Measuring Cotton Consumption: BCI Conversion Factors and Multipliers

Better Cotton Initiative

Version 1.0 – October 2020

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1. Introduction

For retailers and brands, assessing total annual cotton consumption is the first step towards becoming a BCI Member. It forms an important part of the following fundamental aspects of an RB Membership:

- Membership Fees paid to BCI
- Volume-Based Fees (VBF) paid to BCI's Growth and Innovation Fund
- Implementing a Better Cotton sourcing programme
- Making credible claims using the Better Cotton Claims Framework.

Through this document, BCI provides conversion factors and multipliers to be used in calculating total annual cotton fibre consumption.

2. Background Concepts

2. Background Concepts

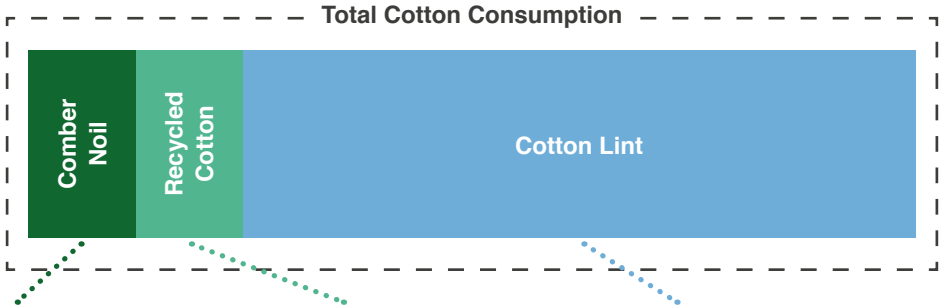
2.1. Total Annual Cotton Consumption

"Total annual cotton consumption" is the total weight of cotton fibres consumed by the supply chain, after the fibres have been separated from the seeds by the ginner, to make all the cotton-containing products (for example, jeans, T-shirts or bed sheets) purchased by a BCI Retailer & Brand (RB) Member for a specific period of 12 months.

- For the apparel and home industry, this typically includes the weight of cotton fibres consumed by spinners to create cotton-containing yarns to make the components of end products.
- For the hygiene, healthcare and consumer goods industries, this typically includes the weight of cotton fibres consumed by spinners, non-woven fabric manufacturers, paper mills and other end-product manufacturers for making end products such as cotton swabs, pet products and toys.

2.2. What is Included in "Cotton Fibres"?

"Cotton fibres" include cotton lint, cotton comber noil and recycled cotton. The following definitions are provided to be used in the context of cotton consumption assessment.



Comber Noil:

Cotton fibre generated as a by-product of the combed yarn spinning process. It is mainly reused in the production of open-end yarns, nonwoven fabrics, hygiene, healthcare and paper products.

Recycled Cotton:

Cotton regenerated from pre-consumer or post-consumer textile products and waste materials through a mechanical or chemical process.

Cotton Lint:

Cotton fibres that are ready to be spun into yarn after being separated from cotton seeds through the ginning process; also referred to as 'virgin cotton'.

Figure 1: Total cotton consumption of a BCI RB Member involves measuring the weight of all cotton fibres, including comber noil, recycled cotton and cotton lint. The proportions shown in the diagram are not representative of actual distributions.

2. Background Concepts

2.3. Textile Production Process and Waste Generation

Cotton fibres are converted into several intermediary products before a cotton-containing end-product is produced.

- At spinning mills, cotton fibres are first converted into different types of yarns
- At fabric mills, yarns are woven or knitted into fabrics
- At manufacturing factories, fabrics are cut and sewn into end-products.

In addition to these major phases of production, raw and intermediary products also go through dyeing and finishing processes.

Fibre losses occur at each step of this production process, affecting a BCI RB Member's total cotton consumption.

Manufacturing losses vary between different levels of supplier in the supply chain, based on the efficiency of the process, specifications and the types of raw materials used, and the desired specifications of the products being produced for customers.

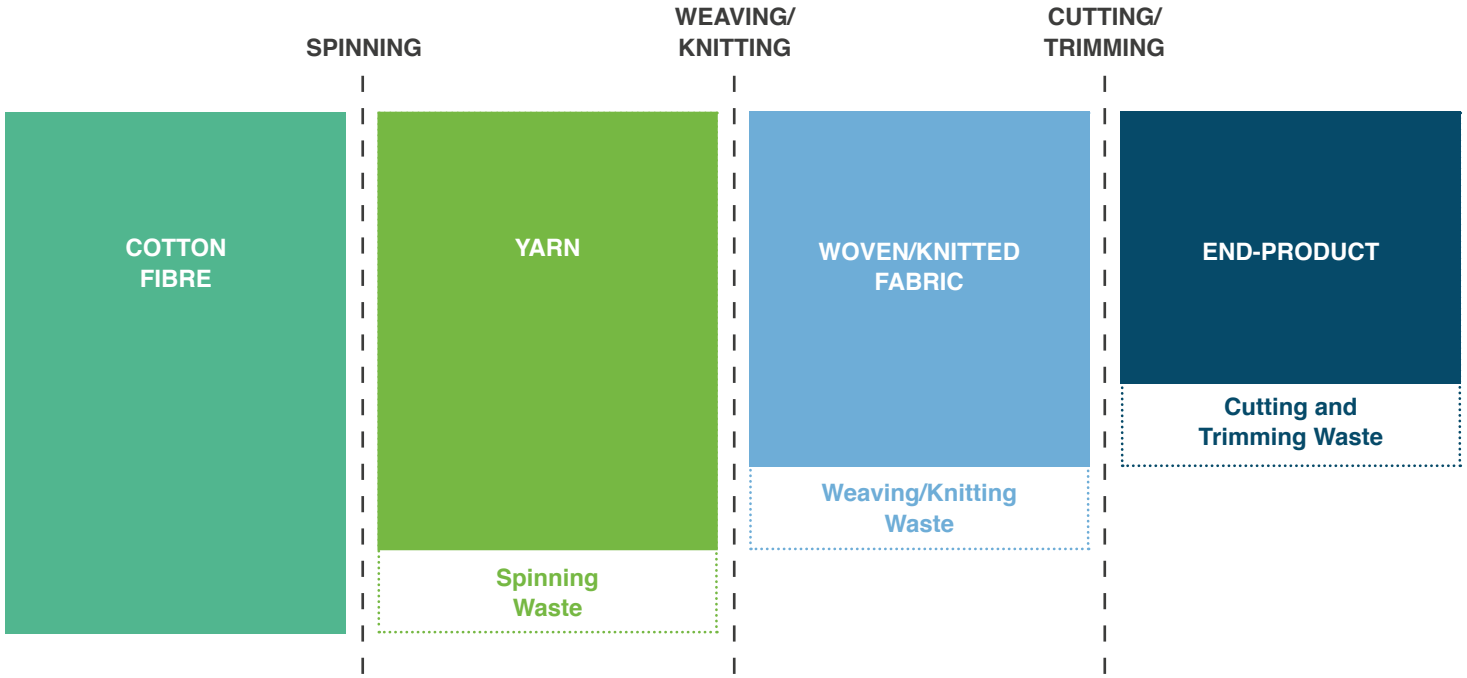


Figure 2: At each step of the manufacturing process, losses mean that the total weight of outputs is lower than the total weight of inputs.

3. Methodology

Two surveys of BCI Supplier and Manufacturer Members were carried out from July to October 2018 and from June to August 2019, to gather data and information for this work.

The methodology for data collection and analysis are described in Annex 1.

A number of organisations, mainly BCI Members, were also consulted during the consolidation of the results - Rieter, Paul Reinhart, Cargill Cotton, Louis Dreyfus Company, The International Cotton Association, Cotton Australia and ABRAPA. Textile Exchange was consulted during the completion of the work.

4. Conversion Rates, Fibre Loss Rates and Multipliers

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4.1 Member Survey Response

201 BCI Members responded to the two-stage BCI Member survey request from July to October 2018 and from June to August 2019. This provided important information used to derive the conversion rates, fibre loss rates and multipliers presented in the following section - Section 4.2 - of this document. These are critical to improving how annual cotton consumption is calculated by BCI Members.

Data collected were consolidated as described in Annex 1 and form the basis of the conversion rates, fibre loss rates and multipliers in this document.

	Yarn Realisation Rate Survey	Fabric & End-Product Multiplier Survey
Countries	5 (IN, BD, PK, CN & TK)	5 (IN, BD, PK, CN & TK)
Cotton Origin	8 (IN, CN, US, PK, BR, AU, Africa & TK)	
Categories	Combed Yarn Carded Yarn Open-End Yarn	Denim, Woven Home Textiles Circular knits, Flat knits, Socks Processes: Fabric Dyeing and Finishing, Yarn Dyeing Apparel: Cut, Make and Trim
Number of Respondents	99	102

4. Conversion Rates, Fibre Loss Rates and Multipliers

4.2 Conversion Rates, Fibre Loss Rates and Multipliers

When assessing the total annual cotton consumption, production process losses are considered as part of three important parameters:

Conversion Rates: The percentage of a manufacturing input that is converted to useful output.

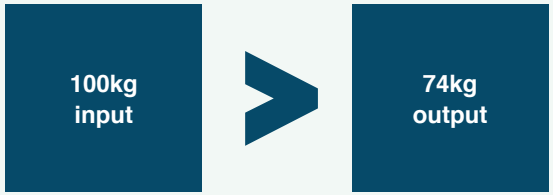
Fibre Loss Rates: The percentage of a manufacturing input that is lost as waste in the manufacturing process.

Multipliers: A mathematical factor used to convert the weight of manufacturing outputs into weight of manufacturing inputs. These are calculated from conversion rates.

The difference between these can be best explained by a short example as follows.

EXAMPLE 1

Consider a spinner consuming 100 kg of cotton fibre to make 74 kg of cotton yarn.



The **Conversion Rate** from fibre to yarn is therefore **74%**

The **Fibre Loss Rate** is **26%** (100% - conversion rate)

The **Yarn to Fibre Multiplier** is **1.35** (ratio of 100 to 74)

Calculating the total cotton consumption given the weight of yarn involves multiplying the yarn weight by 1.35. This “yarn-to-fibre multiplier” is calculated by dividing the input weight (100 kg) by the output weight (74 kg).

The challenge when making total annual cotton consumption calculations is that the output weight, usually end-product weight or fabric weight, is the only information known by RB Members. Therefore, a set of multipliers is required to calculate the input weight in cotton fibres.

In the following sections, we provide possible ranges, expected fibre loss rates and different types of multipliers to assist with total cotton consumption calculations. The assumptions and calculation methods used to obtain these figures can be found in the Annex 1.

4. Conversion Rates, Fibre Loss Rates and Multipliers

4.2.1. Fibre Loss Rates and Multipliers: YARNS

The conversion rate for spinning, which is often referred to as the yarn realisation rate, is one of the most important factors for a spinning mill in terms of the performance of yarn produced and profitability of the plant.

The most important factors that determine this rate are:

- the specifications of the cotton fibres consumed
- the type of yarn being produced, and
- the desired yarn specifications to be achieved.

Among the specifications of cotton fibres consumed, trash content,[1] which is mostly determined by growing, harvesting and ginning conditions, is a significant determinant for the yarn realisation rate. It varies between 2% and 9%, depending on the grade of cotton.

Because of their versatility, ring-spun (combed and/or carded yarns) and rotor-spun yarns (also known as open-end yarns) make up most of the yarns produced in the world. Therefore, for the purposes of this paper, we have collected data on these three major yarn types and used it to determine yarn-to-fibre multipliers for each type.

Compared to carded and open-end yarns, realisation rates for combed yarns differ significantly. This is because combed yarns go through an additional process after the carding process, whereby shorter fibres are "combed" out of the yarn.

Ring-Spun Yarn Processes	Function	Expected Fibre Loss	Average Fibre Loss
Blow Room & Carding	Trash content with attached fibre is removed; fibres are aligned and further cleaned	4% to 18%; most common rate of loss: 10% to 18%	14%
Combing	Further removal of shorter fibres as comber noil	8% to 25%; most common rate of loss: 14% to 17%	16%

Table 1: Different stages of ring-spinning process and the related fibre loss percentages for each stage.

In Table 1:

- The fibre loss during the blow room and carding process is assumed to be twice as much as the trash content in the total cotton fibres consumed at this stage.
- "Noil extraction" refers to the generation of the by-product "comber noil" or "cotton combers". Comber noil is a raw material stock used in open-end yarn production, hygiene and consumer products, nonwoven fabric manufacturing and paper production.
- Average fibre loss rates for different stages of the spinning process were calculated based on the most common average loss rates.

[1] Refers to the percentage of non-lint matter (i.e. leaf fragments of the plant) attached to the cotton fibres.

4. Conversion Rates, Fibre Loss Rates and Multipliers

Yarn Type	Possible Range for Fibre Loss	Expected Fibre Loss	Average Yarn-to-fibre Multipliers
Carded (ring-spun yarn)	10% to 18%	14%	1.16
Combed (ring-spun yarn)	21% to 30%	26%	1.35
Open-End (rotor yarn)	6% to 16%	10%	1.11

Table 2: Fibre loss percentages and yarn-to-fibre multipliers according to yarn type.

Table 2:

- The possible range for fibre loss for carded yarns is equal to the most common expected fibre loss rate during the blow room and carding processes.
- The possible range fibre loss for combed yarns was obtained by combining the most common expected fibre loss for carded yarns and noil extraction rates.
- The possible range for fibre loss for open-end yarns was obtained as a result of the survey ran by BCI among its spinner members.
- The expected fibre loss for different yarn types was equal to the average of the possible ranges for fibre loss. The figure for open-end yarns was adjusted by 1% to be aligned with the most commonly used rate in the industry.
- The average yarn-to-fibre multipliers were obtained using the formula 1 / (1- Expected Fibre Loss Percentage).

Spinning is the part of the production process where the largest range of fibre loss rates is observed. It is therefore important to know the type of yarn used to make the end-product, in order to help ensure the accuracy of cotton consumption calculations.

4. Conversion Rates, Fibre Loss Rates and Multipliers

4.2.2. Fibre Loss Rates and Multipliers: FABRICS

Fibre loss percentages and fabric-to-yarn multipliers differ considerably based on the type of fabric being manufactured. Consequently, the type of fabric used to make the end-product should also be known to help ensure increased accuracy in calculating total cotton consumption.

While fabrics can be categorised in many ways, for the purposes of this document, the following categories and the corresponding multipliers for each category were used.

Type of Fabric	Possible Range for Fibre Loss	Expected Fibre Loss	Average Fabric-to-Yarn Multiplier
Denim	3% to 9%	6%	1.06
Woven	6% to 12%	10%	1.11
Circular Knit	8% to 16%	12%	1.14
Flat Knit	10% to 15%	13%	1.15
Home Textiles	7% to 14%	11%	1.12

Table 3: Fibre loss percentages and fabric-to-yarn multipliers for products made with denim, woven, and circular knit fabrics.

In Table 3:

- "Fibre loss" refers to the total weight loss during fabric production. These loss rates were based on the possible range for fibre loss, which was obtained as a result of a survey of key BCI Member fabric mills.
- "Expected" could refer to either the average or the median value of the raw data on which these figures are based. It is referred to as "average" for simplicity.
- While this guidance document provides "average Fabric-to-Yarn" multipliers for denim, woven and knit fabrics, the multiplier provided for flat knits is the "average end-product-to-yarn", following the specificity of the flat knit process.
- Some rates were adjusted to create alignment in the industry.

4. Conversion Rates, Fibre Loss Rates and Multipliers

4.2.3. Fibre Loss Rates and Multipliers: END PRODUCTS

In the cut, make, trim (CMT) process, "fibre loss" for apparel refers to the total weight lost during the CMT process. A considerable difference in fibre loss is observed between apparel products and home textile products, in particular. Based on the availability of data, different multipliers were calculated to assist total cotton consumption calculations.

End-Product Type	Possible Range for Fibre Loss[2]	Expected Fibre Loss	Average End-Product-to-Fabric Multiplier
Apparel - Knits / Wovens	13% to 23%	18%	1.22
Apparel - Denim	13% to 17%	15%	1.18
Home Textiles	4% to 6%	5%	1.05

Table 4: Fibre loss percentages and end-product-to-fabric multiplier for apparel products.

[2] Here, "fibre loss" for apparel refers to the total weight lost during the CMT process.

4. Conversion Rates, Fibre Loss Rates and Multipliers

4.2.4. Combining Multipliers

The multipliers in Tables 2, 3, and 4 above can be used for relevant textile production cycles to calculate the total cotton consumption of products at different stages of production by multiplying them as illustrated in Figure 3 here.

IF
Yarn-to-Fibre = Multiplier A;
Fabric-to-Yarn = Multiplier B;
End-Product-to-Fabric = Multiplier C,
THEN
the combined multiplier for
Fabric-to-Fibre = A x B;
AND
the combined multiplier for
End-Product-to-Fibre = A x B x C

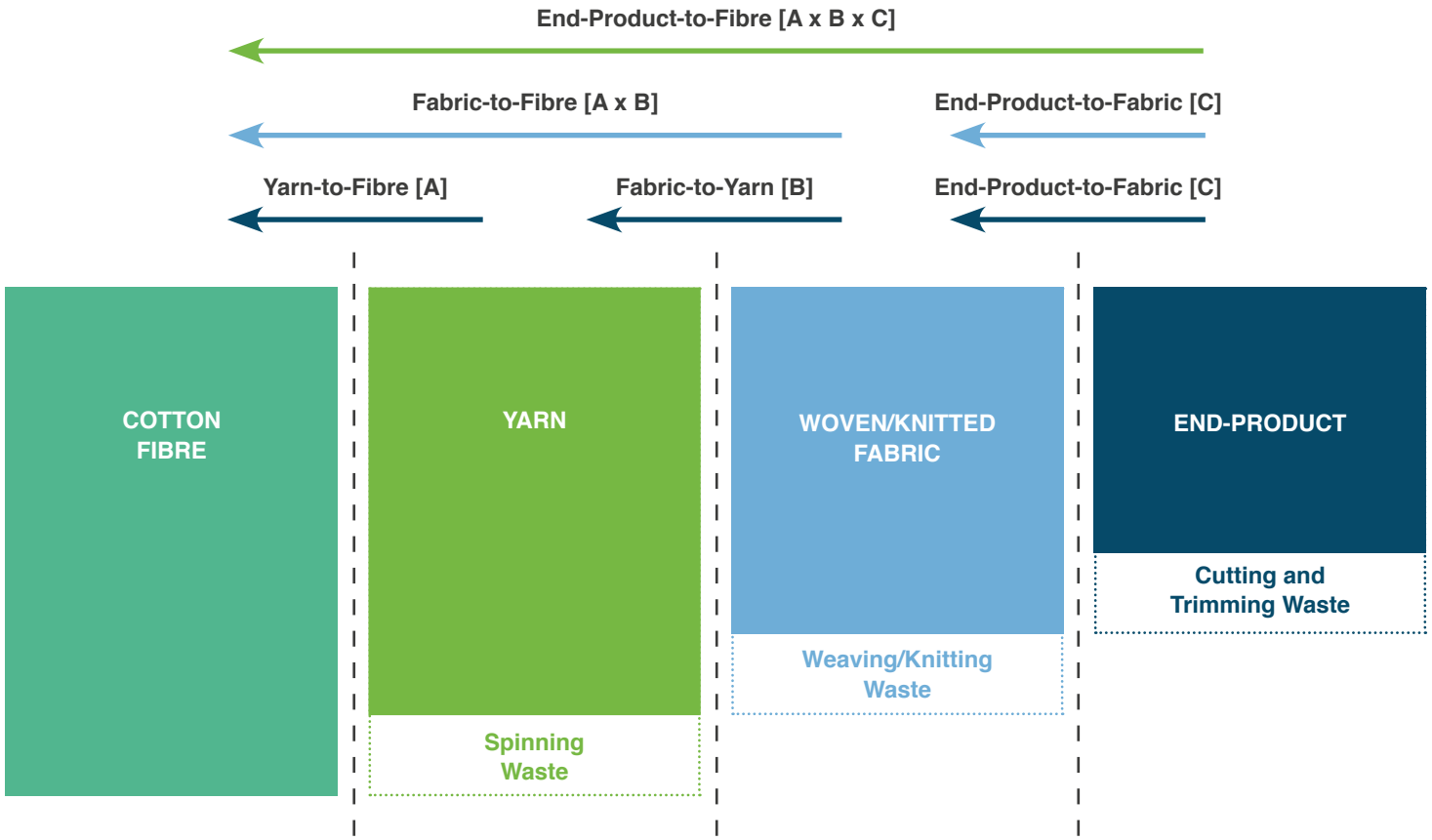


Figure 3: Figure illustrating how Yarn-to-Fabric, Fabric-to-Yarn and End-Product-to-Fabric multipliers are used to create Fabric-to-Fibre and End-Product-to-Fibre calculations.

4. Conversion Rates, Fibre Loss Rates and Multipliers

Customised multipliers can therefore be produced for different end-products, as shown in Table 5.

Multiplier Type	Home Textiles	Apparel: Denim	Apparel: Wovens	Apparel: Flat Knits	Apparel: Circular Knits	Apparel: Yarn and Fabric Types Unknown
End-Product-to-Fabric	1.05	1.18	1.22	1.15	1.22	1.22
Fabric-to-Yarn	1.12	1.06	1.11		1.14	1.14
Yarn-to-Fibre (Open-End)	1.11	1.14	1.14			1.22
Yarn-to-Fibre (Carded)				1.26	1.26	
Yarn-to-Fibre (Combed)						
End-Product-to-Fibre	**1.31**	**1.43**	**1.54**	**1.45**	**1.75**	**1.70**
Fabric-to-Fibre	**1.25**	**1.21**	**1.27**	**-**	**1.44**	**1.39**

Table 5: End-product-to-fibre and fabric-to-fibre multipliers based on fabric, yarn and end-product types.

In many cases, the type of yarn used to produce an end-product may not be known. For example, retailers and brands may not capture this information from their suppliers. In these instances, the average yarn-to-fibre multipliers of possible yarn types suited to the manufacture of the fabric in question can be used in cotton consumption calculations. These are presented in the last column of Table 5.

To calculate the cotton consumption of individual products using these multipliers, the user should multiply the product weight excluding trims and other accessories by the percentage composition of cotton in the product by the combined multiplier of the product stage.

4. Conversion Rates, Fibre Loss Rates and Multipliers

EXAMPLE 2

How much cotton fibre in kg is consumed in a Retailer and Brand order of denim jeans?

A Retailer & Brand places an order of:

- **1,000 units** of pairs of jeans
- Each pair of jeans weighs **0.5kg**
- The jeans have a fabric composition of 75% **cotton**, 25% polyester

The **Net weight of the order** is therefore 500kg (1,000 units X 0.5kg).

The below equation is to be used to calculate the Total Cotton Fibre Consumption of this order.

Total Cotton Fibre Consumption = Net Weight of Order x Percentage of cotton in fabric composition x End-Product -To-Fibre multiplier

Figure 4 shows which multipliers are used in calculating the cotton fibre consumption of a pair of denim jeans.

Total Cotton Fibre Consumption = 500kg x 75% x 1.43 = **536kg**

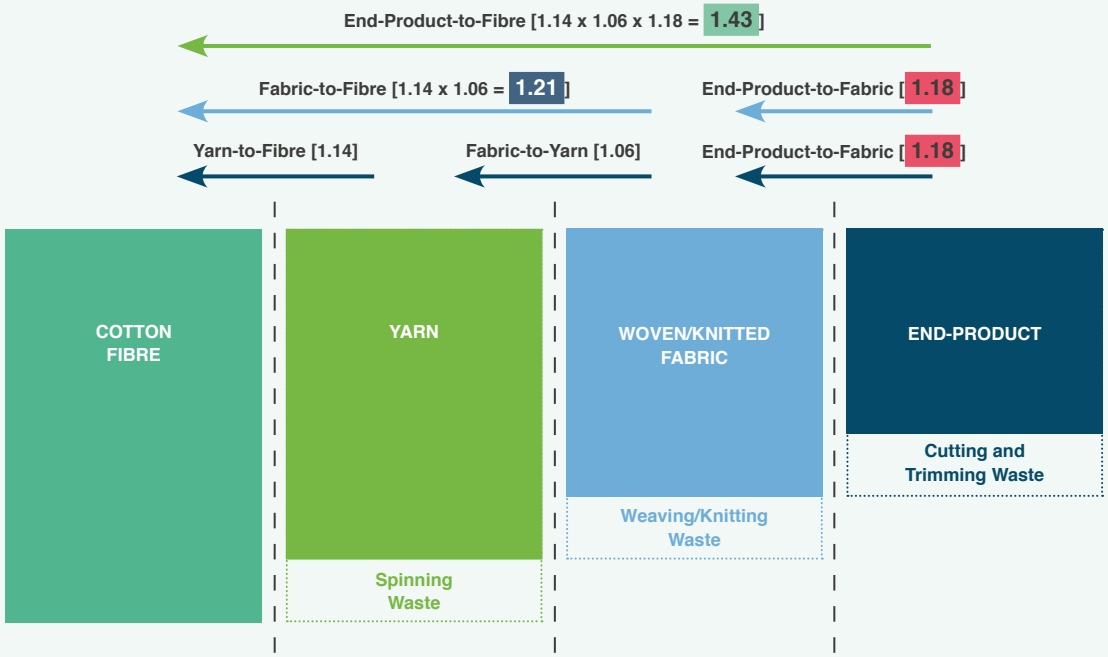
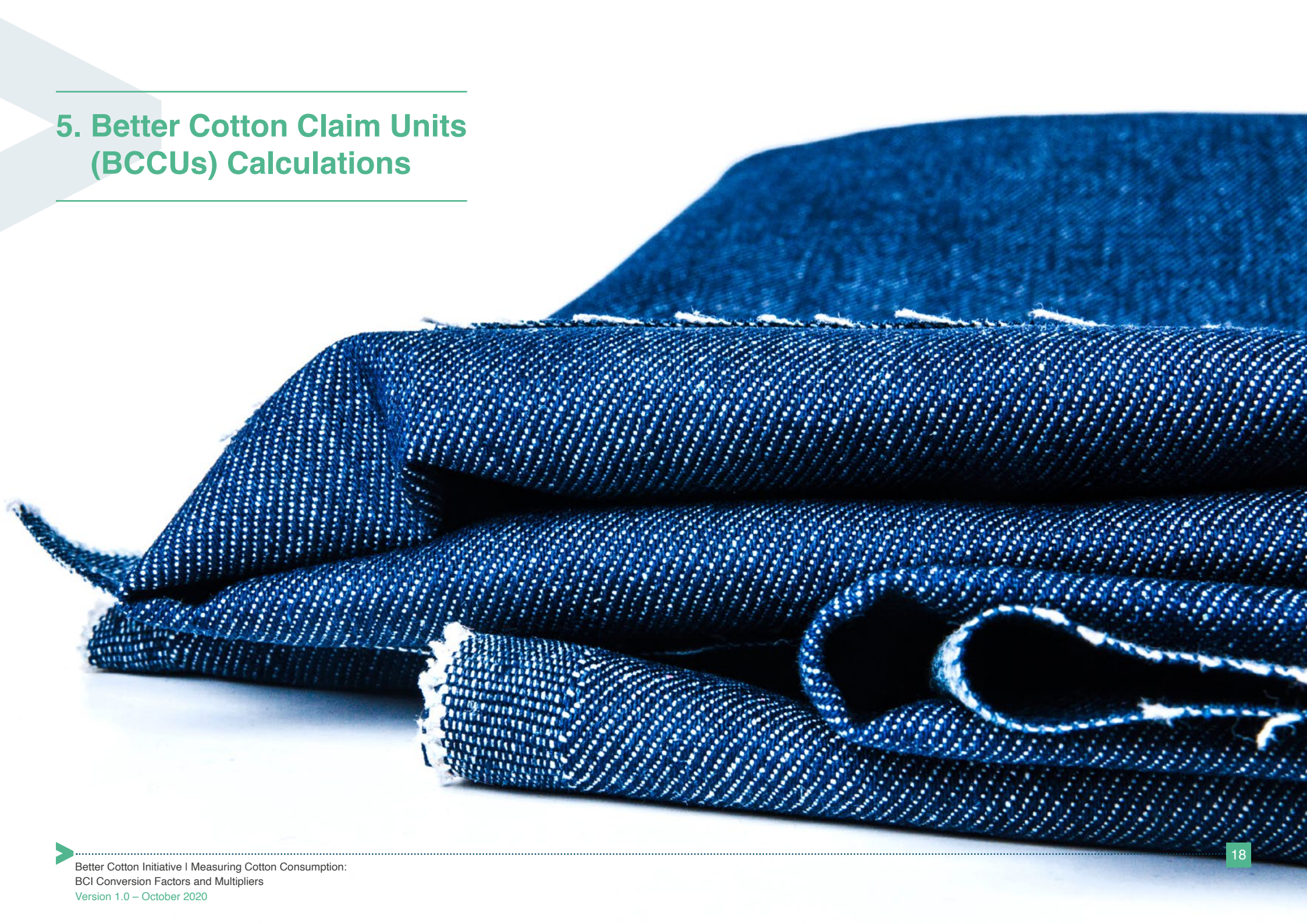


Figure 4: BCI denim multipliers

5. Better Cotton Claim Units (BCCUs) Calculations



5. Better Cotton Claim Units (BCCUs) Calculations

To report the volume of Better Cotton sourced for customers, suppliers and manufacturers enter sales transactions into the Better Cotton Platform (BCP). The type of yarn used in the product is one of the required fields to be completed. Using the built-in yarn-to-fibre multipliers, the BCP automatically calculates how many Better Cotton Claim Units (BCCUs) should be allocated to each entry, as per the Better Cotton Chain of Custody Guidelines. In these transactions, 1 BCCU is equivalent to 1 kg of Better Cotton lint produced by a licensed BCI Farmer. Therefore, BCI Members work in weight and in kg.

EXAMPLE 3

To continue with Example 2, the garment supplier would like to understand how many BCCUs must be allotted to his order of 1,000 pairs of denim jeans for their retailer customer who buys all his orders as Better Cotton. He wants to know how many BCCUs to expect from his fabric supplier.

His Retailer & Brand customer placed an order of:

- **1,000 units** of pairs of jeans
- Each pair of jeans weighs **0.5kg**
- The jeans have a fabric composition of 75% **cotton**, 25% polyester

The **Net weight of the order** is therefore 500kg (1,000 units X 0.5kg).

To calculate how many BCCUs to expect from his fabric supplier, he must first calculate the net weight of cotton in the fabric used to produce the jeans.

For this, the supplier must pick the End-product-to-fabric multiplier for denim from Figure 4 (1.18).

Net weight of cotton in fabric	=	500kg	x	75%	x	1.18	=	**442.5kg**

Once the supplier knows how much cotton is in the fabrics used for the jeans, he can calculate the net weight of cotton fibres used to make the jeans by applying the Fabric-to-Fibre multiplier for denim from Figure 4 (1.21).

Net weight of cotton fibres used to produce the fabric	=	442.5	x	1.21	=	**535kg**

Therefore the garment supplier should expect 535 BCCUs from their supplier.

5. Better Cotton Claim Units (BCCUs) Calculations

5.1 On Discrepancies

The end-product-to-fibre and fabric-to-fibre multipliers seen in Table 5 are based on average fibre loss rates. When averages are used, certain discrepancies are to be expected in calculations. To improve the accuracy of calculations and minimise these discrepancies, the type of fabric and the type of yarn used in the production of an end-product would need to be known. However, retailers and brands do not typically have access to this information at the outset (and do not hold this type of data) when they are making these calculations.

In the case where a Retailer and Brand (RB) Member is using an average yarn-to-fibre multiplier (i.e. the average of combed and carded yarn-to-fibre multipliers), it is inevitable that certain discrepancies are observed between the expected number of BCCUs that RB Members calculate and the number of BCCUs received from the supplier further up the supply chain who selects yarn types when inputting the data for Better Cotton orders.

Below is a simple example that demonstrates how discrepancies can arise even when using average multipliers. These result from RB Members lacking access to the details of their various fabrics down to yarn level, a challenge that is currently difficult to overcome.

EXAMPLE 4

An RB Member calculates expected BCCUs for a product made with circular knit fabrics.

If we assume that a total of 100 kg of 100% cotton yarn of an unknown type was used to make the end-product or the fabric that was used to make this end-product, the possible number of BCCUs obtained for this order could be as follows:

	RB Member	Actual Supplier (1)	Actual Supplier (2)
Situation	Uses the average yarn-to-fibre multiplier shown in Table 5 (1.22).	Uses carded yarn in production. The BCP allocates the BCCUs.	Uses combed yarn in production. The BCP allocates the BCCUs.
Calculation	100 (kg) X 1.22 X 100% = 122 BCCUs	100 (kg) X 1.16 X 100% = 116 BCCUs	100 (kg) X 1.35 X 100% = 135 BCCUs
Resulting discrepancy	**122 estimated BCCUs**	**116 actual BCCUs (-5%)**	**135 actual BCCUs (+11%)**

If RB Members use the average end-product-to-fibre or the fabric-to-fibre multipliers, which are obtained by multiplying average intermediary multipliers, discrepancies with the actual number of BCCUs received can be expected. The magnitude of discrepancies between the expected number of BCCUs and number of BCCUs received depends on the actual type of fabric and yarn used to make the end-product, and which average multiplier the RB Member used. When average multipliers are used, discrepancies should be expected.

6. Next Steps

6.1 Refining Combined Multipliers

Under section 4.2.4 Combining Multipliers, the multiplier for Yarn-to-Fibre has been calculated based on some assumptions (Annex 1). For example, for the Apparel-Wovens category, for the purposes of calculating a Yarn-to-Fibre multiplier, it was assumed that this fabric is produced from 50% Open-End (OE) yarn and 50% Carded yarn. However, yarns are typically used in different proportions. To bring these multipliers closer together, a further study can be conducted to obtain more precise assumptions for each type of yarn used in each category of fabric multipliers.

It is well known that open-end (OE) yarns are widely used in the industry for various applications. It is important to note that OE yarn is produced from a mix of virgin cotton and cotton waste (comber noil). The mix of virgin cotton and comber noil is determined by the supplier, based on the quality of yarn they would like to produce. Comber noil is accounted for in combed yarn consumption today. The average mix of virgin cotton and comber noil is currently not known to BCI. To bring more accuracy to cotton consumption calculations, BCI expects to establish the average mix of virgin cotton and comber noil used for OE yarns from its online system when these factors are updated within the Better Cotton Platform, and by collecting data on this particular cotton fibre fraction over time.

6.2. Implementation

BCI will implement new end-product-to-fibre or fabric-to-fibre multipliers in a phased approach through an RB Member-wide recalculation by the end of 2020. In addition, to complement this approach, we will develop appropriate tools and control processes to help ensure that the multipliers are applied as consistently as possible across the members concerned. The multipliers on the Better Cotton Platform – BCI's online platform for registering data - will also be updated with new multipliers.

All retailers and brands are invited to use the information in this paper as they seek to estimate cotton usage for their cotton sourcing strategies.

Annex 1: Methodology

3.1 Data Collection

To gather the data used in the analysis that informed the ranges, rates and other figures mentioned in this document, several data collection methods were deployed.

1. BCI member spinning mills were surveyed. They were asked to provide BCI with the minimum and maximum fibre loss rates they observe when manufacturing carded, combed and open-end yarns.
2. In addition to spinning mills, BCI also surveyed key fabric mills and end product manufacturers to gather data on fibre loss in manufacturing different types of fabrics and end-products.
3. In addition to surveys, BCI has also reached out to a wide range of producer organisations, merchants, and other organisations that are involved in this type of work.
4. Textile Exchange was consulted extensively and some of the figures seen in this document were directly adopted from its work. Figures mentioned in this document are to be updated in the future, in collaboration with Textile Exchange.

3.2 Data Analysis

Assumptions

In establishing different Yarn-to-Fibre multipliers, certain assumptions were made about the proportional use of the different predominant yarn types for the respective fabric categories. These assumptions are laid out in the following table:

Fabric Category Assumptions (%)	Yarn Usage Assumptions (%)		
	Combed	Carded	Open-end
Denim	-	50%	50%
Woven	-	50%	50%
Circular Knit	50%	50%	-
Flat Knit	50%	50%	-
Home Textiles	-	-	100%

For “Apparel-Yarn and Fabric Types Unknown” category, the assumption was a mix of 80% knits and 20% wovens and denim.

Statistical Analysis

All statistical measures of central tendency (mean, median, mode) and descriptions of dispersion (standard deviation, variance, range) were examined to determine the best measure in determining the “expected fibre loss” rates. It was determined that the expected fibre loss rate would be taken from the mean value of the average of the maximum and minimum values. Put simply, we used the mean of the mean. This is a conservative measure and assumes that the data is distributed relatively normally, without skew. The conversion rate value was always reported as an integer (e.g. 7% instead of 7.1%) using standard rounding rules where 0.5% is rounded to the next highest integer value.

Given the limited data (number of observations), a conservative measure rather than more advanced techniques (e.g. regression analysis) was used. The primary limitations of the analysis were: 1) the size of the data set (number of observations) which was relatively small; and 2) the data was self-reported. The analysis took account of these limitations by focusing on measures less sensitive to outliers (e.g. median versus mean).

Acknowledgements

BCI would like to thank its Supplier and Manufacturer Members for their participation in this study by responding to our surveys. Rieter, Paul Reinhart, Cargill Cotton, Louis Dreyfus Company, The International Cotton Association, Cotton Australia and ABRAPA also informed some to the technical aspects of this work. We worked with Textile Exchange during the final stages of the work to ensure consistency with similar work they were carrying out. Our Advisory Committee – six BCI Retailer and Brand Members – contributed to the final version of this document: adidas Group, Bestseller, C&A, Gap Inc, H&M and Marks & Spencer.

BCI is grateful for all of these contributions.

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