft Excel tool) to assess the resource impacts and track the progress of reducing the life cycle environmental footprints of their portfolio.

Originally developed in 2013 by Environmental Resources Management Limited (ERM), the tool has gone through several iterations, new improvement actions have been added and data has undergone comprehensive revision. In addition, a European version was created to support the European Clothing Action Plan (ECAP)\(^2\). This provides regionalised settings for EU member states so that garment sales to any market in those countries can be reported using settings appropriate to each one.

This report describes the 2019 iteration of the tool. This has been developed by the Resource and Waste Solutions Partnership (RWSP) as a combination of the SCAP and ECAP tools, together with updated data and revised improvement actions, and designated SCAP Footprint Calculator 2.10 (the Footprint Calculator).

The report provides, for the technical reader, extensive documentation to ensure transparency and confidence in the data and methods used in the Footprint Calculator. It provides a summary of the footprint methodology, details the source data used, and illustrates the reductions in carbon, waste and water footprints resulting from a range of improvement actions agreed with members of the SCAP Steering Group. It also identifies the technical elements of the tool that are sensitive in terms of uncertainty in the estimation of total footprints and reductions in footprints.

---

\(^1\) [http://www.wrap.org.uk/sustainable-textiles/scap](http://www.wrap.org.uk/sustainable-textiles/scap)

\(^2\) [http://www.ecap.eu.com/](http://www.ecap.eu.com/)
Contents

1.0 Introduction.................................................................................................................. 7
2.0 Metrics .......................................................................................................................... 9
  2.1 Carbon Footprint Definition......................................................................................... 9
  2.2 Water Footprint Definition......................................................................................... 9
  2.3 Waste Footprint Definition........................................................................................ 10
3.0 Method ........................................................................................................................ 12
  3.1 System Boundary......................................................................................................... 12
    3.1.1 Exclusions............................................................................................................... 15
  3.2 Functional Unit........................................................................................................... 16
  3.3 Fibre Source................................................................................................................ 17
  3.4 Use Phase Electricity Grids........................................................................................ 17
  3.5 Recycling and Recycling Allocation ......................................................................... 18
  3.6 Claiming Benefits from Reuse and Recycling............................................................ 19
4.0 Data................................................................................................................................ 20
  4.1 Type of Data Collected ............................................................................................. 20
  4.2 Data Collection Process............................................................................................. 20
  4.3 Data Quality Assessment ......................................................................................... 21
    4.3.1 Peer review............................................................................................................. 22
  4.4 Cotton ........................................................................................................................ 22
    4.4.1 Conventional cotton ............................................................................................. 24
    4.4.2 Organic cotton....................................................................................................... 27
    4.4.3 Better Cotton Initiative (BCI) cotton..................................................................... 28
    4.4.4 Cotton Made in Africa (CMiA) cotton................................................................. 29
    4.4.5 Field emissions (N2O).......................................................................................... 30
    4.4.6 Waste from cultivation ....................................................................................... 30
    4.4.7 Ginning................................................................................................................ 30
    4.4.8 Spinning............................................................................................................... 32
    4.4.9 Fabric production................................................................................................... 33
    4.4.10 Wet processing .................................................................................................. 34
    4.4.11 Note on garment and cotton fibre sourcing ...................................................... 35
  4.5 Polyester ..................................................................................................................... 36
    4.5.1 Raw materials ....................................................................................................... 36
    4.5.2 Fibre production.................................................................................................... 37
    4.5.3 Spinning................................................................................................................ 38
    4.5.4 Fabric production................................................................................................... 38
    4.5.5 Wet processing....................................................................................................... 38
  4.6 Viscose ........................................................................................................................ 39
    4.6.1 Cultivation and fibre production ........................................................................... 39
    4.6.2 Spinning, fabric production, wet treatment and making up .............................. 40
  4.7 Wool ........................................................................................................................... 40
    4.7.1 Sheep rearing and fibre production ...................................................................... 40
    4.7.2 Spinning................................................................................................................ 40
  4.8 Linen ........................................................................................................................... 41

WRAP - SCAP Footprint Calculator 2.10 Technical Report
4.8.1 Cultivation ................................................................................................................. 41
4.8.2 Fibre and yarn production .......................................................................................... 41
4.8.3 Fabric production and wet processing ........................................................................ 42
4.9 Silk ................................................................................................................................. 42
4.9.1 Silkworm rearing and fibre production ..................................................................... 42
4.9.2 Spinning, fabric production and wet processing ......................................................... 42
4.10 Acrylic ......................................................................................................................... 42
4.10.1 Raw materials .......................................................................................................... 42
4.10.2 Fibre and yarn production ......................................................................................... 43
4.11 Polyamide .................................................................................................................... 43
4.11.1 Raw materials .......................................................................................................... 43
4.11.2 Fibre and yarn production ......................................................................................... 43
4.11.3 Recycled polyamide / Nylon .................................................................................. 43
4.11.4 Yarn production, fabric production and wet processing .......................................... 44
4.12 Polyurethane ................................................................................................................ 44
4.12.1 Raw materials .......................................................................................................... 44
4.12.2 Yarn production, fabric production and wet processing .......................................... 45
4.13 Making up .................................................................................................................... 45
4.14 Use ............................................................................................................................... 45
4.15 Summary of key data ................................................................................................... 46
5.0 Description of the Data Workbook ................................................................................ 48
5.1 Tracing the Data Used in the Tool ................................................................................ 48
6.0 Indicative Baseline and Improved Results Using SCAP Footprint Calculator 2.10 ............................................................................................................................. 50
7.0 Scenario modelling options ............................................................................................ 53
1.0 Introduction

This report describes the SCAP Clothing Footprint Calculator (version 2.10). It provides a summary of the footprint methodology, details the source data used and summarises the results obtained. It is intended for the technical reader to provide a transparent source of evidence to support communication of the footprint calculations.

The Footprint Calculator has been developed from previous iterations of the SCAP and ECAP tools for use as a single tool for SCAP going forwards. It includes both UK specific and regionalised settings for EU member states so that garment sales to any market in those countries can be reported using settings appropriate to each one.

The Footprint Calculator is designed to enable:

- participants in SCAP 2020 to estimate product footprints for clothing as carbon, water and waste impacts in a consistent way, to plan and quantify the potential savings from improvement actions, and to quantify the savings directly attributable to actions they have taken (relative to a baseline year);
- WRAP to report the overall carbon, water and waste impacts and savings associated with SCAP 2020 delivery (collated across all signatories); and
- for SCAP and non-SCAP members (including reuse and recycling organisations) to monitor individual life cycle footprints of operations outside the SCAP agreements.

The report draws extensively on, and synthesises various reports and documents prepared during the development of the SCAP and ECAP tools. However, this report relates specifically to the Footprint Calculator 2.10 and is not intended as a chronology of the tool development. Historical resources are available for reference from WRAP on request.

The structure of this report is as follows:

Section 2 provides the definitions of carbon, waste and water footprint used in the tool.

Section 3 describes the system boundary around the inputs and outputs considered in the tool throughout the life cycle from fibre production to end of life clothing disposal, and describes the assumptions underpinning the calculation methodologies.

Section 4 sets out the data used in each life stage for each of the nine fibre types considered in the tool (cotton, polyester, viscose, wool, linen, silk, acrylic, polyamide and polyurethane). It also describes the steps through which the data were collected and assessed, and provides an indicative assessment of the quality of the data at each life cycle stage.
Section 5 describes structure of the Data Workbook, the full dataset which underpins the Footprint Calculator. This is contained within a separate spreadsheet available on request from WRAP.

Section 6 describes the fourteen default ‘improvement actions’ agreed with the SCAP Metrics Working Group which can be assessed in the Footprint Calculator against which SCAP members report, and provides an indicative summary of the baseline results.

Section 7 in addition to the fourteen default improvement actions, the Footprint Calculator offers eleven ‘improvement scenarios’ which are available to users to assess alternative improvement actions, but for which the data held by retailers for input are insufficiently robust for reporting purposes (for example there is insufficient data to demonstrate actual lifetime extension of garments since in most cases it is not possible to keep track of them once they enter the use phase).

Detail on the user interface, including how to use the tool, is provided in the user guide embedded within the Footprint Calculator.
2.0 Metrics

The SCAP Metrics Working Group identified carbon, water and waste footprints as metrics for indicating the resource impacts of their clothing portfolio.

A definition of carbon, water and waste footprints is provided below. In each case, a life cycle assessment (LCA) approach is followed, whereby all material activities and processes in the clothing life cycle are considered.

2.1 Carbon Footprint Definition

The carbon footprint for a product (a commodity, good or service) is the quantity of greenhouse gas (GHG) emissions associated with the production, use and disposal of that product. In this case, that includes the impacts associated with fibre and fabric production (materials and resources), transport, in use (cleaning) impacts and impacts at end of life (reuse, recycling, landfill etc.).

Emissions of multiple GHGs are considered in the tool, including carbon dioxide, methane and nitrous oxide (N₂O). The impact of these GHGs is measured using a single unit known as carbon dioxide equivalents (CO₂e). This takes into account the relative impact on the atmosphere over a 100 year period of each gas compared with carbon dioxide, e.g. 1kg methane has the same impact in the atmosphere as 25kg CO₂, and therefore 1kg of methane emissions has a carbon footprint of 25kg CO₂e.

The Footprint Calculator measures the carbon footprint in tonnes CO₂e.

2.2 Water Footprint Definition

The Water Footprint Network's Global Water Footprint Assessment methodology is used to calculate the water footprint. Under this approach, the water footprint is defined as the net total volume of freshwater withdrawal over the life cycle of the product to the exclusion of its use by others. Water is considered as being excluded from use by others either by its evaporation to the atmosphere, its incorporation into products or its contamination with pollutants.

The water footprint consists of three components: blue water; green water; and grey water, detailed in Figure 1.

The total water footprint is the sum of the blue, green and grey water footprints and represents the total amount of freshwater withdrawn from human use during the life cycle of a product.

---

3 Materiality refers to the overall contribution to the whole life cycle of a product. It is discussed in more detail in the context of the system boundary (Section 3.1)
The Footprint Calculator measures water footprint in cubic metres (m³).

2.3 Waste Footprint Definition

The waste footprint is the total amount of solid waste associated with the provision of clothing that arises at all stages of the lifecycle (including end of life). It may also be thought of as the ‘material footprint’ of the clothing considered, as waste at each production stage requires additional material to be produced further upstream as an input.

Waste in this sense can be thought of as lost material. Such material losses may be preventable (i.e. reduced or avoided through improved production efficiencies or changes in technology) or may be non-preventable (unavoidable wastes caused by contamination, rejects caused by unavoidable human error and worn-out clothes [i.e. clothing that has no useable life remaining]).

Additionally, material produced as an integral part of a process may leave the system as a useful product that is sold and beneficially used as an input elsewhere with no further processing, e.g. cotton seeds as an input for the production of cotton oil. These are termed as by-products and are not considered as ‘waste’ in the context of the waste footprint.

---

6 i.e. around 2 million tonnes of material are required and eventually wasted at different points in the life-cycle associated with providing, using and disposing of around 1 million tonnes of garments purchased each year in the UK.

7 The definition of waste’ presented here is for the purposes of this tool only, and, while broadly concordant with the legal definition of waste as set out in the Waste Framework Directive, is not the same as its legal definition. It should be noted that some by-products are legally considered ‘waste’.

WRAP - SCAP Footprint Calculator 2.10 Technical Report
Clothing sent to reuse by the initial consumer is still considered in the ‘waste’ footprint. It is assumed that, although this clothing does not directly become waste after its first use, it will eventually become degraded to a point at which it is required to be discarded. This is consistent with the idea that the waste footprint measure used in the tool is akin to a material footprint. An increase in reuse (implemented in the tool as an improvement action) will not therefore directly decrease the overall waste footprint. It will however indirectly lead to a reduction in the waste footprint via the waste avoided in the supply chain as a result of fewer garments being produced.

Since reuse is included as waste and does not affect the waste footprint, the calculator is not used by SCAP to measure waste reduction after the primary use phase through actions taken by retailers.

The Footprint Calculator measures the waste footprint in tonnes.
### 3.0 Method

#### 3.1 System Boundary

The Footprint Calculator provides a cradle-to-grave footprint. The calculator contains an Input/Output model that draws on impact factors and a database specifying individual process steps in the clothing life cycle, to calculate the carbon, water, and waste footprints of clothing during four life cycle stages:

- Fibre production
- Processing
- Use
- End of Life

The following life cycle stages and processes are included in the assessment:

<table>
<thead>
<tr>
<th>Life Cycle Stage</th>
<th>Processes</th>
</tr>
</thead>
</table>
| Fibre production | extraction of raw materials required for the production of fibres  
                   | fibre production (either at farm or factory)  
                   | transport to yarn producer |
| Processing       | fibre preparation (pre-spinning including cleaning, carding and combing)  
                   | yarn production (spinning and winding)  
                   | transport of yarn to fabric production  
                   | fabric production (e.g. weaving or knitting)  
                   | fabric wet treatment (e.g. bleaching, dyeing etc.)  
                   | fabric finishing (e.g. setting the dye, drying, applying protective coatings)  
                   | transport of fabric to garment production  
                   | garment production (cut, make and trim)  
                   | transport of materials and goods to and from production locations  
                   | transport of garments to the country of sale |
| Use              | washing (energy, water and detergent use)  
                   | tumble drying  
                   | ironing |
| End of Life      | reuse UK  
                   | reuse overseas  
                   | recycling  
                   | incineration  
                   | landfill |

---

Note – For natural fibres, ‘waste’ at the cultivation stage (un-harvested material) is assumed returned to the field and is not considered to be a waste.
The general principles of ISO 14040 are followed, with further reference to the GHG Protocol, PAS 2050 and the Water Footprint Network Global Water Footprinting Method. However, there is no single unifying standard for the type of assessment the Footprint Calculator carries out (i.e. product portfolio level footprints of carbon, water and waste) and therefore the tool in its current form cannot be fully compliant with any of these individual standards. Rather, the guiding principles behind the standards have been used as good practice in each of these areas to support the development of a robust tool.

Figure 2 on the following page shows the overall system boundary considered by the Footprint Calculator.
Figure 2  System boundary considered by the Footprint Calculator
3.1.1 Exclusions

Exclusions to the assessment have been made based on their ‘materiality’ (i.e. any process anticipated to contribute <1% of total life cycle GHG emissions based on estimated calculations and prior experience) and relevance to the aims of the project, as per standard LCA practice. The following lifecycle stages/burdens have therefore been excluded from this assessment.

- **Storage at regional distribution centres (RDC)** – *clothing is an ambient product with no requirement for heating or cooling during storage* – the impact of storage at RDCs is therefore negligible.

- **Transportation from RDC to retail outlets** – *transport (with the exception of air freight) is generally a very minor contributor to the life cycle impact of the majority of products* – in addition, the logistical chains of the user retailers are so variable that calculation of a reliable estimate is not possible or desirable given the minor impact of this stage.

- **Storage at retail outlets** – *clothing is an ambient product with no requirement for heating or cooling during storage* – the impact of storage at retail outlets is therefore negligible – in addition, retail situations are so variable that calculation of a reliable estimate is not possible or desirable given the minor impact of this stage.

- **Transportation of consumers to and from the point of retail purchase** – *this is general LCA practice, based on the low impact, variable transport modes and high incidence of multi-purpose journeys by consumers.*

- **Packaging used at all lifecycle stages** – *as a percentage of material use, packaging makes a negligible contribution in the clothing value chain.*

- **Fabric softeners, colour catchers, stain removers etc. or similar material inputs used during washing** – *while detergent is necessary (and therefore included) optional washing auxiliaries are excluded at this point. It is considered unlikely that they will have a major impact with respect to the life cycle of clothing.*

- **Water use for ironing** – *the amount of water used to generate steam in ironing is considered negligible in this context.*

- **Water use in residual waste disposal** – *the amount of water used in residual waste disposal is not considered on the basis of materiality.*

- **Capital goods (e.g. the manufacture of weaving looms, washing machines, irons etc.)** – *this is standard LCA practice – while the manufacture of a machine or building incurs an environmental impact, once divided among the total output of that item during its working lifetime, the impact per kg of output becomes vanishingly small. Note – the energy used by the machine during the production of the material in question is included within the system boundary.*

- **Human energy inputs to processing** – *this is standard LCA practice – while ultimately energy input will have derived from food grown for human consumption (which will have an environmental impact), the complexity of the modelling required and the small contribution of this impact to the overall lifecycle is such that this is excluded as standard.*
Animals providing transport services – this is standard LCA practice, as for energy expended by humans.

The exclusion of distribution and retailer impacts from the SCAP Footprint Calculator was requested by the SCAP Metrics Working Group as energy and resource efficiency in transport, packaging and retail buildings are already being pursued by retailers as a result of other drivers, and therefore the Footprint Calculator should be focused on areas of the lifecycle not currently being measured and scrutinised. This assumption is retained in the current Footprint Calculator.

Biogenic carbon dioxide emissions, which are the release of carbon dioxide through combustion or decomposition of natural fibres, are excluded from the tool as per 2007 IPCC 100 year global warming potentials. Carbon is sequestered from the atmosphere by the plants that form the natural fibres, and this is then released again at end of life. This forms part of the short term carbon cycle (less than the 100 year time frame for the IPCC GWP factors) and does not significantly influence climate change. Consequently, no credit is given for carbon storage in natural fibres. Non-CO₂ emissions from biogenic carbon, i.e. methane, are accounted for in the global warming impact. Biogenic CO₂ emissions resulting from direct land use change are beyond this 100 year timeframe and are therefore included in the carbon footprint.

3.2 Functional Unit

In LCA, results are presented in relation to what is known as the ‘functional unit’. The carbon, water and waste footprint results from the tool are represented in terms of the following functional unit:

*The function of dressing people in garments purchased in the calendar year of assessment for the average lifetime of active use of those garments in the country in which they were purchased.*

The functional unit, as the name suggests, is defined in terms of the function that a product provides, rather than simply referring to the product itself. This serves two purposes. Firstly, it allows the whole of the life cycle of the product, including its use and end of life treatment, to be included explicitly. For example, in order for clothes to perform their function of dressing an individual, they require laundry and eventually disposal. Secondly, by defining a function that can be performed in a variety of ways, fair comparisons can be made between systems achieving this function in different ways.

By default, the average lifetime of garments in the UK is taken to be 3.3 years, and in the EU to be 3.8 years. These figures have been calculated by WRAP from responses to surveys carried out for WRAP by Icaro Research in 2015 and 2016 and published in ‘Valuing Our Clothes – the Cost of Fashion in the UK’⁹ and in ECAP ‘Mapping clothing impacts in Europe: the environmental cost’¹⁰, respectively.

---


The functional unit is converted to a ‘reference flow’ for each individual assessment. A reference flow is the amount and type of product required to fulfil this function. For example, the reference flow for the estimated volume of clothing purchased in the UK in 2016 would be 1.13 million tonnes of clothing, actively used for a lifetime of 3.3 years by one owner (WRAP, 2017, Valuing Our Clothes). Therefore, the cradle to grave calculations in this case include: the impact of materials, processing and production required to make 1.13 million tonnes of garments; the impact of washing, drying and ironing of 1.13 million tonnes of garments over a period of 3.3 years; and the impact of the eventual disposal of 1.13 million tonnes of garments by consumers.

In addition to the primary functional unit, the Footprint Calculator also reports an intensity measure for each impact – the impact per tonne of clothing sold. This is calculated by dividing the total impact, as calculated for the functional unit, and dividing by the total number of tonnes of clothing sold.

By measuring the environmental impacts in this way, comparisons can be made between years of sales and indicators.

3.3 Fibre Source

The sources of fibres can have potentially large effects on the environmental impact of clothing. This is known to be true for cotton, where differences in cultivation practice and yields have a large effect on the impacts incurred. This is discussed further in Section 4.4. For synthetic fibres such differences are likely to be due to differences in energy source and production efficiencies in fibre manufacture. In the absence of reliable data at local level, generic values based on regional data are used in the Footprint Calculator for both man-made and natural fibres. These are replaced with country-specific fibre sources where data has become available.

3.4 Use Phase Electricity Grids

Energy consumption in the use phase of clothing, in washing, drying and ironing clothes, is considered in the Footprint Calculator. The life cycle carbon footprint of this phase can be considerable and is highly dependent on the make-up of the electricity grid used. Data sourced from the European Environment Agency\(^\text{11}\) for the average GHG emissions per kWh electricity consumed for each member state and the EU-28 average is included in the tool.

Consumer behaviour in the different member states may impact upon the amount of energy used. This is not included in the tool, but can be changed by WRAP via the admin interface by clicking on the ‘Edit use phase assumptions’ button.

3.5 Recycling and Recycling Allocation

Two types of recycling are considered in the tool – closed loop recycling and open loop recycling. Closed loop recycling (i.e. clothing being broken down to fibres and these fibres being substituted for virgin fibres in the production of new clothing), remains extremely rare in the mainstream clothing sector. It is included in the tool only as part of the use of mechanically recycled cotton as an improvement action. Open loop recycling is more common in the clothing sector. In this case recycled content that is used in garments has come from other systems, e.g. PET bottles to polyester, and recycling of clothing is assumed to be to other materials, e.g. rags and wipers.

Recycling allocation refers to where in the life cycle of a product the burdens and benefits of an open loop recycling process are attributed to the system. These can either be attributed to users of recycled material (at the ‘cradle’ end of the system), or to the producers of recycled material (at the ‘grave’ end of the system). These are known as the 100:0 and 0:100 approaches, respectively.

An LCA should use one of these two approaches consistently throughout, in order to avoid double-counting. This potentially means that in an assessment that incentivises the use of recycled content by retailers, no benefit is shown to end of life stakeholders, and vice-versa.

The Footprint Calculator has two modes of operation for the retailers: standard mode; and reporting mode; as well as a mode specifically for recycling and reuse organisations.

In ‘standard retailer mode’, both the benefits of the use of recycled content in garments and the displacement benefits associated with recycling of garments at end of life are included. This means that, technically, a 100:100 approach to open loop recycling is taken. This is a decision taken expressly to incentivise action at both ends of the value chain. This mode is used by retailers to assess customised ‘what if’ scenarios relevant to their own value chain, and is not used for reporting to WRAP.

In ‘reporting mode’ an internal switch is activated in the retailer tool which changes the recycling allocation method used to a 0:100 approach, thus avoiding the issue of double counting. This has the effect of assuming that any recycled material used as an input has the same impact associated with it as virgin material. Displacement at end of life is unaffected. This mode is used by retailers to report their data to WRAP for compiling in reports about the SCAP agreement only.

Specifically, the improvement actions for using recycled polyester and recycled polyamide have no effect on the results in reporting mode. The benefit of recycling here has been implicitly allocated to the systems producing the recyclable material. The benefit associated with the closed loop recycling of cotton remains valid, as the benefit is assumed to accrue to the ‘clothing’ system.
The Recycling and Reuse tool part of the tool only uses a 0:100 approach and therefore a separate ‘reporting mode’ is not required.

3.6 Claiming Benefits from Reuse and Recycling

Both retailers and end of life organisations can contribute, via consumer action, to the reuse and recycling of clothes. To encourage all Footprint Calculator tool users to reduce their environmental impacts, both the retailer and end of life parts of the tool include the impacts and benefits of the end of life process. The benefits of these actions can only be realised if other stakeholders (including consumers) take action as well. This is reflected in the wording of the results displayed in the tool (e.g. instead of the main results presented as “my impacts/reductions” they are shown as “the impacts/reductions my organisation has contributed to”) to encourage accurate communication of the figures. The importance of this wording, to ensure unfair claims or double-counting do not occur, is emphasised in the user guide at the beginning of the tool.

When results are collated by WRAP for reporting, WRAP will use data collected from end of life organisations to inform the impact of the various elements of textile reprocessing (i.e. the processing burdens reported by users of different types – collector, recycler, charity shop etc.), and the average fates of clothing dealt with by these organisations (i.e. proportion re-used in the UK vs abroad etc.). This will be combined with data from clothing retailers regarding the volume and composition of clothing sold on the UK market in order to ensure that the whole life cycle is accounted for, but that overall footprint measurements do not double-count the benefits of re-use.
4.0 Data

This section of the report:

◼ provides an overview of the type of data collected;
◼ provides a record of the data collection process undertaken;
◼ describes the data quality assessment conducted;
◼ provides a detailed summary of the data sources and assumptions used in the tool; and
◼ lists the key data sources assessed and used in the dataset.

4.1 Type of Data Collected

A key issue when creating the Footprint Calculator and its predecessor tools was the level of detail at which to compile the data. This essentially came down to two options: either to use process level impact data, that has been calculated elsewhere (e.g. taking the carbon footprint of the cultivation of 1 kg of cotton from a report and using that to represent the cotton growing process); or to disaggregate each process into the material and energy flows required at that stage and then model the impact of each of these separately, i.e. collecting data for average fuel, fertiliser, pesticide use etc. for cotton cultivation and modelling the impact of this process based on these data.

The need for flexibility in terms of scenario analysis, geographic specificity with regard to processes and consistency of approach across a broad range of materials and processes meant that using disaggregated data was the most robust approach for the Footprint Calculator.

4.2 Data Collection Process

There were five stages to the data collection and validation process in the initial phase of the SCAP Footprint Calculator development (2012 – 2013):

◼ review of data sources used in the Phase 1 SCAP Footprint Calculator;
◼ identification of additional data sources;
◼ consultation with industry members;
◼ review of data by expert subcontractors; and
◼ an external, independent peer review.

Data collection was conducted by WRAP’s Consultants with the assistance of three industry expert sub-contractors:

◼ Graham Burden (cotton and natural fibres expert);
◼ Shirley-Anne Sherriff (synthetic fibres expert); and
◼ Phil Patterson (wet treatment and processing expert).

Further phases of review were undertaken in 2015, 2016 and 2018 with the assistance of members of the SCAP Metrics Working Group to identify and evaluate additional data
from academic peer reviewed journals, research studies, industry publications and industry insight as well as updating existing data from publicly available sources such as Eurostat and Comtrade. In particular, these data enabled more recent data to be included in the tool for cotton cultivation, fabric production, use of recycled fibres, and electricity and fuel impact factors for greenhouse gas emissions.

4.3 Data Quality Assessment

In all phases of data collection, the quality of each data point to be used was critically assessed. The data quality assessment method followed the method set out in the internationally recognised Greenhouse Gas Protocol Standard for Product Carbon Footprinting. The same method was used to cover both the water footprint and waste aspects of the dataset.

Data quality was assessed on the basis of five criteria:

- technology;
- time;
- geography;
- completeness; and
- reliability.

These data quality scores are summarised below\(^\text{12}\).

**Table 2: Data quality scores**

<table>
<thead>
<tr>
<th>Score</th>
<th>Technology</th>
<th>Time</th>
<th>Geography</th>
<th>Completeness</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Data generated using the same technology</td>
<td>Data with less than three years of difference</td>
<td>Data from the same area</td>
<td>Data from all relevant process sites over an adequate time period to even out normal fluctuations</td>
<td>Verified data based on measurements</td>
</tr>
<tr>
<td>3</td>
<td>Data generated using a similar but different technology</td>
<td>Data with less than six years of difference</td>
<td>Data from a similar area</td>
<td>Data from &gt;50% of sites for an adequate time period to even out normal fluctuations</td>
<td>Verified data partly based on assumptions or non-verified data based on measurements</td>
</tr>
<tr>
<td>2</td>
<td>Data generated using a different technology</td>
<td>Data with less than 10 years of difference</td>
<td>Data from a different area</td>
<td>Data from &lt;50% of sites for an adequate time period to even out normal fluctuations or from &gt;50% of sites but for shorter time period</td>
<td>Non-verified data based on assumptions or qualified estimate (eg by sector expert)</td>
</tr>
</tbody>
</table>

\(^\text{12}\) More detail on the assessment method can be found at [www.ghgprotocol.org](http://www.ghgprotocol.org)
A single data quality score for each data point was calculated as the mean of the five category scores. No weighting was applied. The importance of particular data points in influencing the final results was also assessed in the data quality assessment based on basic calculations and prior experience.

Data points were additionally classified into three categories: referenced; calculated; and assumed. Assumed values are mainly related to transport methods to the EU and some geographic gaps for cotton data. Calculated values are mainly for water footprint data for cotton to split it over several processing stages. A description of each datapoint can be found in column AX of the database tab within the Footprint Calculator Data Workbook.

The sheer volume of data that underpins the Footprint Calculator is such that a detailed explanation of each datapoint is not feasible in the context of this report. However, each datapoint can be traced to its source using the Data Workbook spreadsheet (available from WRAP). A summary of the key data sources and assumptions used to compile the data is provided in the sections below, including justification of their use as a source.

4.3.1 Peer review

Both the SCAP and ECAP tools and the accompanying reports have been subject to detailed internal and external peer review. As a synthesis of the SCAP and ECAP tools, the Footprint Calculator has not been subject to further external peer review. This report therefore relies on previous assessments that confirmed the tools to be fit for purpose, transparent and robust, and that whilst there remain a number of limitations in the tools, that these are well documented and they should not take anything away from their value in encouraging sector improvements.

4.4 Cotton

As noted, the sources of fibres can have potentially large effects on the environmental impact of clothing. This is particularly true for cotton, where differences in cultivation practice and yields have large effects on the impacts incurred. Cotton data is therefore differentiated by country of origin and by method of cultivation, notably:

- Conventional cotton;
- Organic cotton;
- Better Cotton Initiative (BCI) cotton;
- Cotton Made in Africa (CMiA) cotton; and

| 1 | Data where technology is unknown | Data with more than 10 years of difference or the age of the data are unknown | Data from an area that is unknown | Data from <50% of sites for shorter time period or representativeness unknown | Non-qualified estimate |
REEL Cotton from the Cotton Connect initiative\textsuperscript{13}.

BCI, Organic, CMiA and REEL cotton are considered ‘improved’ cottons. However, data for these cottons are NOT directly comparable with the global average impact of conventional cotton when calculating the benefits associated with their cultivation.

Cultivation of improved cotton by each of these four methods uses fewer resources per tonne of cotton, and therefore has a lower environmental impact, than conventional cotton grown in the same country. However, the impact associated with these cottons is not necessarily lower than the impact of the ‘global average’ cotton used in the baseline. This is due to favourable growing conditions (and therefore high yields and low resource needs) in countries that are prevalent in the baseline but in which these improved cottons are not grown. This leads to a perverse situation in which, when directly compared, global average conventional cotton has a lower impact in some cases than improved cotton.

In order more accurately to reflect the benefits associated with the increased use of improved cottons, and following consultation with the SCAP Metrics Working Group, the benefits associated with the cultivation of these cottons is calculated in the following way:

- The impact of conventional cotton cultivation in each of the countries in which the improved cottons are grown for which conventional data are available is calculated from the baseline data provided in the sections below.
- The impact of the cultivation of each improved cotton in each country is calculated from the baseline data provided in the sections below.
- The carbon and water benefit associated with the cultivation of improved cotton in each of these countries (displacing the cultivation of conventional cotton in the same country) is calculated by subtracting the impact per tonne of the improved cotton from the impact per tonne of conventional cotton for that country.
- Where an improved cotton is grown in more than one country, a weighted average of the benefits associated with that cotton is taken, weighted by production data for that cotton type.
- For each of the improved types, a new ‘pseudo-cotton’ is created for use in the tool with an impact equal to the impact of the global average tonne of cotton minus the benefit per tonne associated with the improved cotton.

This means that for every tonne of improved cotton used, the benefit associated with the cultivation of that improved cotton over its conventional equivalent in the same country is included in the calculations.

\textit{Note on allocation of impacts}

The impact from the cultivation of seed cotton is allocated to cotton lint and cotton seed using economic allocation. It is assumed that the cotton lint accounts for 84\% of the value

\textsuperscript{13} http://cottonconnect.org/
of the seed cotton (the remaining 16% is attributed to the cotton seed), therefore 84% of the impact of cotton cultivation is allocated to cotton lint.

**Note on water use in cotton cultivation**

For all cottons, water used in cotton cultivation is considered as part of the water footprint. The assumption is made that this is drawn from local sources (‘blue’ water) rather than being process water, and this contributes the carbon footprint indirectly only through the energy required to pump irrigation water to where it is used.

### 4.4.1 Conventional cotton

**Cultivation**

Data are available for the cultivation of conventional cotton from China, India, USA, Pakistan, Brazil, Uzbekistan, Turkey and Australia.

Two data sources are used. For consistency in UK SCAP reporting against the 2012 baseline, data from the previous SCAP tool version (2.9) have been retained. These are derived using consumption, import and export figures for cotton lint taken from the USDA online Cotton and Wool Yearbook\(^{14}\), based on a 5-year average for the period 2009 - 2013 to account for annual fluctuations in crop productions. (For cotton-producing countries which are not major UK garment sources (i.e. Australia, USA and Brazil), only exports to those countries which are garment sources were considered). These data are accessed directly in UK SCAP reporting mode.

The baseline scenario in the updated Footprint Calculator contains data on the split in the source of cotton for EU member states and the UK derived from trade statistics from the UN Comtrade database\(^{15}\). Details of the calculation process can be found in Section 4.4.11. The geographic split for the ultimate source of cotton lint varies for each EU member state. As an illustrative example, for the United Kingdom this is calculated, and compared with the version 2.9 data, below:

<table>
<thead>
<tr>
<th>Version 2.9 SCAP Footprint Calculator</th>
<th>Version 2.10 Footprint Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>China 35.6%</td>
<td>China 37.7%</td>
</tr>
<tr>
<td>India 30.4%</td>
<td>India 36.8%</td>
</tr>
<tr>
<td>USA 13.4%</td>
<td>USA 8.5%</td>
</tr>
<tr>
<td>Pakistan 10.3%</td>
<td>Pakistan 7.0%</td>
</tr>
<tr>
<td>Turkey 2.7%</td>
<td>Turkey 6.9%</td>
</tr>
<tr>
<td>Australia 4.4%</td>
<td>Australia 2.1%</td>
</tr>
<tr>
<td>Brazil 3.3%</td>
<td>Brazil 1.0%</td>
</tr>
</tbody>
</table>


Cotton from Uzbekistan is not included in the UK assessment due to the high proportion of SCAP members which actively boycott Uzbek cotton. The split used in the tool has been scaled up to account for this ‘missing’ Uzbek cotton16.

**Yield of cotton lint**

Yields of lint (kg/ha) for all countries are taken from the USDA online database17 for 2013. Data for 2010 for annual lint production are also used, since this is the year matching the available data for total fertiliser inputs. This has been done as fertilisers typically have the largest impact on the GHG emissions for the crop.

**Fertilisers**

Total amounts of each fertiliser (Nitrogen (N), Phosphate (P), Potassium (K)) used for cotton in each country for 2010-2011 is taken from the International Fertiliser Industry Association18 and converted to average allocation rate (kg/ha) by dividing by the total area under cotton cultivation in 2010 taken from USDA Cotton Workbooks – area cultivated for cotton in 2010.

**Pesticide input**


*India, USA, Brazil, Turkey, Australia* – Data are taken from ‘Pesticide use in cotton in Australia, Brazil, India, Turkey and the USA’, a report commissioned by SEEP20, part of the International Cotton Advisory Committee, in 2010. This is considered to be a recent and reliable source.

*Pakistan* – Data are taken from 2006 Agricultural Statistics for Pakistan21. 62% of total pesticide consumption for the country is for cotton.

*Uzbekistan* – Data are taken from Pesticide Action Network’s 2006 report ‘The Deadly Chemicals in Cotton’22. Although potentially partisan, the report is the best available source of data.

**Energy (diesel and electricity)**

Diesel is primarily used in the mechanised harvesting of cotton and in powering irrigation pumps. The main electricity requirement is also in powering irrigation pumps.

---

16 However, data on cotton from Uzbekistan is held in the background of the tool and can be included in the assessment via the Regionalisation settings in the Clothing Footprint Calculator
19 http://www.sciencemag.org/content/295/5555/674.abstract
20 http://library.wur.nl/WebQuery/wurpubs/413467
21 http://www.pbs.gov.pk/content/agriculture-statistics-pakistan-2010-11
22 https://ejfoundation.org/reports/the-deadly-chemicals-in-cotton
The average amount of diesel and electricity used per ha is calculated using country-specific data for diesel and electricity consumption in agriculture from the United Nations Energy Statistics Database in 2015\(^{\text{23}}\). This is apportioned per ha based on total agricultural land area in 2015 sourced from the Farming and Agriculture Organisation (FAO) of the United Nations\(^{\text{24}}\).

It is recognised that there are uncertainties associated with other agricultural land uses that are included within the total energy consumption and land area values. However, given the small impact of energy consumption on the overall results, this is considered to be a reasonable approach.

Based on expert advice, 100% of cotton is hand-picked in Turkey, requiring no diesel consumption.

**GHG emissions from direct land use change (dLUC)**

Significant GHG emissions have been identified for India and minor emissions for Australia as a result of land use change for the growing of cotton. Emissions are calculated following 2006 IPCC Guidelines\(^{\text{25}}\). FAO country data for area harvested for each crop in each country have been used based on total areas under cultivation for all FAO recorded crops in 2012 (the most recent year for which crop area data is available) and 1992 (20 years prior).

**Irrigation water input**

Water footprint data for Blue, Green and Grey water in all countries are taken from Chapagain et al. (2006)\(^{\text{26}}\), ‘The water footprint of cotton consumption’. It is taken to be the ‘virtual blue water’ figure, as this refers to water withdrawn from ground and surface water. This is the most comprehensive water footprint assessment of cotton at a global level currently available.

\(^{\text{23}}\) https://unstats.un.org/unsd/energystats/data/


\(^{\text{25}}\) Appendix B of GHG Protocol ‘Product Life Cycle Accounting and Reporting Standard’

4.4.2 Organic cotton

Cultivation

More than 80% of organic cotton is grown in India. Data are taken from a life cycle assessment (LCA) by PE International (2014)\(^{27}\) based on a Master’s Thesis by Slotyuk (2013)\(^ {28} \) for the following states in India:

- Madhya Pradesh (MP)
- Andhra Pradesh (AP)
- Orissa (OR)
- Rajasthan (RJ)
- Maharashtra (MH)

In addition, data for China, Turkey, USA and Tanzania is based on the PE International (2014) report.

The percentage contribution from each country is calculated using production data for 2011/12 supplied in the PE International LCA.

Only data from the five Indian states and China and Turkey are used in the updated database: the USA is excluded as it contributes a very low percentage contribution of the global production (<2%) of which a high proportion would be assumed to be used domestically; for Tanzania, while the percentage contribution is greater (approx. 6%), no conventional cotton production data are available with which to calculate a comparison in Tanzania.

The calculations for calculating the improvement factor (relative to conventional cotton) are provided in the sheet Organic Savings contained in the Data Workbook.

Yield of cotton lint

Yields for all regions and countries are calculated using data provided in Section 8.2 ‘Life Cycle Inventory Data’ of the PE International LCA (2014). Cotton lint yield is calculated from the yield of seed cotton and the cotton lint: seed cotton ratio.

Fertilisers

Fertiliser inputs for all regions and countries are taken from data provided in Section 8.2 ‘Life Cycle Inventory Data’ of the PE International LCA (2014).

Pesticide input

Pesticide inputs for all regions and countries are taken from data provided in Section 8.2 ‘Life Cycle Inventory Data’ of the PE International LCA (2014).

---

\(^{27}\) Life Cycle Assessment of Organic Cotton: A global average (2014) PE International

Energy (diesel and electricity)
Electricity and diesel inputs for all regions and countries are taken from data provided in Section 8.2 ‘Life Cycle Inventory Data’ of the PE International LCA (2014). Electricity use data for the five Indian regions provided in the LCA are significantly lower than assumed for conventional production based on UN statistics for agriculture.

GHG emissions from direct land use change (dLUC)
As per conventional cotton.

Irrigation water input
The blue water footprint is assumed to equal the amount of irrigation water applied, as provided in Section 8.2 ‘Life Cycle Inventory Data’ of the PE International LCA (2014). In the absence of actual data for each country / province, the green and grey water footprint are assumed to be the same as conventional for each country on a per ha basis. Differences are as a result of the differential yields. This is an acknowledged limitation of the currently available data.

4.4.3 Better Cotton Initiative (BCI) cotton

Cultivation
Data for BCI farms and conventional farms were provided in personal correspondence and subsequently published in summary in the Better Cotton Initiative Harvest Reports\textsuperscript{29} for Brazil, India, Mali and Pakistan. BCI data are for 2014 except for Brazil, for which 2010 data are used.

Production in Senegal, the USA and Australia are excluded from the calculations as no data are available for BCI farms. No conventional cotton data to enable comparison are available for Mozambique and Tajikistan, so are excluded from the calculation. The calculated benefit of BCI cotton over conventional cotton is weighted by the BCI production data for China, India, Mali, Pakistan, Turkey, Brazil (>93% of production). Brazil is not a major source of finished garments to the EU, and only exports of BCI cotton to those countries which are EU garment sources are considered. This is estimated to be 41.2% of BCI production-based USDA statistics for the proportion of total cotton production exported from Brazil (based on 2009-2013 five-year average).

To calculate the relative impact of BCI cotton to conventional, the 2014 comparison data provided by BCI has been used. This allows for comparisons to be made based on data for the same year for each country, targeted at the same regions as BCI production. Also, other country level conventional data is not available for some BCI producing countries. The raw data and calculations for calculating the improvement factor (relative to conventional cotton) are provided in the sheet BCI-2014 contained in the Data Workbook.

\textsuperscript{29} \url{https://bettercotton.org/harvest-reports/}
Yield of cotton lint
Data for BCI farms and conventional farms from 2014, supplied by BCI, are used for all countries except Brazil, for which 2010 data are used for both BCI and conventional.

Fertilisers
Data for BCI farms and conventional farms from 2014, supplied by BCI, are used for all countries except Brazil, for which 2010 data are used for both BCI and conventional. Data from 2014 is split by N, P and K. Data for Brazil assumes that the N, P and K split is the same as conventional cotton cultivation in Brazil.

Pesticide input
Data for total pesticide use is provided by BCI for 2014.

Energy (Diesel and electricity)
Energy data are not provided by BCI, therefore the same assumptions as conventional cotton are used. This is a worst case assumption which may not take into account higher levels of hand picking in organic agriculture. However, given the high incidence of hand picking in most countries considered, and the small impact on the overall results, this is considered reasonable.

GHG emissions from direct land use change (dLUC)
As conventional cotton.

Irrigation water input
The blue water footprint is assumed to equal the amount of irrigation water applied, as provided by BCI for each country in 2014. As only 2011 data is available for Brazil the blue water footprint is assumed to be the same as for conventional cotton. In the absence of actual data for each country / province, the green and grey water footprint are assumed to be the same as conventional for each country on a per ha basis. Differences are as a result of the differential yields. This is an acknowledged limitation of the currently available data.

4.4.4 Cotton Made in Africa (CMiA) cotton

Cultivation
CMiA countries are Burkina Faso, Ivory Coast, Malawi and Zambia. Data for these countries is taken from the report ‘The Carbon and Water Footprint of Cotton made in Africa’, Systain (2013)\(^\text{30}\). However, no conventional cotton cultivation data are available for African countries. Following consultation with the Metrics Working Group, BCI and CMiA, the improvement associated with BCI cotton is used to represent CMiA cotton as the production methods are deemed to be equivalent.

**Yield of cotton lint**

Yield data for Burkina Faso and Malawi are taken from the Systain report (2013). More recent data for Ivory Coast and Zambia are taken from the report ‘Life Cycle Assessment (LCA) of Cotton made in Africa (CMiA) by PE International (2014)’.

**Fertilisers**

Fertiliser data for Burkina Faso and Malawi are taken from the Systain report (2013). More recent data for Ivory Coast and Zambia are taken from the CMiA report by PE International (2014).

**Pesticide input**

Fertiliser data for Burkina Faso and Malawi are taken from the Systain report (2013). More recent data for Ivory Coast and Zambia are taken from the CMiA report by PE International (2014).

**Energy (Diesel and electricity)**

Energy use data are taken from the Systain report (2013).

**GHG emissions from direct land use change (dLUC)**

As conventional cotton.

**Irrigation water input**

Irrigation water use data are taken from the Systain report (2013).

### 4.4.5 Field emissions (N\textsubscript{2}O)

Field emissions of N\textsubscript{2}O, a powerful greenhouse gas resulting from the breakdown of organic and synthetic fertilisers in soil, are calculated for all types of cotton using the fertiliser input data described above. The equations used to calculate these emissions are those published by the IPCC for use in GHG accounting and reporting for agriculture.

### 4.4.6 Waste from cultivation

No waste is considered at the cultivation stage. Non-boll parts of the plant are assumed to be returned to the field and are not considered a waste. The cotton seed and 'linters' that accompany the lint are useful co-products and are not considered to be a waste.

### 4.4.7 Ginning

**Location**

Ginning technology and electricity grid mixes used vary from country to country. Ginning is assumed to take place in the same country as cultivation. This is a reasonable

assumption given the limited international trade in seed cotton and the fact that, in reality, cotton is normally ginned as close to the site of cultivation as is possible (Graham Burden pers. comm.). Thus, the geographical split of ginning processes is identical to the cultivation split described above.

**Energy**

*China* – Data on energy use in ginning for China are taken from Ecoinvent. This is the most reliable and up to date data source available for this geography.

*India, Turkey, Syria* – Data on electricity consumption of a roller gin, as commonly used in these countries, is taken from a 2010 World Bank report on the economics of roller ginning. Additional electricity for other post-harvest activities (cleaning, packaging, handling) is based on data for an Australian ginning facility (Ismali et al. 2010). Electricity input is assumed to be 61% of the total energy requirement (as per Australian ginning), whilst the remaining 39% is natural gas.

*USA* – The average cost of electrical energy and dryer fuel for ginning one bale of cotton (226.8 kg) in 2010 is taken from 'The Cost of Ginning Cotton - 2010 Survey Results' by Valco et al. Electricity and natural gas costs $0.12/kWh electricity and $0.03/kWh gas are assumed.

*Pakistan* – Pakistan typically uses the same type of ginning machinery as the USA, but uses much older technology. Therefore, the same approach is taken as for the USA, but the 'Maximum' cost per bale is used, in order to represent the least efficient machines used in the USA.

*Brazil, Uzbekistan* – No data are available. New Developments in Cotton Ginning presented at ICAC meeting in Burkina Faso 2008 indicates that performance in Uzbekistan and Brazil is similar to that in China (Graham Burden, pers. comm.). Therefore, data for China are used.

*Australia* – Data are taken from Ismail et al. (2010).

*Mali* – Ginning in Mali is assumed to be similar to that found in Pakistan.

*CMiA countries* (Benin, Burkina Faso, Ivory Coast, Malawi, Zambia) – Data for energy use in ginning are provided by CMiA.

**Waste**

As the yield figures used are for cotton lint (as opposed to seed cotton), which is technically the output of ginning, no waste is considered at the ginning stage. The lint

---


and the seed are both considered to be products, minimising likely waste arising from the ginning process.

**Water**

No water is used in the ginning process. All water footprint data for ‘cotton lint’ is attributed to the cultivation phase, as described above.

**Note on allocation of impacts**

For the same reasons as described above for cultivation, 84% of the impact of ginning is applied to the lint, on the basis of economic allocation.

### 4.4.8 Spinning

**Location**

All processes from spinning of yarn through to making up are assumed to take place in the country from which the garment is ultimately purchased. This is a limiting assumption that had to be made in the absence of better information. The percentage split of countries from which garments are imported is calculated for each EU member state based on UN Comtrade data (see section 4.4.11). As an illustrative example, for the United Kingdom these locations are as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>33%</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>28%</td>
</tr>
<tr>
<td>Turkey</td>
<td>13%</td>
</tr>
<tr>
<td>India</td>
<td>11%</td>
</tr>
<tr>
<td>Pakistan</td>
<td>6%</td>
</tr>
<tr>
<td>Cambodia</td>
<td>4%</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>4%</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1%</td>
</tr>
<tr>
<td>Vietnam</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Technology**

There are three commonly used spinning technologies, each producing yarns of different types. These are included in the model based on the approximate world installation of these machines (Graham Burden, pers.comm.). These are:

- Ring spun – carded  50%
- Ring spun – combed  25%
- Rotor/open ended  25%

It is assumed that each country uses the same mix of technologies. This is unlikely to be exactly right, but is a reasonable assumption given the lack of data.
**Energy**

Energy use for processes required before spinning (opening, cleaning, mixing, carding, predraw, combing, drawing and roving) are taken from 'Life Cycle Assessment of Cotton Fiber and Fabric' by Cotton Incorporated (2012)\(^{36}\), an LCA that takes an industry wide perspective. Ring spun – combed cotton requires all of these processes, ring spun – carded requires all but combing, and rotor all but combing and roving.

Energy use data for ring and rotor spinning are taken from the same report.

All heat is assumed to be from natural gas; all electricity is assumed to be grid electricity. While this may not be the case for individual spinning mills (which may use biomass or wind power), it is considered a reasonable approach.

**Waste**

Waste data for carded, combed and open-ended spinning was provided by Rieter, a major spinning machine manufacturer, to Graham Burden as part of another project in 2009. These data are used in the model:

- Ring spun combed requires 1.368 kg lint/kg yarn
- Ring spun carded requires 1.13 kg lint/kg yarn
- Rotor/open ended requires 1.1 kg lint/kg yarn

**Water**

Water footprint data are taken from ‘The water footprint of cotton consumption’ by Chapagain et al. (2006)\(^{37}\). These data refer to the production of grey fabric. 50% of the water impact is attributed to the spinning stage and 50% to the fabric production stage. The figures are adjusted to account for the waste produced at the spinning stage.

4.4.9 Fabric production

**Locations**

The locations for fabric production are assumed to be the same as for all processes from spinning to making up.

**Energy**

Energy data are taken from the Cotton Incorporated (2012) report. These were compiled by Cotton Incorporated from a survey of 11 representative textile mills of different types.

\(^{36}\) [http://cottontoday.cottoninc.com/sustainability-about/LCI-LCA-Cotton-Fiber-Fabric/]

Waste data for fabric production are taken from ‘EDIPTTEX – Environmental assessment of textiles’, a report issued by the Danish Ministry for Environment in 2007\(^{38}\).

**Water**

Water footprint data are taken from Chapagain et al. (2006). These data refer to the production of grey fabric. 50% of the water impact is attributed to the spinning stage and 50% to the fabric production stage. The figures are adjusted to account for the waste produced at the spinning stage.

### 4.4.10 Wet processing

**Location**

The locations for wet processing are assumed to be the same as for all processes from spinning to making up, as explained above.

**Technology**

Two generic dyeing processes are considered for cotton, continuous dyeing and batch dyeing. In addition, data for cold pad batch (CPB) dyeing is included in the tool as an improvement action (see Section 6). In the absence of reliable data, all fabric is assumed to be batch dyed by default, as batch dyeing is the more common type of dyeing process. The typical finishing processes associated with each of these dyeing types are also included as a separate life cycle stage.

**Energy and materials**

Energy and materials data for batch and continuous dyeing and the associated finishing is taken from 'Reducing Pollution in Wet Processing of Cotton/Polyester Fabrics', Kazakeviciute et al (2004)\(^{39}\), a report published by the Lithuanian Textile Institute. Data for CPB dyeing are taken from Colour Connections (2016)\(^{40}\).

**Water**

Water footprint data for batch and continuous dyeing are taken from Chapagain et al (2006). This treats wet processing as a single process and does not differentiate between dyeing and finishing. 75% of the water footprint is allocated to the dyeing process, with 25% to the finishing process. Data for CPB dyeing are again taken from Colour Connections (2016).

**Waste**


4.4.11 Note on garment and cotton fibre sourcing

As noted, the source of cotton fibre can have potentially large effects on the environmental impact of clothing, as differences in cultivation practice and yields have large effects on the impact incurred. Data on the split between sources of cotton in the revised tool is taken from UN Comtrade\textsuperscript{41} trade data and the USDA cotton and wool yearbook\textsuperscript{42}. Nine major countries that import clothing to the UK and EU are considered\textsuperscript{43}. However, examination of the data indicates that there are also major intra-EU trade flows. Given the relatively small amount of garment production in EU countries in comparison to the major garment producing nations, this intra-union trade is assumed to be re-export of goods imported from outside of the EU: for example, 34% of garment imports to the Republic of Ireland came from the UK in 2015. It is considered unlikely that these garments truly originated in the UK.

In order to resolve these intermediate trades, a matrix inversion technique, borrowed from the compilation of life cycle inventories, was applied to the trade data. This can resolve both simple and complex trading networks (Figure 3).

\textbf{Figure 3} Resolving intra-EU trades

\begin{figure}
\centering
\includegraphics[width=\textwidth]{image}
\caption{Resolving intra-EU trades}
\end{figure}

\begin{itemize}
\item \textsuperscript{41}http://comtrade.un.org/data/
\item \textsuperscript{42}United States Department for Agriculture (USDA) Foreign Agricultural Service Production, Supply and Distribution, 2014/2015. "Cotton and Wool Yearbooks".
\item \textsuperscript{43}China, Bangladesh, Turkey, India, Cambodia, Pakistan, Vietnam, Sri Lanka and Indonesia
\end{itemize}
The trade flows were based on average data for 2011 - 2015. Resolving these trade flows, over 80% of garment imports are captured for 24 out of the 28 member states. The exceptions are Italy (79%), Latvia (79%), Lithuania (68%) and Estonia (66%). Imports from other countries are then apportioned to the nine SCAP garment producing countries based on the proportion of imports to each member state.

The ultimate source of cotton fibres for each member state is then calculated based on the likely source of cotton in each of the garment producing nations. Production, import and export data from the USDA cotton and wool yearbook is used to calculate the proportion of garments made from domestic and imported cotton. The source of imported cotton is calculated using Comtrade data. No cotton import data were available for Pakistan, Sri Lanka, Vietnam and Indonesia. It is assumed that the sources of cotton for Pakistan and Sri Lanka are the same as India, and that Vietnam and Indonesia are the same as Cambodia.

During the development of the original SCAP tool, it was decided that cotton from Uzbekistan should be excluded from the supply chain of UK garments on the basis of widely held policies within the retail sector against its use. For the Footprint Calculator, Uzbek cotton can be optionally included or excluded using a check box in the user interface. This checkbox can be removed and a default decision hard coded into the tool should a decision on this issue be taken at some point in the future.

4.5 Polyester

4.5.1 Raw materials

Carbon footprint
The raw material for polyester production is polyethylene terephthalate (PET). The data for the carbon footprint of PET production are derived from the Plastics Europe Eco-profile. This is an open access library of LCI data from the European plastics industry. The LCIs are aggregated and anonymised data from their members. This is the most up to date and accurate plastics dataset available. It includes the extraction and refining of crude oil, as well as the polymerisation and granulation processes to make PET.

Water
Water footprint data for PET production are those calculated by URS (2012) in ‘Valuing our clothes: the evidence base - Appendix V Water footprint’.

44 https://www.plasticseurope.org/en/resources/eco-profiles
45 URS (2012), available from WRAP
Waste
No data for solid waste in the production of PET were available. It is likely to be negligible.

Recycled polyester
For recycled polyester, post-consumer PET bottles are assumed to be the input to the fibre production stage. Under the recycling allocation method used in the tool, these are assumed to arrive ‘burden-free’, as all of the impact associated with their production is allocated to their first use as a bottle.

4.5.2 Fibre production

Locations
60% of polyester fabric is assumed to be produced in China, with the remaining 40% from India. Due to a lack of data, it is assumed that all stages, from fibre production to fabric production take place in the same country, so this sourcing split is used for all of these stages.

Technology
There are two main types of polyester fibre that are produced: filament; and staple. Filament fibres are single, long extruded strands of fibre. Staple fibres are filament fibres that have been cut to a defined and consistent length to mimic natural fibres. In the baseline dataset, all fibres are assumed to be filament fibres, as this is the more common of the two.

Energy
Energy data for polyester fibre production are taken from a study conducted by ERM for Marks and Spencer in 2002\(^{46}\). These are data for filament production. In the absence of specific data for staple production, the same data are used as it is unlikely that the difference would be significant.

Waste
Waste in the production of polyester fibres is assumed to be 10% of raw material input. This assumption was made by Shirley-Anne Sherriff (pers. comm), a synthetic textiles expert with an in-depth knowledge of the sector.

Water
Accurate water footprint data for polyester fibre production do not currently exist. However, the significance of the water footprint at this life cycle stage is likely to be negligible: a value of 0.1m\(^3\) blue water/t is used, taken from URS (2012).

\(^{46}\) ERM (2002) Streamlined Life Cycle Assessment of Two Marks & Spencer plc Apparel Products
Recycled polyester

In addition to the data above for fibre production, the data for recycled polyester includes the energy and materials required to convert post-consumer PET bottles into the input required for this process. These data are taken from 'Life Cycle Inventory of 100% post-consumer HDPE and PET recycled resin from post-consumer containers and packaging', a 2010 report prepared by Franklin Associates for a consortium of four industry bodies in the USA, including the American Chemistry Council.

4.5.3 Spinning

Locations
As described above in 4.4.8.

Technology
In the absence of high quality specific data, spinning of polyester to yarn is assumed to require similar energy and material requirements to the spinning of cotton. Data for ring spun – combed spinning is used to represent the spinning of both staple and filament fibre. These spinning data are considered as accurate and up to date. Waste data specific to polyester are taken from the ERM Marks and Spencer 2002 study.

4.5.4 Fabric production

Locations
As described above in 4.4.9.

Technology
In the absence of high quality specific data, weaving and knitting of polyester to fabric are assumed to require similar energy and material requirements to the weaving and knitting of cotton. Energy, material and water data for these processes for cotton are repeated for polyester. Waste data specific to polyester are taken from the ERM Marks and Spencer 2002 study.

4.5.5 Wet processing

Location
As described above in 4.4.10.

Technology
Two generic dyeing types are considered for polyester: batch dyeing and continuous dyeing. Data for dope dyeing is also included in the tool as an improvement action (see Section 6). In the absence of reliable data, all fabric is assumed to be batch dyed by default, as batch dyeing is the more common type of dyeing process. The typical

finishing processes associated with each of these dyeing processes are also included in the model as a separate life cycle stage.

Energy and materials

Water

Waste
Waste data for wet processing are taken from ‘EDIPTEX – Environmental assessment of textiles’, a report issued by the Danish Ministry for Environment in 200751.

4.6 Viscose

4.6.1 Cultivation and fibre production

Data for viscose is taken from a published LCA study by Shen and Patel (2010), ‘Life Cycle Assessment of Man-Made Cellulose Fibres’52. This is based on information from Lenzing, a major viscose and lyocell manufacturer. Consultation with Lenzing confirmed that this study remains the most recent and comprehensive source of data. However, LCI data is not provided in this study and only characterised impacts in the form of carbon footprint figures and aggregated solid waste data are available. These include the cultivation of the trees, extraction of cellulose and processing to raw fibre as a single step. There is no way to disaggregate these data. As a result, the data for viscose fibre production are all applied to the ‘processing to fibre’ stage of the life cycle. This does not mean that there is no impact at the ‘Extraction’ phase; it is simply a limitation of the dataset.

Data in this report are available for the production of viscose in Asia and Europe, as well as lyocell (an improved fibre option).

In the absence of better data, the water footprint data used are those calculated by URS (2012).

---

50 URS (2012), available from WRAP
52 https://pdfs.semanticscholar.org/584f/6f4c7a0d6d88d1936b922786a78da6921.pdf

WRAP - SCAP Footprint Calculator 2.10 Technical Report
82% of viscose fibre is assumed to be sourced from Asia, with 18% from Europe, based on International Trade Centre data.

### 4.6.2 Spinning, fabric production, wet treatment and making up

Without specific data for viscose for these life cycle stages, it is assumed to be produced using similar technology to synthetic fibres and therefore the same data as for polyester are used for each of these stages.

In the absence of better data, the water footprint data used are those calculated by URS (2012).

### 4.7 Wool

#### 4.7.1 Sheep rearing and fibre production

**Variants**

Data for sheep rearing in Australia (Merino), New Zealand (Romney) and the United Kingdom (Lleyn and Cheviot) are taken from Wiedemann et al. (2015)\(^{53}\). International Trade Centre data are used to calculate a split of 19% from New Zealand and 81% from Australia for the baseline. UK wool is available as an optional dataset in the calculator.

**Materials, energy and on-farm emissions**

LCIA data from Wiedemann et al. (2015) are used to describe the carbon footprint results for feed, fertiliser, fuel and energy use and on-farm emissions of methane and \(N_2O\).

**Allocation**

Wool is a co-product of sheep meat. The inputs described above are allocated to the wool using protein mass allocation, as recommended by the IWTO\(^{54}\). Data using economic allocation is available as an optional dataset in the calculator.

**Water**

In the absence of new data, the water footprint data used are those calculated by URS (2012).

#### 4.7.2 Spinning

**Location**

A split of 71% from China and 29% in Italy is used for wool yarn and fabric production, based on International Trade Centre statistics.

\(^{53}\) Application of life cycle assessment to sheep production systems: investigating co-production of wool and meat using case studies from major global producers [https://link.springer.com/article/10.1007%2Fs11367-015-0849-z](https://link.springer.com/article/10.1007%2Fs11367-015-0849-z)

\(^{54}\) [https://www.iwto.org/resources/guidelines](https://www.iwto.org/resources/guidelines)
Technology
Data for two types of spinning technology are available in the tool: woollen; and worsted. All wool is assumed to go through the worsted process.

Pre-spinning for wool consists of scouring, carding and combing. Woollen yarn is not combed.

Energy
Energy data for each of these processes are taken from a 2006 life cycle assessment of the New Zealand Merino Wool industry\textsuperscript{55}.

In the absence of better data, energy data for spinning are assumed to be similar to cotton. Worsted fibre is assumed to be similar to ring combed cotton. Woollen fibre is assumed to be similar to ring carded cotton. It is acknowledged that this is unlikely to be the case in practice.

4.5.15 Fabric production and wet processing

In the absence of better data, wool fabric production and wet processing are assumed to be similar to cotton. It is acknowledged that this is unlikely to be the case in practice.

4.8 Linen

4.8.1 Cultivation

Data for flax cultivation are taken from a 2008 report by INRA – ‘The environmental impacts of the production of hemp and flax textile yarn’\textsuperscript{56}. Detailed LCI data for yield, fuel, energy and material use (fertilisers and pesticides) are used. Data for cultivation, harvesting and retting processes are combined as they are continuous processes.

In the absence of better data, the water footprint data used are those calculated by URS (2012).

4.8.2 Fibre and yarn production

Data for the fibre and yarn production stages are taken from the INRA report mentioned above. Scutching, the separation of the fibres from the woody core and the bark is used to represent fibre production. Hackling, roving and bleaching are combined to represent pre-spinning, while spinning and winding are used for the spinning stage.

In the absence of better data, the water footprint data used are those calculated by URS (2012)


\textsuperscript{56} http://blogs.ubc.ca/ecohealth449/files/2011/01/Hemp-yarn.pdf
4.8.3 Fabric production and wet processing

In the absence of specific data, data for cotton are used to represent the production of fabric and wet processing stages for linen.

4.9 Silk

4.9.1 Silkworm rearing and fibre production

Silk is derived from the cocoons of silkworms fed with mulberry leaves. Cradle to gate carbon footprint data for the production of raw silk are extracted from Astudillo et al. (2014) ‘Life cycle assessment of Indian silk’\(^\text{57}\). This includes mulberry cultivation, silkworm rearing and silk reeling.

The water footprint for silkworm rearing is very high as many mulberry leaves are required to feed the silkworms (240 t leaves per tonne of silk). Water footprint data for mulberry cultivation are allocated to 1 kg of raw silk using allocation factors extracted from the supplementary material from Astudillo et al.

4.9.2 Spinning, fabric production and wet processing

While detailed information on the processes required to make silk is available, no specific energy data relating to these processes could be found. Silk spinning, fabric production and wet processing are therefore assumed to be similar to the processes used for cotton, for which high quality data are available. Given the low use of silk by the majority of retailers, this is not considered to be of major significance.

4.10 Acrylic

4.10.1 Raw materials

LCI data for the raw materials to polyacrylonitrile production are not available. Aggregated data for the production of polyacrylonitrile fibres (PAN) from acrylonitrile and methacrylate are taken from the European Life Cycle Database and adapted for Chinese electricity. This includes the impacts associated with the extraction and refining of these petrochemicals, as well as the process of polymerisation. These data cannot be disaggregated and are applied to the ‘extraction’ stage. This does not mean that there is no impact of the ‘processing to fibre’ phase, or that there are no data for this stage, it is simply a limitation of the dataset.

Water footprint data for acrylic are only available for the raw materials. The data used are those calculated by URS (2012).

\(^\text{57}\) https://www.sciencedirect.com/science/article/pii/S0959652614005939
4.10.2 Fibre and yarn production

No specific data for these life cycle stages for these fibres are available. Data for polyester are therefore used, as the processes involved are likely to be similar. Likewise, no water footprint data exist for the fibre production stage for acrylic. This is not considered to be an important data gap in the context of the life cycle of clothing, as water use at this stage is likely to be negligible in comparison to other processes.

4.11 Polyamide

4.11.1 Raw materials

LCI data for the raw materials to polyamide production are not available. Aggregated data in the form of a carbon footprint are available for caprolactam, the precursor to polyamide, from the Australian LCI database\(^58\).

Carbon footprint and process (blue) water data from the Plastics Europe (2014) ‘EcoProfile of Polyamide 6.6\(^59\) are used for polyamide granulate production.

4.11.2 Fibre and yarn production

No specific data for polyamide fibre production are available. Therefore, data used to characterise the production of polyester filament fibre are used to represent production of polyamide / nylon fibre. This assumption should not materially influence the results, as they are similar processes and the melting point of nylon and polyester are also similar\(^60\).

4.11.3 Recycled polyamide / Nylon

Nylon can be recycled using a chemical process or by a mechanical and remelt process. Data assessing the environmental impact of recycled nylon are only identified for the chemical recycling process. This is available in an Environmental Product Declaration (EPD) produced by the company Aquafil, for the production of recycled nylon polymer in plants in Italy and Slovenia\(^61\).

Technology

Nylon waste which can be used as an input to the recycling process primarily consists of industrial offcuts, used carpets and fishing nets. Following collection and sorting, the waste fibres are shredded, and then chemically treated in a depolymerisation reaction


\(^{59}\) https://www.plasticseurope.org/en/resources/eco-profiles

\(^{60}\) The melting point for polyamide (nylon 6) is 220°C (https://en.wikipedia.org/wiki/Nylon_6) compared to 260°C for polyester (https://en.wikipedia.org/wiki/Polyethylene_terephthalate).

to produce caprolactam, the monomer for nylon polymer production. The caprolactam is then polymerised to produce the nylon polymer. The nylon polymer then undergoes a spin melting process to produce the nylon filament fibres required to produce nylon yarn. All data other than the melt spinning process step are covered by and are sourced from the EPD.

Switching from the use of virgin nylon to recycled nylon only impacts the Extraction and Processing to Fibre life cycle stages. All other life cycle stages are the same for virgin and recycled nylon. The data available for all of the process steps covered by the EPD are aggregated data for processes that would be included in the Extraction and Processing to Fibre life cycle stages. Consequently, it is not possible to split the calculation between two life cycle stages and all impact for the nylon recycling process is assessed as part of the Processing to Fibre life cycle stage in the Footprint Calculator.

**Carbon Footprint**

Data provided in the EPD are not sufficiently disaggregated to model all of the inputs and outputs for the carbon footprint. Therefore, the carbon footprint results presented in the EPD are used to represent the carbon footprint of all processes except for the melt spinning process step, for which data for the production of polyester filament fibre are used.

**Water Footprint**

No data are available for the water footprint of the nylon recycling process. Therefore, it has been assumed to be the same as virgin nylon production.

**Waste Footprint**

The waste footprint for recycled nylon is calculated based on data provided in the EPD for the amount of waste nylon material required to produce 1 kg of recycled nylon polymer and the assumed wastage from the melt spinning process (approximately 1%).

**4.11.4 Yarn production, fabric production and wet processing**

No specific data for the production of these fibres are available. Therefore, the same data as for the production and wet processing of polyester filament are used, as the processes involved are likely to be similar.

**4.12 Polyurethane**

**4.12.1 Raw materials**

The raw materials for polyurethane are polyols and toluene diisocyanate. No LCI data for these raw materials are available. However, aggregated data in the form of a carbon footprint, from the Ecoinvent database, are used.

In the absence of better data, the water footprint data used are those calculated by URS (2012).
4.12.2 Yarn production, fabric production and wet processing

No specific data for the production of these fibres are available. Therefore, the same data as for the production and wet processing of polyester filament are used, as the processes involved are likely to be similar.

4.13 Making up

The same making up data is used for all fibre types.

Energy and waste data are taken from ‘EDIPTEX – Environmental assessment of textiles’, a report issued by the Danish Ministry for Environment in 2007. In the absence of better data, the water footprint data used are those calculated by URS (2012).

4.14 Use

Use includes the washing, drying and ironing of clothing by households. The same use phase profile is assumed for all fibre types. This was an assumption agreed with the SCAP Metrics Working Group. The basis for this assumption is that people do not routinely separate clothing by fibre type when washing and drying. Segregation prior to washing, if there is any, usually takes the form of separation of whites from colours and the separation of delicates into a separate wash. While this will reflect fibre type to some extent, this is not modelled explicitly.

Additionally, it is assumed that the majority of tumble dryers have a fixed cycle which uses the same amount of energy, regardless of the composition of the clothing inside. This is a conservative, worst case assumption.

Data for energy use in wash cycles at different temperatures have been derived by WRAP from responses to surveys of washing behaviour carried out for WRAP by Icaro Research in 2015 and 2016 and published in ‘Valuing Our Clothes 2’ and the WRAP 2016 EU Clothing Survey (ECAP), respectively, as follows:

<table>
<thead>
<tr>
<th>Wash temperature</th>
<th>EU average (2016)</th>
<th>UK average (2015/16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15C</td>
<td>15%</td>
<td>4.5%</td>
</tr>
<tr>
<td>30C</td>
<td>23%</td>
<td>38%</td>
</tr>
<tr>
<td>40C</td>
<td>19%</td>
<td>49.5%</td>
</tr>
<tr>
<td>50C</td>
<td>8%</td>
<td>3%</td>
</tr>
<tr>
<td>60C</td>
<td>23%</td>
<td>4.5%</td>
</tr>
<tr>
<td>70C</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>90C</td>
<td>10%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

The onward destination of discarded clothing also differs between member states. One such important difference is the proportion of residual waste that is sent to landfill or to incineration in each member state. Eurostat data\textsuperscript{64} indicates that this runs the entire spectrum from nearly 100% incineration (Sweden, Germany) to 100% landfill (Greece, Latvia).

The end of life mass flow in the tool uses country-specific landfill and incineration rates, based on Eurostat average data from 2016, when calculating the final destinations of discarded clothing.

4.15 Summary of key data

An overall view of the quality of the data used in the tool is shown in the heatmap below.

Each datapoint in the tool has been assessed for quality as described above, with a maximum score of 4 meaning the highest quality data.

**Figure 3: Data Quality Scoring**

<table>
<thead>
<tr>
<th></th>
<th>Extraction</th>
<th>Processing to fibre</th>
<th>Trans. to yarn producer</th>
<th>Pre-spinn.</th>
<th>Spinning/Winding</th>
<th>Trans. to fabric producer</th>
<th>Weaving/Knitting</th>
<th>Wet treatment</th>
<th>Finishing</th>
<th>Trans. to garment producer</th>
<th>Making up</th>
<th>Trans. to CoS</th>
<th>Drying</th>
<th>Ironing</th>
<th>Reuse CoS</th>
<th>Reuse overseas</th>
<th>Recycling</th>
<th>Incineration</th>
<th>Landfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>2.6</td>
<td>2.7</td>
<td>1.0</td>
<td>2.6</td>
<td>2.7</td>
<td>1.0</td>
<td>2.8</td>
<td>2.4</td>
<td>1.0</td>
<td>2.2</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Wool</td>
<td>3.2</td>
<td>2.1</td>
<td>1.0</td>
<td>2.5</td>
<td>2.5</td>
<td>1.0</td>
<td>2.5</td>
<td>2.4</td>
<td>1.0</td>
<td>2.2</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Silk</td>
<td>2.8</td>
<td>1.0</td>
<td>2.3</td>
<td>2.3</td>
<td>1.0</td>
<td>2.8</td>
<td>2.4</td>
<td>2.4</td>
<td>1.0</td>
<td>2.2</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Flax/Linen</td>
<td>2.0</td>
<td>2.0</td>
<td>1.0</td>
<td>2.3</td>
<td>2.3</td>
<td>1.0</td>
<td>2.8</td>
<td>2.4</td>
<td>1.0</td>
<td>2.2</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Viscose</td>
<td>2.8</td>
<td>1.0</td>
<td>2.4</td>
<td>2.8</td>
<td>1.0</td>
<td>2.8</td>
<td>2.3</td>
<td>2.3</td>
<td>1.0</td>
<td>2.1</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Polyester</td>
<td>2.8</td>
<td>2.3</td>
<td>1.0</td>
<td>2.7</td>
<td>2.8</td>
<td>1.0</td>
<td>2.8</td>
<td>2.3</td>
<td>1.0</td>
<td>2.5</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Acrylic</td>
<td>3.0</td>
<td>1.0</td>
<td>2.5</td>
<td>2.8</td>
<td>1.0</td>
<td>2.8</td>
<td>2.3</td>
<td>2.3</td>
<td>1.0</td>
<td>2.1</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Polyamide</td>
<td>2.8</td>
<td>1.0</td>
<td>2.5</td>
<td>2.8</td>
<td>1.0</td>
<td>2.8</td>
<td>2.3</td>
<td>2.3</td>
<td>1.0</td>
<td>2.1</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Polyurethane/ polypropylene</td>
<td>2.8</td>
<td>2.2</td>
<td>1.0</td>
<td>2.5</td>
<td>2.8</td>
<td>1.0</td>
<td>2.8</td>
<td>2.3</td>
<td>1.0</td>
<td>2.1</td>
<td>1.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Data quality in the key areas of the tool is generally good. The quality scores of 1.0 for each of the transport stages are representative of the fact that these are based on assumptions concerning distance and mode of transport. This is the most sensible and widely used approach in studies of this kind, and, as the impact of transport represents

\textsuperscript{64} http://ec.europa.eu/eurostat/web/environment/waste/main-tables; Municipal waste generation and treatment, by type of treatment method (tsdpc240)
a negligible amount in the context of the whole value chain in all three impact categories, is not considered to be a limitation of the data.
5.0 Description of the Data Workbook

Raw data used to provide the background data for the Footprint Calculator are held external to the tool itself in the Data Workbook. This workbook contains all the raw data and references for the data used in the Footprint Calculator. In addition, calculations to transform the data into the form required for the tool are implemented in the workbook. This includes agricultural models to calculate the embodied greenhouse gas (GHG) emissions from the production of fertiliser and pesticides used and direct GHG emissions from the application of nitrogen fertiliser in agriculture.

The Data Workbook consists of five main tabs described below.

Table 3: Description of the dataset spreadsheet

<table>
<thead>
<tr>
<th>Tab</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL DATA</td>
<td>Compilation of all of the raw numbers taken from the source documents used, together with any calculations required to transform them into the required format (e.g. unit conversions)</td>
</tr>
<tr>
<td>Data Quality Assessment</td>
<td>Data quality assessment of each of the datapoints included in the dataset (details below)</td>
</tr>
<tr>
<td>Database</td>
<td>Compiled dataset consisting of the material and energy flows for each life cycle stage for each fibre, linking to the ALL DATA tab. Each row contains multiple datapoints, an aggregated data quality score, and references to all of the source documents used. A hardcoded copy of this tab is transferred into the tool itself.</td>
</tr>
<tr>
<td>EFs</td>
<td>Short for Emissions Factors. These are the secondary impact factors used in the tool.</td>
</tr>
<tr>
<td>All parameters-baseline (Final)</td>
<td>A list of all of the parameters used in the baseline scenario that describe the geographic/technological split of processes used.</td>
</tr>
<tr>
<td>LISTS</td>
<td>Data validation lists used for consistency during the compilation of the dataset.</td>
</tr>
<tr>
<td>Crop Calculations Tabs</td>
<td>A set of tabs to the right of the ‘CROP CALCULATIONS’ marker tab that contain all of the calculations and equations associated with crop cultivation used in the model.</td>
</tr>
</tbody>
</table>

5.1 Tracing the Data Used in the Tool

The final database used by the tool should be viewed in conjunction with the data quality assessment as this contains weblinks to each individual source document. Each row in the dataset contains all of the LCI data needed to model one lifecycle stage of one fibre being processed in a particular way, or at a particular location, with data for materials, energy and water use entered in separate columns. Therefore, multiple data points assessed in the data quality assessment (potentially from multiple, but compatible sources) may be represented in a single process.

The data quality assessment considers each of these data points separately and includes a reference and weblink to the particular document from which the data are taken. In addition, column AT in the database contains the reference code for each of the references used in that process, as well as to which numbers they refer. Any

---

Current version corresponding to SCAP Footprint Calculator version 2.10 is WCFC Data Workbook v3, available from WRAP
calculations that have taken place in order to convert the data into the correct form, e.g. imperial to metric units, relating inputs to yields of crops etc., can be found in the spreadsheet that contains the database and the data quality assessment.

The full dataset, supporting calculations and data quality assessment are contained within an Excel file made available to the peer reviewer and to any SCAP member or third party that requires it. A full list of data sources used is included in the tool available to the peer reviewer and to any SCAP member or third party that requires it.
6.0 Indicative Baseline and Improved Results Using SCAP Footprint Calculator Version 2.10

Fourteen default ‘improvement actions’ can be assessed in the Footprint Calculator. These include actions at every stage of the life cycle. When the tool is in ‘reporting mode’, only these improvement actions can be selected. These are described in the table below, together with the effect they have when applied to the model. These results are based on a fibre split calculated from data reported to WRAP by SCAP members. The results in the table below are for a total of 352,825 tonnes of clothing with the following split of fibres: 48% Cotton; 29% Polyester; 9% Viscose; 6% Polyamide; 3% Acrylic; 3% Elastane; 1% Wool; 1% Linen; 1% Other; and <1% Silk.

The tool allows users to customise current, and to build new, improvement actions with their own data or those from their suppliers. The functionality was designed specifically to allow users to evaluate efficiency improvements in more detail through altering specific manufacturing processes (e.g. spinning) and to account for location differences by altering the location from which cotton and other materials are sourced, as well as using country-specific electricity mixes for processing.

<table>
<thead>
<tr>
<th>Improvement Action</th>
<th>Action</th>
<th>Impact</th>
<th>Unit</th>
<th>Baseline Scenario</th>
<th>Improved Scenario</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conventional Cotton to BCI Cotton</td>
<td>Replace conventional cotton with BCI cotton. Default applies to 20% of cotton.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,810,000</td>
<td>-0.51%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,100,000,000</td>
<td>-3.67%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>-</td>
</tr>
<tr>
<td>2. Conventional Cotton to Organic Cotton</td>
<td>Replace conventional cotton with organic cotton. Default applies to 20% of cotton</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,720,000</td>
<td>-1.66%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,040,000,000</td>
<td>-6.42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>-</td>
</tr>
<tr>
<td>3. Conventional Cotton to CMiA</td>
<td>Replace conventional cotton with CMiA cotton. Default applies to 20% of cotton.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,790,000</td>
<td>-0.76%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,100,000,000</td>
<td>-3.67%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>-</td>
</tr>
<tr>
<td>4. Conventional Cotton to REEL cotton</td>
<td>Replace conventional cotton with Cotton Connect REEL cotton. Default applies to 20% of cotton.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,820,000</td>
<td>-0.38%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,100,000,000</td>
<td>-3.67%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>-</td>
</tr>
<tr>
<td>5. Conventional Cotton to Recover (recycled) cotton</td>
<td></td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,670,000</td>
<td>-2.29%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>1,820,000,000</td>
<td>-16.51%</td>
</tr>
<tr>
<td>Improvement Action</td>
<td>Action</td>
<td>Impact</td>
<td>Unit</td>
<td>Baseline Scenario</td>
<td>Improved Scenario</td>
<td>% change</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------</td>
<td>--------</td>
<td>------</td>
<td>------------------</td>
<td>------------------</td>
<td>----------</td>
</tr>
<tr>
<td>6. Virgin Polyester to Recycled Polyester</td>
<td>Replace polyester with recycled polyester (assumed reclaimed from outside of clothing sector). Default applies to 20% of polyester</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,760,000</td>
<td>-1.15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,180,000,000</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>560,000</td>
<td>1.08%</td>
</tr>
<tr>
<td>7. Viscose to Lyocell</td>
<td>Replace Viscose with Lyocell (or equivalent). Default applies to 20% of Viscose.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,760,000</td>
<td>-1.15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,180,000,000</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>-</td>
</tr>
<tr>
<td>8. More in country reuse of pre-owned garments</td>
<td>Extend average active lifetime of clothing by 2% through promoting sales of pre-owned garments (doubling from current baseline of 1%). Pre-owned garments assumed to be sold in both retail stores and charity shops. Default applies to 100% of clothing.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,740,000</td>
<td>-1.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,140,000,000</td>
<td>-1.83%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>550,000</td>
<td>-0.72%</td>
</tr>
<tr>
<td>9. Hire and repair services dematerialise retail sales</td>
<td>Extend clothing lifetimes by 1% through provision of in-store services for the hiring and repair of clothing. Default applies to 100% of clothing.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,800,000</td>
<td>-0.64%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,160,000,000</td>
<td>-0.92%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>552,000</td>
<td>-0.36%</td>
</tr>
<tr>
<td>10. Virgin Polyamide / Nylon to Recycled Polyamide / Nylon</td>
<td>Replace polyamide with recycled polyamide using chemical recycling process (Not appropriate for recycled polyamide from mechanical recycling process). Default applies to 20% replacement.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,850,000</td>
<td>-0.10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,180,000,000</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>553,000</td>
<td>-0.18%</td>
</tr>
<tr>
<td>11. Conventional dyeing to dope dyeing of synthetic fibres</td>
<td>Applied to all synthetic fibres (polyester; polyamide; polypropylene; and acrylic). Dyes are added during spinning removing the need for conventional dyeing. Default applies to 20% of dyeing operations.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,780,000</td>
<td>-0.89%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,180,000,000</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>-</td>
</tr>
<tr>
<td>12. Conventional dyeing to CPB dyeing of natural fibres</td>
<td>Applied to the natural fibres; cotton, wool, linen and viscose. Dyes are cold rolled onto fabric requiring less energy and water. Default applies to 20% of dyeing operations.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,790,000</td>
<td>-0.76%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,170,000,000</td>
<td>-0.46%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>-</td>
</tr>
</tbody>
</table>
13. Conventional dyeing to spin dyeing of viscose

<table>
<thead>
<tr>
<th>Improvement Action</th>
<th>Action</th>
<th>Impact</th>
<th>Unit</th>
<th>Baseline Scenario</th>
<th>Improved Scenario</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional dyeing to spin dyeing of viscose</td>
<td>Applied to viscose only (using data from Terinte et al (2014)). Dyes are added to the fibre mass prior to spinning removing the need for conventional dyeing. Default applies to 20% of dyeing operations.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,830,000</td>
<td>-0.25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,180,000,000</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>555,000</td>
<td>0.18%</td>
</tr>
</tbody>
</table>

14. Increase in collection for reuse/recycling

<table>
<thead>
<tr>
<th>Improvement Action</th>
<th>Action</th>
<th>Impact</th>
<th>Unit</th>
<th>Baseline Scenario</th>
<th>Improved Scenario</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in collection for reuse/recycling</td>
<td>Increase in clothing collection for reuse/recycling, halving landfill.</td>
<td>Carbon</td>
<td>t CO₂e</td>
<td>7,850,000</td>
<td>7,610,000</td>
<td>-3.06%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>m³</td>
<td>2,180,000,000</td>
<td>2,180,000,000</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td>tonnes</td>
<td>554,000</td>
<td>554,000</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
### Scenario modelling options

In addition to the fourteen default improvement actions, the Footprint Calculator offers eleven improvement scenarios.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Stage</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. Cotton to Polycotton</td>
<td>Design &amp; Production</td>
<td>Replace cotton with polycotton. Default is a 5% decrease in cotton. This is manifest as a 10% increase in 50:50 polycotton:cotton blend. (To customise reductions in cotton, apply this scenario to twice as much cotton as is desired - i.e. 5% decrease = apply to 10%; 10% decrease = apply to 20% etc). Note this is a complex scenario and cannot be edited directly.</td>
</tr>
<tr>
<td>16. Eco-efficiency in raw material/fibre production</td>
<td>Design &amp; Production</td>
<td>Improve process efficiency in material and fibre production stages by 10% for energy and water. Default applies to 10% of production.</td>
</tr>
<tr>
<td>17. Eco-efficiency in yarn production</td>
<td>Design &amp; Production</td>
<td>Improve process efficiency in yarn production stage by 10% for energy, water and chemical inputs. Default applies to 10% of production.</td>
</tr>
<tr>
<td>18. Eco-efficiency in fabric production</td>
<td>Design &amp; Production</td>
<td>Improve process efficiency in material production stage by 10% for energy, water and chemical inputs. Default applies to 10% of production.</td>
</tr>
<tr>
<td>19. New fabric dyeing</td>
<td>Design &amp; Production</td>
<td>Improvements in technology lead to a 65% decrease in water and chemical use and a 25% decrease in energy use. Default applies to 10% of production.</td>
</tr>
<tr>
<td>20. Eco-efficiency in cutting and making-up stages</td>
<td>Design &amp; Production</td>
<td>Improve process efficiency in cutting and making-up production stages by 10% for energy, water and chemical inputs. Default applies to 25% of production.</td>
</tr>
<tr>
<td>21. Longer lifetime for new clothing</td>
<td>Design &amp; Production/In-use/End of life</td>
<td>Extend average active lifetime of clothing by 10% through improved design and influencing consumer behaviour. Default applies to 100% of clothing.</td>
</tr>
<tr>
<td>22. Change in consumer laundry behaviour</td>
<td>In-use</td>
<td>Increase households washing at 40 degrees rather than washing at 60+ degrees through information actions aimed at consumer laundry behaviour. (This scenario is likely to be updated based on feedback from the SCAP influencing consumer behaviour group).</td>
</tr>
<tr>
<td>23. Novozymes Biopolishing</td>
<td>User defined</td>
<td>Biopolishing with Novozymes enzymes at the finishing stage for cotton (removing...</td>
</tr>
</tbody>
</table>
loose ends of cellulose fibres from the surface of the fabric) leads to a 20% increase in garment lifetime (for cotton garments). It is assumed the conventional approach is taken, which requires an extra bath. This is a worst case assumption. 20% lifetime extension is a conservative estimate based on a survey of 310 people carried out for Novozymes in which 70% of respondents said they would keep a biopolished T-shirt for 50% to twice as long. Note - the 'apply to x%' percentage entered should be the proportion of cotton garments treated with the biopolishing process.

<table>
<thead>
<tr>
<th>Section</th>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.</td>
<td>Korbond - Repair - Low - 10%</td>
<td>User defined</td>
</tr>
<tr>
<td>25.</td>
<td>Korbond repair - High - 30%</td>
<td>User defined</td>
</tr>
</tbody>
</table>
www.wrap.org.uk/footprintcalculator