

TEXTE

73/2025

# Cost allocation and incentive mechanisms for environmental protection in the cotton-garment supply chain

Summarised results for decision makers in the industry

Based on reports by

Joseph Strasser, Bibiana Garcia, Carolin Grüning, Chung Tran, Kristiina Martin, Jürgen Hannak, Josephine Jüde, Michelle Becker  
adelphi, Berlin

Janina Grabs  
ESADE Business School, Barcelona, Spain

Joerg Hofstetter  
KEDGE Business School, Talence, France

Edited by

Maik Nagel, Christoph Töpfer and Jan Kosmol  
Section I 1.5 and Section III 2.1



TEXTE 73/2025

REFOPLAN of the Federal Ministry for the Environment,  
Nature Conservation, Nuclear Safety and Consumer  
Protection

Project No. (FKZ) 32722 14 1010  
FB001916/ENG

## **Cost allocation and incentive mechanisms for environmental protection in the cotton- garment supply chain**

Summarised results for decision makers in the industry

Based on reports by

Joseph Strasser, Bibiana Garcia, Carolin Grüning, Chung  
Tran, Kristiina Martin, Jürgen Hannak, Josephine Jüde,  
Michelle Becker  
adelphi, Berlin

Janina Grabs  
ESADE Business School, Barcelona, Spain

Joerg Hofstetter  
KEDGE Business School, Talence, France

Edited by

Maik Nagel, Christoph Töpfer and Jan Kosmol  
Section I 1.5 and Section III 2.1

## **Imprint**

### **Publisher**

Umweltbundesamt  
Wörlitzer Platz 1  
06844 Dessau-Roßlau  
Tel: +49 340-2103-0  
Fax: +49 340-2103-2285  
[buergerservice@uba.de](mailto:buergerservice@uba.de)  
Internet: [www.umweltbundesamt.de](http://www.umweltbundesamt.de)

### **Report performed by:**

adelphi research gGmbH  
Alt-Moabit 91  
10559 Berlin  
Germany

### **Report completed in:**

December 2024

### **Edited by:**

Section I 1.5  
Maik Nagel, Christoph Töpfer

### **DOI:**

<https://doi.org/10.60810/openumwelt-8134>

ISSN 1862-4804

Dessau-Roßlau, November 2025

Please note that this document is a compilation of information published in three UBA research reports. Please do not cite this document but refer to the published reports instead (see List of references).

**Abstract: Cost allocation and incentive mechanisms for environmental protection in the cotton-garment supply chain**

The research project “Cost allocation and incentive mechanisms for the environment, climate protection and resource conservation along global supply chains” (project number 3722 14 101 0) commissioned by the German Environment Agency investigated (dis)incentives for and barriers to the implementation of environmental measures as well as the exchange of information between different actors along selected global supply chains. The project focused on five supply chains from raw material to the end product that represent key sectors of the German industry with a high potential for environmental and human rights risks: cotton-readymade garments; tin – tin solder; natural rubber – car tyres; coffee – coffee for consumption; iron ore – quality steel for automotive industry. It aimed to provide guidance to business and policy makers to facilitate the practical implementation of effective environmental upgrade measures along these global supply chains and to allocate the distribution of the resulting cost and benefits more equitably. This report consolidates the research findings for the cotton-garments supply chain. It is a compilation of texts already published in other reports with the purpose of informing decision makers in the cotton-garment supply chain.

**Kurzbeschreibung: Kostenverteilungs- und Anreizmechanismen für den Umweltschutz in der Baumwoll-/Textillieferkette**

Das vom Umweltbundesamt in Auftrag gegebene Forschungsprojekt „Kostenallokation und Anreizmechanismen für Umwelt-, Klima- und Ressourcenschutz entlang globaler Lieferketten“ (Forschungskennzahl 3722 14 101 0) analysierte (Fehl-)Anreize und Barrieren für die Umsetzung von Umweltschutzmaßnahmen sowie den Informationsaustausch zwischen verschiedenen Akteur\*innen entlang ausgewählter globaler Lieferketten. Das Projekt konzentrierte sich auf fünf Lieferketten, die Schlüsselsektoren der deutschen Industrie mit einem hohen Potenzial für Umwelt- und Menschenrechtsrisiken darstellen und betrachtet diese vom Rohstoff bis zum Endprodukt: Baumwolle – Konfektionsware, Zinn – Lötzinn, Naturkautschuk / Autoreifen, Kaffee – Konsumkaffee, Eisenerz – Qualitätsstahl für die Automobilindustrie. Das Projekt soll Unternehmen und politischen Entscheidungsträger\*innen als Orientierungshilfe dienen, um die praktische Umsetzung wirksamer Umweltschutzmaßnahmen entlang der globalen Lieferketten zu erleichtern und die daraus resultierenden Kosten und Nutzen gleichmäßiger zu verteilen. Dieser Bericht fasst die Forschungsergebnisse für die Baumwoll-/Textillieferkette zusammen. Der Bericht ist eine Zusammenstellung von Texten, die bereits in anderen Forschungsberichten veröffentlicht wurden, mit dem Ziel Entscheidungsträger\*innen in der Baumwoll-/Textillieferkette zu informieren.

## Table of contents

Table of contents.....	6
List of figures .....	7
List of tables .....	8
1 Introduction and background of the research project.....	9
2 Supply chain profile for cotton and garment .....	11
2.1 Background .....	11
2.2 Market structure .....	12
2.3 The cotton-garment value chain.....	15
2.4 Pricing.....	20
2.5 Power relationships .....	21
2.6 Addressing environmental impacts by voluntary measures.....	24
2.7 Current/future trends and developments .....	26
2.8 Institutional incentive mechanisms and barriers.....	29
3 Sustainable supply chain management approaches and instruments.....	33
3.1 Main environmental impacts in the cotton-garment supply chain .....	33
3.2 Sustainable supply chain management approaches and instruments used in the cotton-garment supply chain.....	35
4 Roadmap for the cotton-garment supply chain.....	44
4.1 Environmental target and background .....	44
4.2 Description of the roadmap .....	47
4.2.1 Instrument 1: Water stewardship programme.....	48
4.2.2 Instrument 2: Codes of Conduct vs. Environmental Performance Clauses .....	50
4.2.3 Instrument 3: Responsible purchasing practices.....	52
4.2.4 Instrument 4: Offtake agreements .....	53
4.2.5 Instrument 5: Process certifications .....	54
4.2.6 Instrument 6: Environmental performance platforms .....	56
4.2.7 Instrument 7: Green and collaborative financing.....	58
4.2.8 Instrument 8: Training/capacity building.....	59
4.2.9 Improved supplier/factory communication.....	61
4.2.10 Direct sourcing/vertical supply chain integration.....	61
4.2.11 Policymaking/lobbying.....	62
4.3 Other instruments.....	63

4.4 Discussion of the roadmap for the cotton-garment supply chain.....	64
List of references .....	66

## List of figures

Figure 1:	Leading countries of origin for clothing imports into Germany 2022, based on import value by country.....	12
Figure 2:	Leading cotton producing countries in 2021/2022, by country .....	12
Figure 3	Top 10 export countries of raw cotton, 2021.....	13
Figure 4	Top 10 import countries of raw cotton, 2021 .....	13
Figure 5:	Countries importing garments, by continent, in 2018 (in percentage) .....	14
Figure 6:	Cotton-garment value chain.....	16
Figure 7:	Selected key structures and processes of the cotton-garment value chain.....	19
Figure 8:	Subsidies provided by governments to the cotton sector .....	21
Figure 9:	Selected certifications in the cotton garment supply chain.....	26
Figure 10:	Matrix of instruments and approaches in the cotton-garment supply chain.....	43
Figure 11:	Roadmap for improved environmental performance in the cotton-garment supply chain .....	48

## List of tables

Table 1:	Main environmental impacts in the cotton garment value chain .....	17
Table 2:	Dominant business models and governance in the cotton-garment value chain .....	23
Table 3:	Differences in buyer-supplier relationships by supplier importance (tier 1) .....	24
Table 4:	Market, consumer and technology trends .....	28
Table 5:	Main environmental impacts along the cotton-garment supply chain .....	34
Table 6:	Key actors and actions for implementing a water stewardship programme .....	49
Table 7:	Key actors and actions for implementing environmental performance clauses .....	51
Table 8:	Key actors and actions for implementing responsible purchasing practices .....	52
Table 9:	Key actors and actions for implementing offtake agreements	53
Table 10:	Key actors and actions for implementing process certifications .....	55
Table 11:	Key actors and actions for using environmental performance platforms .....	57
Table 12:	Key actors and actions for implementing green and collaborative financing .....	58
Table 13:	Key actors and actions for implementing training and capacity building .....	59
Table 14:	Key actors and actions for improved communication between brands/retailers and suppliers/factories .....	61
Table 15:	Key actors and actions for direct sourcing/vertical supply chain integration .....	62
Table 16:	Key actors and actions for policymaking/lobbying .....	62



# 1 Introduction and background of the research project

The research project “Cost allocation and incentive mechanisms for the environment, climate protection and resource conservation along global supply chains”, commissioned by the German Environment Agency, investigates (dis)incentives for and barriers to the implementation of environmental upgrading activities as well as the exchange of information between different actors along selected global supply chains. The report addresses the issue that the implementation of environmental upgrading activities is often accompanied by significant costs (both financially and in terms of resources and expenditure). Observations from the research conducted in the project confirm that these costs are often unevenly distributed among the actors involved in the setting of global supply chains - the costs are often higher for the less powerful and financially weak suppliers, while the benefits from the implementation of environmental protection measures (e.g. improved reputation) are focused to a greater extent on more powerful and financially stronger, larger purchasing companies. This can hinder the effective implementation of environmental and climate protection as well as cooperation between supply chain actors. For this reason, the report is intended to provide guidance to businesses and policy makers to facilitate the practical implementation of environmental upgrading activities along global supply chains and to improve the distribution of cost and benefits in the process.

The project focuses on global supply chains from raw material to the end product that represent key sectors of the German economy with a high potential for adverse environmental impacts. We analyse the following five supply chains:

- ▶ Cotton and the manufacturing of cotton-based ready-made garments
- ▶ Tin and tin solder for the manufacturing of electronics
- ▶ Natural rubber and car tyres for the automotive industry
- ▶ Coffee for retail and consumer brands
- ▶ Iron ore and quality steel for the automotive industry

Building on the findings this report will synthesise the overall project findings, ultimately resulting in a roadmap combining seven instruments that appear most promising to more equitably distribute costs and benefits and thus support the effective implementation of environmental upgrading activities in the global **cotton and the manufacturing of cotton-based ready-made garments supply chain**. These instruments were chosen based on a qualitative assessment of all materials collected throughout the project implementation – consisting of an extensive literature review, workshops and interviews with practitioners and various industry experts. They were mentioned repeatedly as being the most promising approaches to environmental upgrading, cost-benefit sharing and cooperation between different stakeholders along global supply chains. Some are already in use, while most are not yet used or still in pilot phases in the analysed supply chains.

Chapter 2 contains a supply chain profile for the cotton-garment industry. By focusing on the market design, e. g. market structures, pricing mechanisms, power structures in the value chain and barriers for mainstreaming environment protection in the supply chain, this chapter lays the ground for the analysis of how to promote sustainable supply chain management (SSCM) in the industry. Chapter 3 maps the main environmental impacts in the cotton-garment supply chain and provides an overview of the SSCM instruments already in use by garment producers and their suppliers or that are currently emerging. Chapter 4 presents a roadmap for the introduction of SSCM instruments that can deliver meaningful incentives to improve wastewater

quality along the cotton-garment supply chain at all stages. The roadmap was created in close collaboration with a European retail chain that is known for its wide range of consumer goods, including textiles and fashion. Additionally, it is backed by research, interviews with other industry representatives and workshops.

By considering SSCM instruments and related incentive mechanisms that go beyond current practice, the report aims to support industrial actors as well as those who regulate, finance or otherwise support these sectors in furthering an equitable distribution of costs and benefits, supporting the effective implementation of environmental upgrade activities along global supply chains.

## 2 Supply chain profile for cotton and garment

This chapter is an excerpt of the report “Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains - Analysis of the cotton, tin, natural rubber, coffee and iron ore supply chains” (Strasser et al. 2024). The supply chain profile for the cotton-garment supply chain contains background information on the commodities, an explanation of the market structure, the functioning of the value chain, pricing mechanisms and power relationships, an indication of how the industry addresses its environmental impacts as well as an outlook on market, consumer and technology trends that will likely shape the future composition and functioning of the value chain. The chapter ends with lining out selected institutional incentive mechanisms and barriers for environmental upgrading of cotton-garment supply chain.

### 2.1 Background

Cotton is the second most common fibre in the world after polyester and accounts for 24% of global fibre production. At 80%, cotton is the most widely used natural fibre, with 30% of total production processed into finished products for the textile and fashion industry (Lanfranchi and Cline 2021; Cotton Connect 2022). The cotton industry secures the livelihoods of approximately 100 million households, especially in lower-income countries (Voora et al. 2023a). However, resource-intensive production and unsustainable practices have led to high levels of environmental pollution and poverty in some regions (Lanfranchi and Cline 2021).

In many societies, cotton played an important role in the early stages of industrialisation. The labour-intensive textile and clothing industry were one of the first industries in Germany. Cotton used to be imported from cotton growing countries and further processed to garments and other articles. Since the 1970s, globalisation has initiated a structural change that has led German companies to outsource labour-intensive, cotton-based clothing production to low-cost countries in Southern Europe, Asia, and Eastern Europe. Instead of cotton, German companies have specialised in the production of more value-added technical textiles, which are often based on synthetic fibres<sup>1</sup>. As clothing consumption has dramatically increased over the years (Changing Markets Foundation 2022)<sup>2</sup>, Germany relies heavily on imports, mostly from countries like China, Bangladesh, Türkiye and Vietnam (see Figure 1). In 2020, Germany imported clothing products worth 38.4 billion U.S. dollars, which makes it the second largest importer of clothing in the world after the United States of America (WTO 2022b). Given the high reliance on suppliers of cotton, intermediate and final products, the following profile focuses on the readymade garment supply chain as a cotton-based commodity<sup>3</sup>.

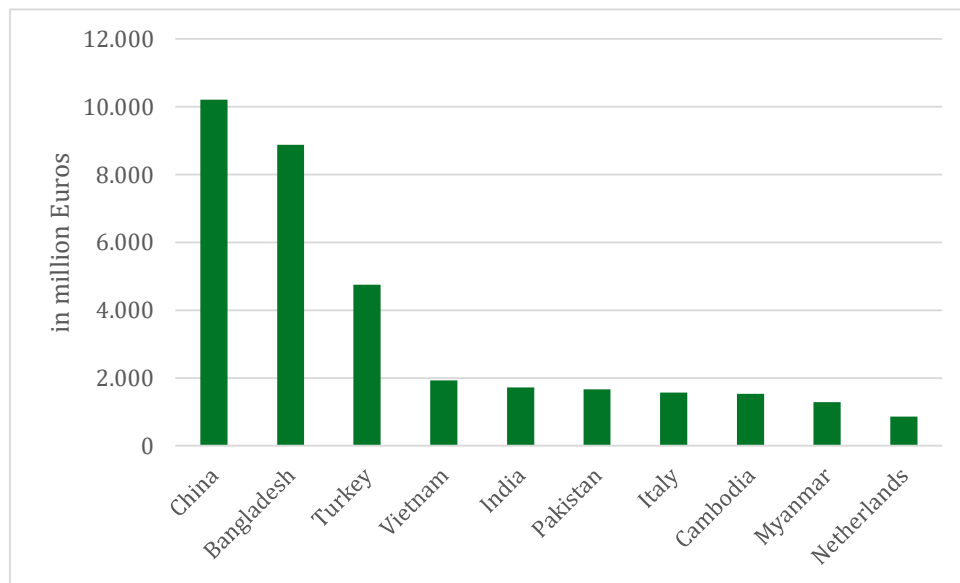
---

1 Home textiles and technical textiles, which are often made of synthetics, are not considered in this study.

2 Overall consumption of garments has doubled in the past 20 years to 62 million tonnes.

3 This supply chain profile uses the terms “readymade garments”, “apparel” and “clothing” interchangeably.

**Figure 1: Leading countries of origin for clothing imports into Germany 2022, based on import value by country**

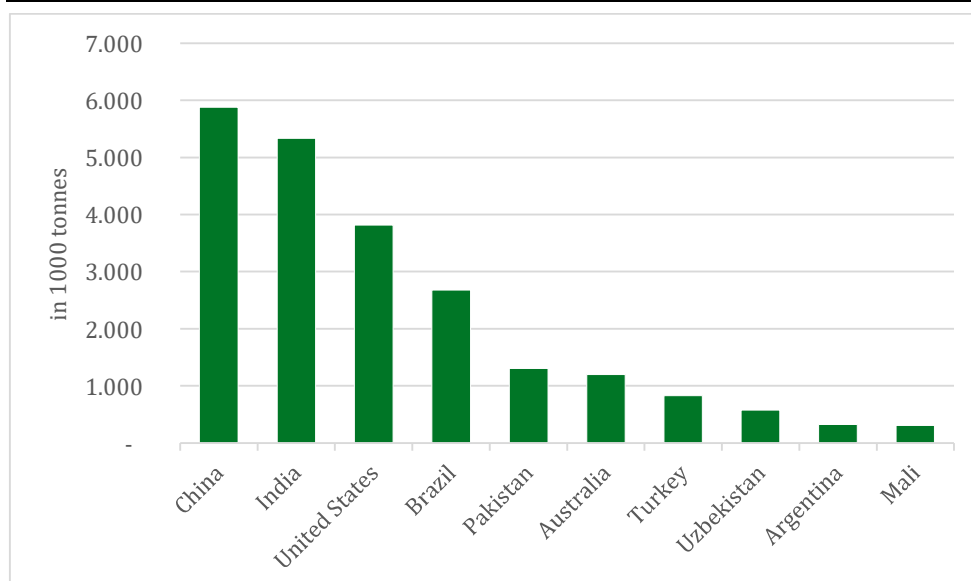


Source: adelphi, based on information from Destatis (2023)

## 2.2 Market structure

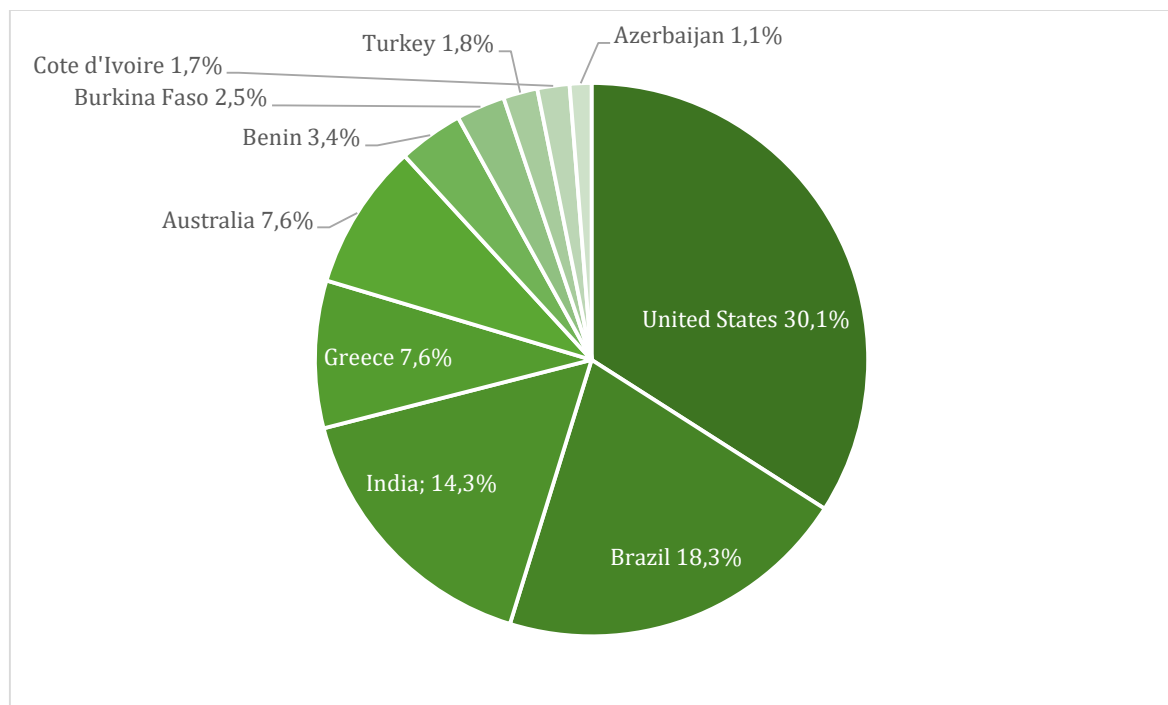
Cotton is cultivated in over 80 countries, with production concentrated in China, India, the U.S., Brazil and Pakistan (see Figure 2). The plant grows in hot and dry conditions, but needs some moisture, which varies with geographical region and may require supplementary irrigation (Voora et al. 2023a). While large farms dominate in the U.S., in the Global South smallholder cotton farming is predominant, producing more than 60% of the global cotton. As a reference, South Asia (Bangladesh, India, Pakistan, Sri Lanka) produced approximately 7.4 million tonnes (29%) of the total cotton production in 2018; 90% of it was genetically modified (Voora et al. 2023a).

**Figure 2: Leading cotton producing countries in 2021/2022, by country**



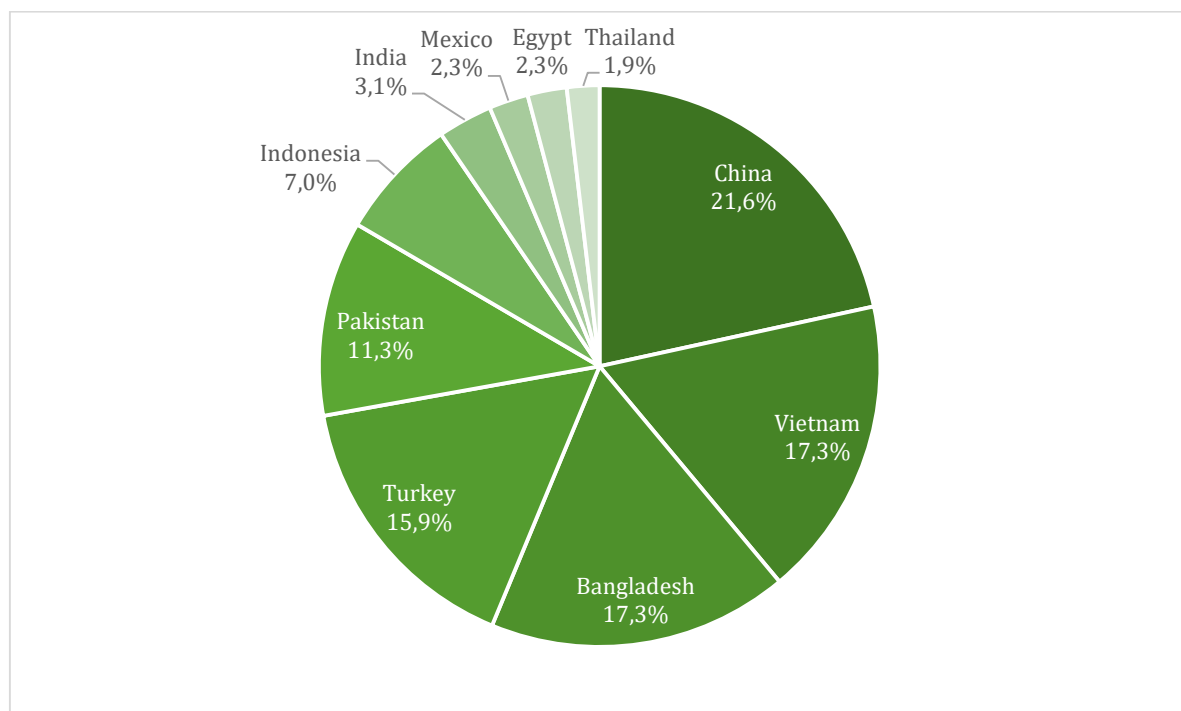
Source: adelphi, based on information from U.S. Department of Agriculture (2022)

**Figure 3 Top 10 export countries of raw cotton, 2021**



Source: adelphi, based on information from OEC (2023e)

**Figure 4 Top 10 import countries of raw cotton, 2021**



Source: adelphi, based on information from OEC (2023f)

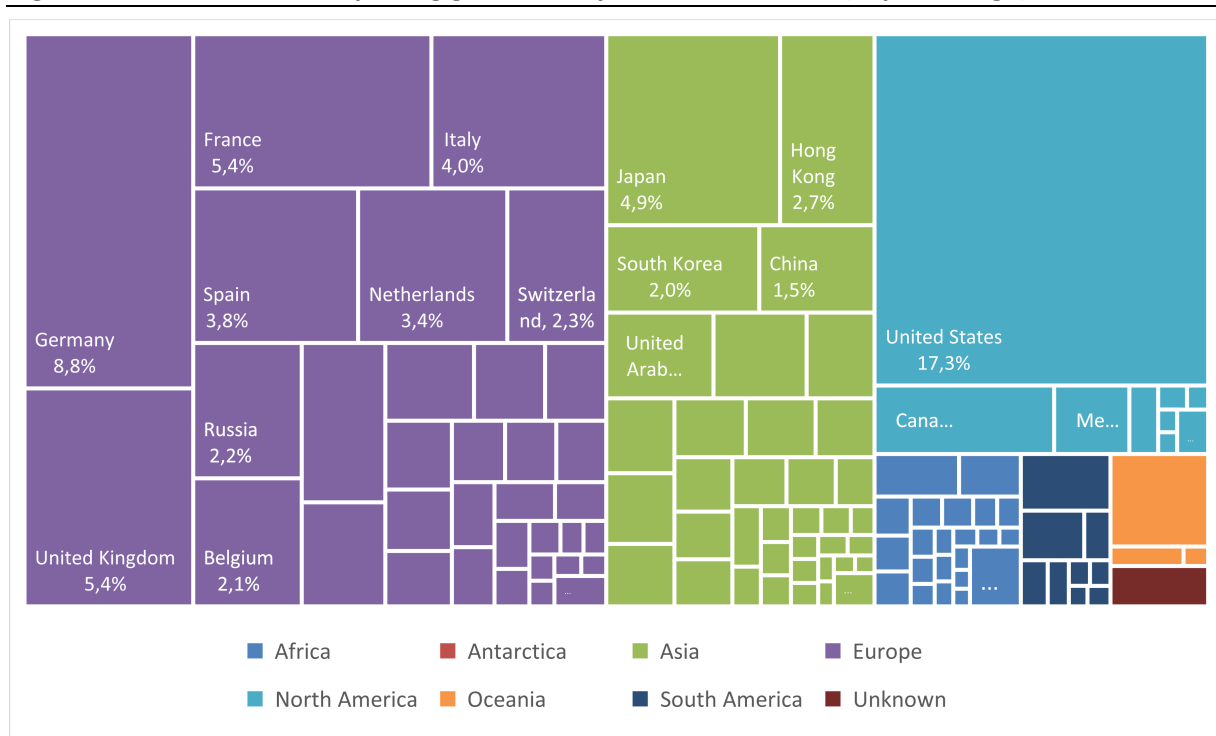
**Cotton exports** are led by the U.S., Brazil, India (see Figure 3). China, India, Pakistan, Türkiye and some Central Asian countries export, but mostly keep their cotton for internal value addition and process it further until finishing. China's ranking (32<sup>nd</sup>), which is lower than in previous years, could be due to two factors: i) allegations of exploitation of Uyghurs in cotton cultivation and subsequent import bans (e.g. by the U.S.) on cotton products from the region

(Kimble 2022); ii) China's large processing capacity for the domestic market, partly reflected in in the country being the largest importer of cotton (\$3.49b; 18.7%) (see Figure 4).

The garment market consists of a large number of producer firms, mostly in the Global South. In 2021, the key export countries for clothing, including natural fibres and synthetic materials, were China – by far – followed by the European Union (EU), Bangladesh, Vietnam and Türkiye<sup>4</sup>. Apart from China, South Asian manufacturers from Bangladesh, India and Pakistan dominate **cotton-based garment exports**, in large part due to the strong backward linkages and domestic availability of cotton in India and Pakistan (ILO 2018). Bangladesh, currently the second largest exporting country of garments, relies on imports of cotton yarn and fabrics, which it then finishes at low labour costs. Southeast Asian countries on the other hand, such as Cambodia, Vietnam, Indonesia and Myanmar, process a larger share of human-made fibres, i.e. synthetic and cellulosic fibres (ILO 2018). In countries like Bangladesh, Cambodia, Myanmar and Vietnam, low value-added **cut-make-trim (CMT) operations** predominate. Thanks to its large capacities and strong backward linkages, the Chinese garment industry exports by far the largest volumes of products based on both cotton and synthetic fibres, strengthening its bargaining position with international buyers, although China's position in the value chain has been weakened lately (see Section 2.7).

The **main consumer markets**<sup>5</sup> for cotton-based garments are the U.S., within the EU mainly Germany and France, and the United Kingdom. As data on cotton garment imports are not widely available, Figure 5 refers to all imported garments, that is also those made of synthetic materials. The dominance of Europe and North America as consumer markets in relation to their population compared to Asia is striking.

**Figure 5: Countries importing garments, by continent, in 2018 (in percentage)**



Source: adelphi, based on data from OEC (2023a)

<sup>4</sup> Data about the clothing/garment industry may be inconsistent, involve other sectors (e.g. leather) or use estimations. Unfortunately, reliable data on cotton-based garment exports were not available.

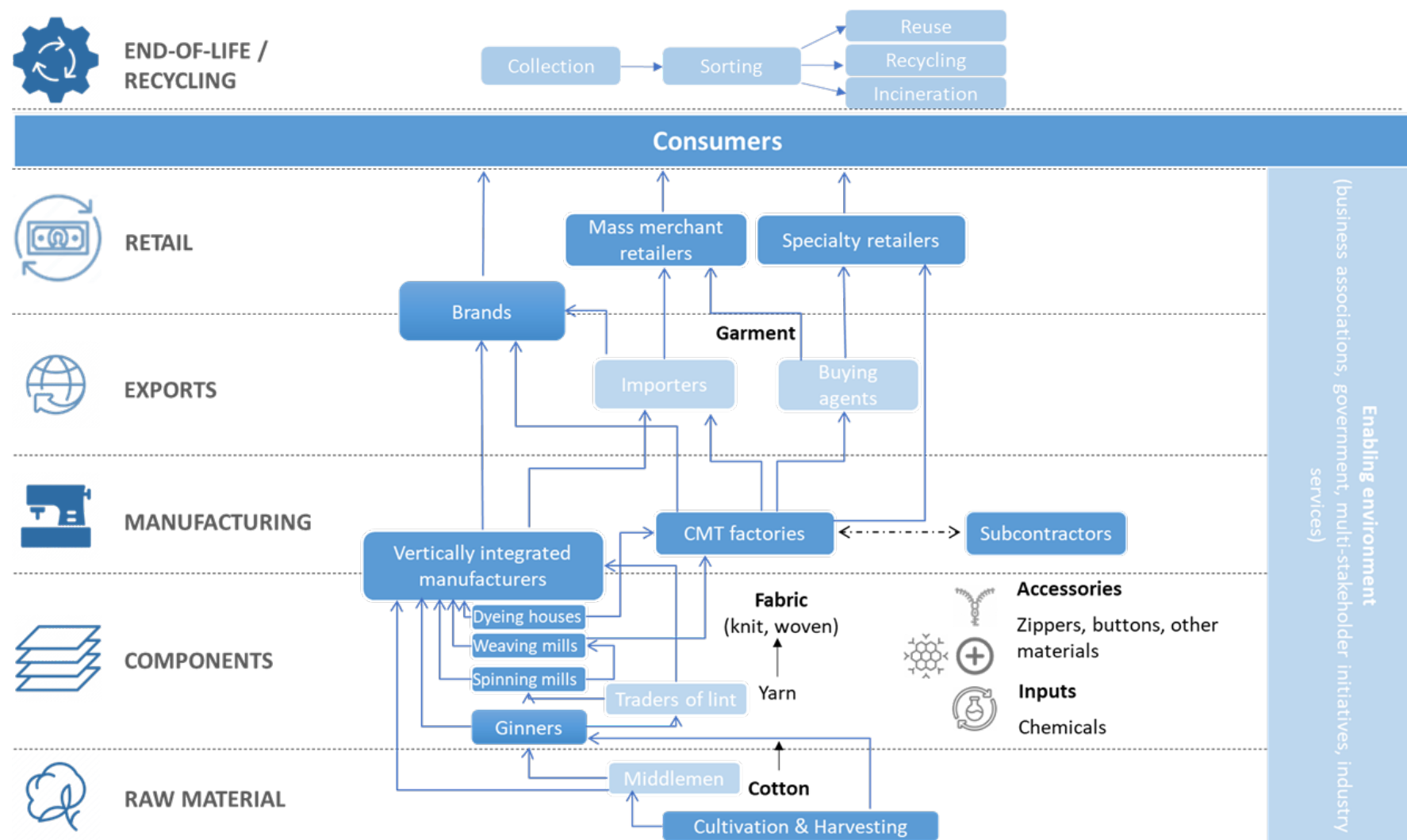
<sup>5</sup> The term consumer market refers to imports. Re-exports are not considered.

## 2.3 The cotton-garment value chain

International garment production is increasingly organised in global value chains, with buying companies (e.g., brands/retailers) splitting up their operations, some of which are carried out in-house (e.g. R&D, design) or are outsourced to manufacturing firms (suppliers) in low-cost countries.

The **cotton-garment value chain** as portrayed in Figure 6 is organised in five stages (raw material, components, manufacturing, exports, retail) and is to be complemented by post-consumption processes like collection of post-consumer waste, sorting and recycling.

Figure 6: Cotton-garment value chain



Source: adelphi, adapted from ILO (2018)



**Cotton farmers** grow cotton mainly for its fibre. There are three types of cotton: conventional cotton, sustainable cotton and organic cotton. **Conventional cotton** usually uses seeds that have been genetically modified or treated with chemicals to increase yield (Textile Exchange n.d.). The use of pesticides and fertilisers is essential in the cultivation of conventional cotton. Genetically modified cotton has become a growing industry for countries that are dependent on cotton imports (e.g. Bangladesh), that want to reduce their dependence on Asia because of high transportation and logistics costs (e.g. EU and North American markets) or that need to adapt to the changing climatic conditions (Voora et al. 2023a). **Sustainable cotton** aims to make more efficient use of natural resources such as water, land, carbon and energy, but is not completely free from pesticides and fertilisers (CottonWorks™ n.d.). **Organic cotton** is not genetically modified or treated with pesticides and fertilisers.

The cotton, harvested either by machine or manually, will go through the **ginning** process where the fibre is separated from the seeds and other impurities. Traders purchase large quantities of cotton lint and sell them on to spinners. In the spinning process, the fibres are processed into **yarn** and passed on to the weaving or knitting process, where they are made into **fabrics**. Wet processes, such as bleaching, dyeing, washing and printing are particularly resource-intensive and constitute one of the main environmental hotspots in the supply chain (see Table 1).

The cotton-garment supply chain is characterised by the “**fast fashion**” business model, which has led to labour rights violations (e.g. child labour, forced labour, bonded labour, lack of freedom of association) and negative environmental impacts in the entire supply chain, from cultivation to manufacturing and end-of-use. Table 1 shows the environmental impacts that are common in the supply chain and therefore relevant for the industry. This does not mean that every impact listed will occur in every cotton-garment supply chain.

Table 1: Main environmental impacts in the cotton garment value chain

Supply chain segments	Environmental impacts
Cultivation & harvesting	Depleting water reserves: high water use for irrigation, deteriorating groundwater reserves
	Decreasing biodiversity: use of genetically modified seeds, fertilisers, pesticides
	Decreasing soil quality: use of fertilisers, pesticides
Textile processing & manufacturing	High water consumption, inefficient use of water, inadequate waste water treatment
	Use of hazardous chemicals, inadequate chemical management
	High energy consumption; use of non-renewable energy sources; increase in greenhouse gas (GHG) emissions

Source: adelphi, based on information from Coscieme et al. (2022) and Voora et al. (2023a)

At the manufacturing level, we can broadly distinguish between **vertically integrated manufacturers** and **cut-make-trim (CMT) manufacturers**<sup>6</sup>. **CMT manufacturers** carry out the final assembly of the garment, i.e. the labour-intensive production steps, such as cutting and sewing. They supply brands/retailers either directly or, more often, indirectly through intermediaries (e.g. importers, buying agents) and are usually contractually obliged by their customers to source their materials (e.g. fabric, accessories) from **nominated suppliers**. The CMT business model is based on competitive prices as suppliers usually charge for the processing stages and not for the final product (Nadvi et al. 2004). **Vertically integrated firms**

<sup>6</sup> Other business models, such as contract-based services to carry out specific operations, are not considered.

integrate all processes from spinning onwards, giving them a competitive edge in pricing, volume/size, production costs and transparency, and overall a better bargaining position as there are fewer intermediaries involved (Ahmed and Nathan 2016). According to a cotton standard organisation, there are highly integrated facilities in some geographies (e.g. Pakistan), where companies even go back to growing in order to maintain as much benefit as possible.

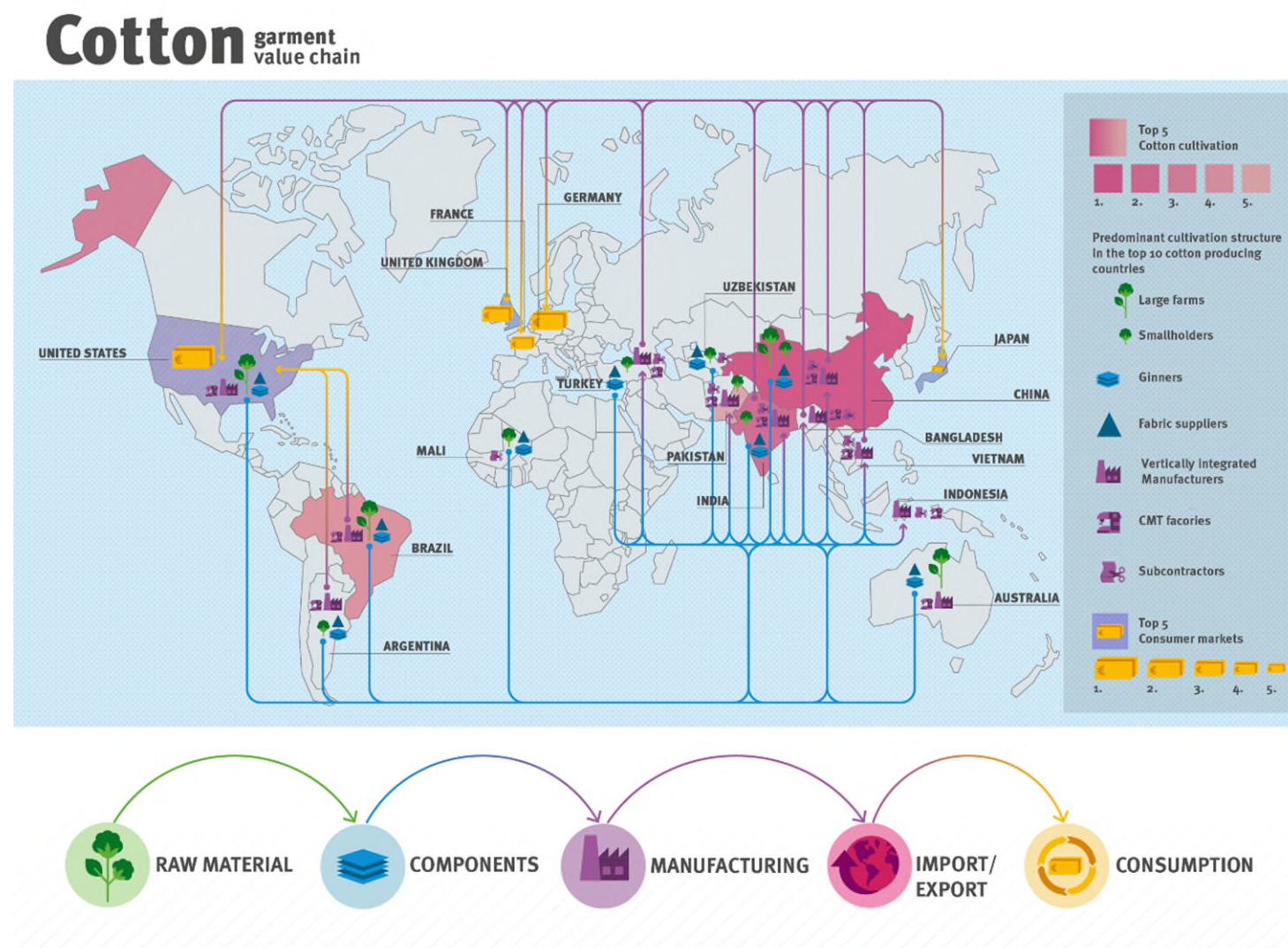
China is a major market for **accessories** (e.g. button, zippers) and **inputs**, such as textile processing and finishing chemicals, which further reduces the price competitiveness of tier 1 producers in other countries, which are heavily dependent on low-cost imports of chemicals and accessories. The final product, i.e. **readymade garments**, can be divided into **woven garments** (e.g. shirts, denim) and **knitwear** (e.g. t-shirts, sweaters). With the demand for knitwear, the use of human-made fibres is also increasing. Many of these factories use blended fabrics.

Based on the data presented earlier, Figure 7 shows selected key structures (main producer / consumer markets; actors) and processes (e.g. product flows) in the cotton garment value chain<sup>7</sup> in a thematic map.

---

<sup>7</sup> Please note that for practical reasons, the thematic map shows the markets, actors and product flows in a highly simplified way. It does not claim to be exhaustive and does not represent the full complexity of the cotton garment value chain.

Figure 7: Selected key structures and processes of the cotton-garment value chain



Source: Own illustration.

## 2.4 Pricing

Pricing in the cotton-garment supply chain is particularly complex at the raw material level. In later stages, prices are negotiated between buyers and suppliers to cover the supplier's production cost and allow for some profit margin. Price negotiations are part of a broader framework of purchasing practices that are highly contested between buyers and suppliers, as discussed in more detail in Section 2.5.

Cotton is mainly traded in the form of **futures contracts and options**, mostly on the New York futures market (Cotton Outlook 2023a). Cotton futures are used to speculate on the future price of cotton, which involves considerable risk and requires market knowledge. According to Cotton Outlook, less than 2% of contracts are actually delivered. Instead, they are used more as a price finding tool or a hedging mechanism. Other highly speculative forms are derivatives, such as contracts for difference, which are available on online trading platforms and trade on whether the price of cotton will go up or down. As there were significant discrepancies between the futures and the actual cotton values in the past, the **Cotlook A Index** was created, which is now the most important price measure (Cotton Outlook 2023a). Compiled from the five cheapest offering prices for a number of growths to the end users, i.e. the mills, the Cotton A Index assumes that the most competitive growths are likely to be traded the most (Cotton Outlook 2023b). Over the decades, in addition to the importance of the markets, the geographical basis of the quotations has shifted from Europe to the Far East.

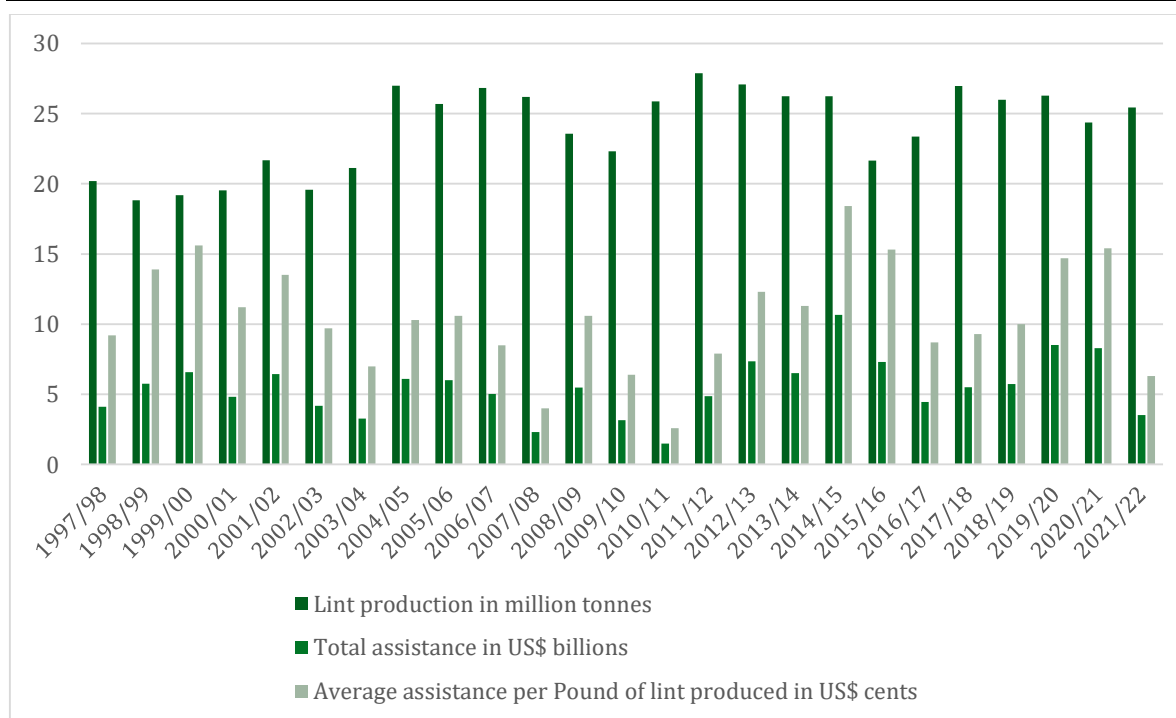
**Cotton prices** are volatile and largely determined by the quality of the fibre, geography, the climatic conditions in which it is grown, and government subsidies (CBI 2020a). Climate and extreme weather events such as floods and droughts have a significant impact on crop yields and thus on prices (Avatrade 2023). Staple length increases the quality of the yarn and thus the final fabric. Countries that produce large quantities of sustainable cotton, like India, affect the prices of both conventional and sustainable cotton – as does China, the country with the greatest demand for cotton. It is noteworthy that the price difference between organic and conventional cotton differs between the countries, which may be related to the specific growths and the availability of inputs, such as fertilisers and pesticides in China, which makes it costlier to shift to organic production. Other factors affecting cotton prices are competing fibres and materials such as polyester, which dominates the textile market with more than 60 million tonnes in 2021, compared to approximately 26 million tonnes of cotton lint in 2020 (ICAC n.d.)<sup>8</sup>. In this context, lower oil prices mean cheaper polyester, which in turn can have an impact on the price of cotton. According to the ICAC (2022), government subsidies to the cotton sector in 11 countries declined from a total of \$8.5 billion in 2019/20 to \$3.5 billion in 2021/22 (see Figure 8). This is attributed to the negative correlation between subsidies and prices, i.e. when prices are low – as during the Covid-19 pandemic when cotton demand first dropped and was brought back on track after the lockdowns were lifted – subsidies tend to increase (ICAC 2022).

### The Cotlook A Index

The **Cotlook A Index** is the average of the cheapest five cotton futures quotations in Asia and the benchmark index of the industry. It is used by many buyers and traders as a reference for prices paid to ginners (Voora et al. 2023a).

<sup>8</sup> The calculated figure refers to data provided by ICAC n.d., which uses cotton lint, i.e. cotton fibre that remains after cotton seed, leaves and casings have been eliminated during ginning (Textile Exchange n.d.).

**Figure 8: Subsidies provided by governments to the cotton sector**



adelphi, based on information from ICAC (2022)

## 2.5 Power relationships

While pricing at the commodity level is dominated by the futures market, brands and retailers have more power to impose prices on their suppliers, depending on the business model. This section shows that cost and benefits in the cotton garment supply chain are unevenly distributed, primarily due to power imbalances in the supply chain and purchasing practices where buying companies externalise risks to weaker supply chain partners (Khan et al. 2019; Ethical Trading Initiative et al. 2022).

In general, **governance** in the cotton garment value chain is **dominated by powerful buyers** such as brands and retailers that maintain captive relationships with a large number of suppliers (Gereffi et al. 2005). Following Gereffi et al.'s (2005) approach, lead firms exert control over their suppliers by imposing a set of requirements (e.g. quality, production process and, increasingly, sustainability), increasing the barrier for them to switch buyers. **Brands and retailers**, especially the larger ones, rarely work directly with garment manufacturers, but place orders through **intermediaries**, contracting out manufacturing and sourcing from importers or trading groups/buying agencies (Serdijn et al. 2020). Only a few still have an integrated supply chain with their own production facilities and thus control of most of the operations (ILO 2018). **Retailers** can be divided into **mass merchants** and **specialty retailers**. Mass merchants sell a wide range of consumer goods as well as clothing. Specialist clothing retailers sell only their own brand. Both types of retailers completely outsource the production and rely on importers and trading companies/buying agents (ILO 2018). Brands and retailers in the highly competitive consumer markets control access to the most value-added segments of the cotton value chain, such as R&D, product design or marketing (see Figure 6). When clothing is a rather small segment, such as in supermarkets, it is also common that design activities are outsourced to intermediaries, such as importers.

The power of the buyers of the final product, however, only extends as far as the spinning process (yarn), often only as far as the fabric suppliers. **Power dynamics may well shift** along



the supply chain depending on the market and business model. In markets like the U.S., Brazil and Australia, where large, mechanised farms dominate, powerful, multi-million-dollar ginning companies directly source from cotton growers. By contrast, smallholders in South Asia, for example, have less control over pricing as they are mostly dependent on middlemen who act either as brokers (commission agents for ginneries) or traders. In general, **cotton farming systems and institutional support** determine the competitiveness of the cotton industry in the respective country. **Smallholder cotton farmers** in developing countries are among the weakest actors in the cotton value chain. Low prices stand against high production costs (e.g. fertilisers, insecticides), lack of market information or lack of funds and availability of quality seeds, which reduces profit margins. Price pressure, in part is also driven by the subsidy regime in the U.S; farmers in more organised economies such as China and the U.S. have better technological capacities and enjoy more institutional support like subsidies for cotton inputs (e.g. fertilisers, harvesting) or quality seeds (Voora et al. 2023a). In the U.S., farmers are paid after ginning, where quality is determined, while smallholders in the Global South are paid based on raw cotton delivered, which in turn disadvantages them. Where farmers are not organised, they are often heavily dependent on powerful ginneries and traders, who sell the cotton on to spinning mills and weaving companies or buying teams of brands (Voora et al. 2023a).

The main **business models** of buyers, including brands/retailers, importers and traders, for sourcing cotton-based garments for the German/European mass market can be summarised as is in Table 2. Buyers purchasing large quantities rely on a vast network of suppliers embedded in a highly competitive environment. **Brands/retailers** have **pricing power** and are in a better position to protect themselves from market volatility, as they usually source from importers and trading companies.

- The first dominant business model is the highly competitive **auction-based system**, which is common with **mass merchant retailers** like Aldi or Lidl, catering large volumes to the low-end market. The contract is usually awarded to suppliers through intermediaries (importers, traders) based on a number of criteria, such as quality, price, sustainability and lead time, among others. Interviews with traders and producers suggest that price is ultimately the decisive factor. Premiums for compliance with sustainability standards are not granted – a concern repeatedly voiced by industry representatives such as the STAR Network (Sustainable Textile of the Asian Region), an alliance of Asian manufacturer associations.
- Some **specialty retailers** (e.g. H&M, adidas) source directly from a limited number of **key suppliers** (fabric and/or finished product) who are able to deliver either a specific product or/and large quantities; **occasional suppliers** are used to fill capacity gaps and do not account for more than 10% of the buyer's volume (Aridov et al. 2014). Buying at scale gives companies the capacity to tie large suppliers strategically to their business. Large order volumes on a regular basis may also compensate for unsustainable practices (e.g. low prices, open costing, last minute changes) that reflect the asymmetrical power relationship and often have detrimental consequences for the workforce. If customer oversight is insufficient, there is a risk that official suppliers subcontract additional volumes to sub-suppliers (subcontractors), even though they are not contractually allowed to do so, who are often not subject to internal audit procedures in terms of working conditions or health and safety practices (Labowitz and Baumann-Pauly 2015). Occasional suppliers tend to accept worse conditions just to enter the market, are more connected to buying agencies/trading companies, and receive less support from their customers.
- The third business model takes a more **collaborative approach** and is currently practiced, for instance, by members of the Fair Wear Foundation (FWF), a not-for-profit that works

with 130 member brands in the garment industry to improve working conditions in their supplier factories (FWF n.d.). The focus lies on labour standards; environmental issues are not addressed. Unlike the prevailing “check-the-box” audit approach, FWF members work closely with their suppliers to improve key sustainability metrics, recognising that this is a process rather than an outcome. Alliances with other stakeholders (civil society, unions, academia) are impact-driven to find practical solutions to issues that are often ignored in the market, such as living wages or gender equality (Fair Wear Foundation n.d.). Member brands, which are mostly small and medium-sized companies, are subject to regular performance checks, which are reported on publicly. Trust and collaboration are at the core of this business model, which naturally is difficult to adapt to the mass market. Given the smaller quantities these brands purchase, power is not necessarily concentrated at the downstream end.

**Table 2: Dominant business models and governance in the cotton-garment value chain**

Business model	Type of buyers	Governance	Type of relationship	Procurement procedure
Auction system	mass merchant retailers	captive	short-term sourcing contracts	highly competitive; price dominant
Mix of key & occasional suppliers	brands, specialty retailers	relational; captive	longer term contracts with strategic suppliers; short-term with others	competitive; strategic factors (e.g. product, size)
Cooperative approach	small and medium-sized	relational	built on trust and joint responsibility; longer term contracts	cooperative; focus on sustainable improvement

Source: adelphi, based on classification by Gereffi et al. (2005) and information from expert interviews

**Capabilities** are a major factor in power relationships. Interviews with buying and supplying companies conducted as part of this research suggest that the prices of **CMT factories (tier 1)**<sup>9</sup> sourcing from nominated fabric suppliers (tier 2) are set in advance by buyers and fabric suppliers and cannot be re-negotiated, indicating an **imbalance of power** in the supply chain. For buyers, this is a way to ensure that certain sustainability requirements (e.g. certifications) are met. CMT manufacturers can only exercise bargaining power over non-nominated suppliers from whom they are allowed to source directly, but their share is rather small. As described earlier (see 2.2), **vertically integrated firms** have more control over their backward linkages and thus a competitive edge in pricing, volume/size, production costs and transparency, and overall a better bargaining position as there are fewer intermediaries involved (Ahmed and Nathan 2016). These capabilities often determine whether a firm can rise to become a key supplier. While CMT factories may well be of strategic value to a buyer because they can offer a specific (e.g. niche) product at a specific cost and thus become a key supplier, their operations are easier to substitute than those of vertically integrated firms or, for instance, specific fabric suppliers. In general – this may vary in individual cases – key suppliers maintain closer ties to

<sup>9</sup> Supply chains can be divided into tiers, with tier 1 being the supplier closest to the final buyer (i.e. brands/retailers, traders, importers). In the textile supply chain, tier 1 would be the final assembly, i.e. RMG factories (cut-make-trim, washing/dyeing/printing). Tier 2 would be the supplier of tier 1, i.e. the fabric supplier (weaving/knitting mills). Tier 3, spinning mills, would supply the yarn to the weaving/knitting mill. Tier 4 could be a gin or, which is more common, the cotton grower. There are also reports that are less granular in their tiering analysis, assigning tier 3 to cotton growers. Vertically integrated factories may comprise several tiers, i.e. CMT plus dyeing/washing/printing (tier 1) plus weaving/knitting (tier 2) plus spinning (tier 3). Some companies in Pakistan even have all production steps under one roof, including cotton cultivation.

their buyers and therefore enjoy better conditions, making them less vulnerable in a variety of aspects, as highlighted in Table 3:

**Table 3: Differences in buyer-supplier relationships by supplier importance (tier 1)**

Aspects	Key suppliers	Occasional suppliers
<b>Order volume</b>	Continuous, large	Occasional, small
<b>Payment terms</b>	Short-term (e.g. LC at sight, i.e. at the release of the goods)	Long-term (e.g. 60-120 days and beyond)
<b>Commitment</b>	Long-term	Temporary
<b>Sustainability requirements</b>	Required, continuous monitoring (self-assessment, internal audit, third-party audit)	Required, but less stringent controls
<b>Support</b>	Guidance by buyers (quality, sustainability); incorporation in development programmes (sustainability); no financial support	No direct support
<b>Power relationship</b>	Asymmetrical, but supplier is not easily interchangeable	Asymmetrical relationship

Source: adelphi, based on information from expert interviews

## 2.6 Addressing environmental impacts by voluntary measures

**Environmental laws and regulations** aim to protect people and the environment. Regulatory and enforcement bodies in producer countries use different tools to address negative impacts, such as environmental impact assessments or financial sanctions (Sharpe et al. 2022). The authors' field experience in the sector has shown that, due to lacking resources and capacity among local environmental authorities, procedures are often non-transparent and not as strict as required by law, allowing suppliers to circumvent regulations.

Against a backdrop of deteriorating labour and environmental conditions, and major disasters such as the collapse of Rana Plaza, companies have been increasingly pressured to adopt **voluntary sustainability standards** and sign up to international agreements such as the Bangladesh Accord (now: RMG Sustainability Council – RSC). Implementing those requirements has significantly improved occupational safety and health (OSH). However, other labour rights, such as minimum wages (living wages), freedom of association or collective bargaining, which have a significant impact on prices, continue to be violated. Environmental issues have only gained prominence in recent years due to increasing pollution and vulnerability to climate change and related environmental policy developments.

Depending on the market, buyers require third-party certification of materials, products, the facility or processes from their suppliers.

- As for **materials**, among the most important voluntary cotton sustainability standards are Cotton made in Africa (CmiA), Better Cotton Initiative (BCI), Organic Cotton Standard (OCS), FairTrade International Small Producer Organization, Standard with Fibre Crop Criteria, USDA National Organic Program, EU organic programme, Indian National Programme for Organic Production, and the Responsible Environment Enhanced Livelihoods (REEL). The main sustainability standards operating in South Asian cotton markets are Better Cotton, Fairtrade and the Reel Cotton Code. According to the WWF (2023), **voluntary cotton standards** vary in scope, maturity and coverage of sustainability issues. Most of the



standards cannot ensure full sustainability in all its social, environmental and economic dimensions. However, non-certified production does not necessarily mean that the agricultural practices are harmful to workers or the environment. Very often, it is financial reasons or inadequate agricultural extension services that prevent smallholders from going through the costly certification process. But only if the working methods and production processes are independently verified, do they provide the level of assurance that customers and end consumers expect.

- ▶ The requirements for **products** can contain specifications on the composition to prove that they are safe for use (e.g. OEKO-TEX Standard 100), meaning that all materials have been tested and no harmful substances can be detected in the final product. When entering the EU, products need to comply with the General Product Safety Directive (GPSD: 2001/95/EC) and the REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulation (CBI 2022b). Product standards may also prescribe the use of recycled material, such as the Global Recycled Standard (GRS).
- ▶ **Process standards** define procedures to carry out tasks and operations to ensure, for instance, quality (e.g. ISO 9001), environmental protection (e.g. ISO 14001), occupational safety and health (e.g. ISO 45001) or energy management (e.g. ISO 50001). They do not set requirements for sustainability performance. There are various social and environmental standards that either analyse and evaluate the manufacturing processes as holistically as possible (e.g. STeP by OEKO-TEX®, Global Organic Textile Standard – GOTS) or limit themselves to specific areas, such as working conditions (e.g. SA8000).

The German Green Button is a meta label that requires companies and products to meet a number of social and environmental criteria and to implement a due diligence process in their supply chain (Grüner Knopf n.d.). Various certifications have already been recognised, such as OEKO-TEX® MADE IN GREEN, OEKO-TEX® STANDARD 100, Bluesign Product, GOTS, Cradle to Cradle, Fairtrade Cotton and SA8000 (Hohenstein 2023). Relevance outside the German market is low. Figure 9 highlights some of the certifications that are common in the garment supply chain.

**Figure 9: Selected certifications in the cotton garment supply chain**



Source: In Litore; Logowik n.d.; CEO Water Mandate n.d.; it fits - Organic Textile Partner n.d.

In various multi-stakeholder initiatives, companies are working together with civil society organisations, trade unions and government actors to make the textile supply chain more sustainable (e.g. Partnership for Sustainable Textiles, Fair Wear Foundation). They all seek to alleviate power imbalances and improve conditions in the textile sector, without particular focus on cotton. Also, membership initiatives, such as the amfori Business Social Compliance Initiative (BSCI) and the Business Environmental Performance Initiative (BEPI) aim to promote socially and environmentally responsible production conditions (amfori n.d.). While all these initiatives are promising efforts to induce change, few have actually improved collaboration across the sector to improve transparency and reduce power asymmetry, as demonstrated during the COVID-19 pandemic (ILO 2021).

Molenaar et al. (2022) point to low and unstable prices as one of the root causes for environmental externalities, arguing that prices and purchasing practices have not been sufficiently reflected in voluntary sustainability standards. They demonstrate for a number of commodities that persistently low prices discourage producers from investing in profitability and sustainability and eventually exacerbate environmental degradation.

Interviews suggest that large suppliers tend to consider the **sustainability requirements of renowned brands and retailers** to be more stringent, as they maintain their own data validation system (internal auditing and controls, i.e. buyers send their own compliance team for inspection). Reference is often made to corporate Restricted Substances Lists (RSL) and Manufacturing Restricted Substances Lists (MRSL), which may be more demanding than voluntary standards and certifications. In addition, buyers may hire **third parties to verify the data** submitted by the supplier. The level of competence of the suppliers determines whether they can carry out a root cause analysis themselves and take measures against violations of the standards. Normally, customers with access to supplier data point out these violations, e.g. in emission levels (polluting substances), which the suppliers then have to remedy without any support from their customers. Since suppliers are primarily interested in exporting their product with the required certification, they make the effort to meet the standards. Confidence in the data, however, is a major challenge, especially as the audit and certification process is prone to fraud, as evidenced by the case of the Indian organic cotton industry last year (Wicker et al. 2022).

## 2.7 Current/future trends and developments

EU policies and initiatives promoting sustainability, human rights and circularity in the textiles sector have had a limited impact on the industry as of yet. However, this is likely to change in light of the increasing sustainability regulations. REACH has regulated the production and import of chemicals quite effectively since 2007, which the industry has largely followed. With the upcoming *EU Corporate Sustainability Reporting Directive (CSRD)*, the *EU Corporate Sustainability Due Diligence Directive (CSDDD)*, to be enacted in 2024, and the already enacted *German Supply Chain Due Diligence Act*, companies of certain sizes are or will be required to

avoid or remedy human right infringements and certain environmental damages in their supply chains and provide transparency about their due diligence processes. Both buyers and suppliers have understood that sustainability is no longer a “nice to have” but a “must have” and that they need to implement the required practices and collect data for reporting (e.g. Global Fashion Agenda, apparel impact institute). Smaller companies are also increasingly aware of the need to adopt more sustainable practices in areas such as material sourcing, production processes, and waste management, as legislation requirements become more stringent. These practices include the use of recycled or sustainable materials, such as organic cotton, and the adoption of circular business models, such as designing products for durability and repairability and recycling end-of-life products. With the Circular Economy Action Plan 2020, the EU Strategy for Sustainable and Circular Textiles 2022, the proposal for a new Ecodesign for Sustainable Products Regulation 2022 and the proposal to amend the Waste Framework Directive 2023, EU legislation is moving towards a circular economy and extended producer responsibility schemes for textiles (European Commission 2023b; European Commission n.d.). It remains to be seen what the final EU legislation will look like and how strict their performance requirements will be.

The COVID-19 pandemic and the Russian war against Ukraine have highlighted the vulnerability of the global textile supply chain and its interdependencies. Tendencies to move production to countries closer to the home market, also called nearshoring, in this case to the Central-Eastern European region (Dobos 2022), were triggered by supply chain disruptions during the pandemic, especially in China, but curbed by the war in Ukraine. Nevertheless, these events have affected the structure and power relations in the supply chain. Companies had to adjust their operations, and, where possible, move to local sourcing and shorter supply chains to reduce supply chain risk. Several Estonian brands, for instance, withdrew from the Russian market and started sourcing from European countries (Ukraine, Poland, Italy). The large-scale withdrawal of major brands from the Russian market, the strict lockdown measures in China during the COVID-19 pandemic and reports about forced labour in cotton farming in Xinjiang pushed buyers to restructure their supply chains, shifting ginning, spinning and fabric mills to other countries in Southeast (e.g. Vietnam) and South Asia (e.g. Bangladesh). As a result, CMT manufacturers, for instance in Bangladesh, have benefited from shorter lead times and a lowered dependency on imports. This has improved their competitiveness against China, whose dominance in textile processing and finishing chemicals already significantly limits the price competitiveness of tier 1 producers, e.g. in Bangladesh, who are highly dependent on low-cost chemical imports. Table 4 summarises the market, consumer and technology trends that may gain importance in the near future.

**Table 4: Market, consumer and technology trends**

<b>Market trends</b>	<ul style="list-style-type: none"> <li>▶ Increasing demand for sustainable and ethically sourced cotton may lead to the development of more transparent supply chains</li> <li>▶ Growing demand for organic cotton, which, however, currently cannot be matched by the supply (CALIDA 2021; Textile Exchange 2022)</li> <li>▶ Increasing competition from synthetic fibres, such as polyester, due to their lower cost and simpler manufacturing process</li> <li>▶ Fluctuations in cotton prices due to global economic and political events</li> <li>▶ Shifts in global cotton production, with countries such as India and Brazil increasing their share of the market while China's share decreases</li> </ul>
<b>Consumer trends</b>	<ul style="list-style-type: none"> <li>▶ Less purchases due to economic and political uncertainties – inflation and war led to insecurities, which may lower the consumption of apparel</li> <li>▶ Rising living standards in emerging and developing countries could increase clothing consumption</li> <li>▶ Rising regulatory requirements and consumer demand for transparency and traceability in the supply chain, with consumers wanting to know where their cotton garments come from and how they were produced</li> <li>▶ Increasing use of social media and e-commerce platforms to research and purchase cotton products</li> <li>▶ Rise in circular business models (e.g. repair, second-hand market)</li> </ul>
<b>Technology trends</b>	<ul style="list-style-type: none"> <li>▶ Development of new technologies and innovations in cotton production (e.g. carbon sequestration) and processing (e.g. more efficient spinning and weaving processes) as well as development of new technologies for recycling of cotton-garment waste</li> <li>▶ Adoption of digital tools and platforms to aid data-led decision making, enabling greater transparency and efficiency at all levels of the cotton garment supply chain</li> <li>▶ Artificial intelligence to be used for predictive modelling and decision support, for processing complex documents, rules, terms and technical information, or for translating contracts and agreements with international partners</li> </ul>

Sources: adelphi, based on information from Textile Exchange (2022), OECD and FAO (2021), Amed et al. (2022), Cotton Outlook (2023a)

## Outlook

The global demand for cotton and apparel is expected to grow steadily, driven by factors such as population growth and rising disposable incomes in emerging markets; at the same time, an increasing awareness of sustainability and ethical concerns are expected to drive the demand for sustainable clothing (Amed et al. 2022). The adoption of new technologies such as automation and digitalisation are expected to increase efficiency and productivity in the industry, while also enabling greater transparency (e.g. digital solutions for reporting) and traceability throughout

the supply chain. However, high inflation rates, global warming, the ongoing war in Ukraine, and other geopolitical crises (e.g. China-Taiwan, U.S.-Chinese trade war) make the general outlook unpredictable. Claims made during the pandemic about large-scale nearshoring of manufacturing capacity have faded and remain rather unrealistic, given the investment in markets such as Bangladesh and the loss of manufacturing skills in Europe (Henkel n.d.). Interviews with suppliers in the cotton garment supply chain also indicate that they expect more customer demands to be placed on production, especially with regard to adaptation to climate change and the decarbonisation of the industry. They see the opportunities of automation, but are wary of how artificial intelligence might transform this labour-intensive industry.

## 2.8 Institutional incentive mechanisms and barriers

### Environmental legislation in producing countries

In terms of **national legislation**, the four South Asian countries (Bangladesh, India, Pakistan, Sri Lanka) under review by (Voora et al. 2023b) maintain government agencies to monitor the cotton and textile sectors, usually with a focus on research, quality control and export promotion and tending to disregard social and environmental aspects. Seed technology is one of the priority issues in Pakistan, as it contributes to increasing the output of the domestic cotton production (Pakistan Ministry of Commerce). Pakistan's textile and apparel policy primarily centres around increasing added value and productivity; organic cotton and sustainable practices (e.g. Better Cotton Initiative) are mentioned, but are not at the heart of policy. Isolated attempts have been made to promote organic cotton production, such as the Punjab Cotton Control Order in Pakistan, which refers to ecologically safe seeds that may be used in a certain area (Voora et al. 2023b). The main strategic objective of Pakistan's textile and apparel policy is to rebuild the profitability of cotton producers, focusing on quality, yield and production costs. In India and Pakistan, for instance, governments rely on economic incentives by promoting cotton cultivation through minimum support prices (Voora et al. 2023a; Voora et al. 2023b). There are efforts to re-establish a Cotton Hedge Trading facility to stabilise cotton prices for farmers (Pakistan Ministry of Commerce). Typically, the countries in question have general environmental regulations, with specific parameters for the use of agrochemicals, water protection and prices for farmers. Cotton-specific regulations, particularly on sustainable cotton farming practices, are usually lacking, although some governments (e.g. Pakistan) have started developing long-term strategies to establish an organic cotton production (Baloch et al. 2021). Very often also, exports are regulated, while imports lack policies on sustainable cotton. In Pakistan, as in other countries, there is a duty drawback scheme for value-added textile products (Pakistan Ministry of Commerce). Under the drawback scheme, companies can get taxes refunded if they have paid duties on imported inputs used in the production of textile products that are exported. It is usually only available to manufacturing exporters to add value and, in the case of Pakistan, is conditional on membership in a textile association. The drawback rates of Pakistan ranged from two to four percent in 2020 (Khan 2020).

India, the second largest producer of cotton, has issued a number of policy initiatives aiming to boost the local textile industry. The Cotton Corporation of India (CCI) is a governmental agency reporting to the Ministry of Textiles whose main task is to stabilise cotton prices through price support measures (The Cotton Corporation of India Ltd. n.d.). CCI is a major buyer of cotton, especially in off-season and when prices are falling below the minimum support price. India is the largest producer of organic cotton (38%) and cotton grown on land that is converted from conventional to organic farming, the so-called in-conversion cotton (86%) (Textile Exchange 2022). Pakistan ranks ninth, accounting for less than 2%. Current initiatives and policies mostly seek to establish India as a manufacturing hub aiming for investment, export promotion and employment (Joshi et al.). The Amended Technology Upgradation Fund Scheme (ATUFS)

provides financial support to textile mills to modernise their technology (India Ministry of Textiles 2020). The Scheme for Integrated Textile Parks (SITP) finances the establishment of textile parks with adequate infrastructure and common facilities, such as warehouses and training centres (Joshi et al.). As of August 2023, 54 textile parks have been approved (India Ministry of Textiles 2023). The Production Linked Incentive (PLI) scheme for the textile industry provides incentives to increase domestic production capacity. It is primarily aimed at improving India's competitiveness in synthetic fibres and technical textiles where the growth potential is considered highest (India Ministry of Textiles n.d.); cotton is not specifically targeted.

### Environmental policy measures in consumer markets

The **European Green Deal** aims to transform the European economy towards climate neutrality by 2050. It requires companies in the EU to make their supply chains more sustainable by ensuring human rights and reducing negative environmental impacts (e.g. carbon emissions) (Siddi 2023). A set of strategies and policies, some of which have already been touched upon in 2.7 (e.g. CSRD, CSDDD), address human rights and negative environmental impacts of the dominant fast fashion business model. National due diligence laws such as the *German Supply Chain Due Diligence Act* or the French "*Loi de Vigilance*" also play an important role in anchoring the risk-based due diligence process in the company's management systems. Companies above a certain size are now required to carry out risk assessments, for which it is essential to map the supply chain to understand where the main risks lie and take remedial action where necessary. This will be particularly challenging for companies whose business model is to source predominantly indirectly from a large network of suppliers. Collaboration is strongest with key/strategic suppliers or in a business model that is designed for cooperation and long-term partnership from the outset. Several interviews with stakeholders in Bangladesh revealed that management systems and proper data management (e.g. collection, analysis, documentation) are the main challenges for companies in the EU to account for their carbon emissions.

Along with the due diligence legislation, the *EU Circular Economy Action Plan* and the proposal for a new Ecodesign for Sustainable Products Regulation play a major role in reducing negative environmental impacts by transitioning towards a circular economy that ensures products are designed to last, are easy to reuse, repair and recycle (European Commission 2020). To do this, companies need to take a closer look at the composition of their products and move towards materials (e.g. fibres, accessories) that are more durable, reusable, repairable and recyclable.

The *EU Carbon Border Adjustment Mechanism* (CBAM), which is phased in from October 2023 for the import of products that are carbon-intensive or most at risk of carbon leakage, is widely seen as an incentive for industries to innovate and switch to low-carbon energy sources (European Commission 2021). The mechanism does not yet cover the cotton and garment/textile industries, so RMG producer markets like Bangladesh or Cambodia will not be directly affected, although garment manufacturing hubs like Bangladesh expect it to be only a matter of time before the mechanism is extended to other sectors (Uddin 2023). Practitioners see an opportunity for the Bangladeshi RMG sector to incorporate the tariff into the pricing, which has not happened as of yet (Uddin 2023). The Sustainable Global Supply Chains Report criticises a lack of research into the implications of environmental policies for the governance of global supply chains (Altenburg et al. 2022). Carbon pricing and CBAM also draw criticism as to maintaining unequal relationships between buyer and supplier countries, as support for the transformation of energy and production systems is not provided (WTO 2022a). If supplier countries are unable to adapt their trade and sustainability policies to the changing environmental policies of consumer countries, this can have a negative economic impact on trade patterns (UNCTAD 2022).



## Trade agreements and policies

Trade policies can be used to create incentives for more environmentally friendly production processes or materials from sustainable, in the sense of certified and verified, sources (Textile Exchange 2021). Textile Exchange sees increased cost as the main barrier to the adoption of environmentally friendly materials like organic cotton or recycled fibres, as they are considered to be the more sustainable choice thanks to a lower carbon footprint than their conventional (virgin) counterparts. Advocating for improved supply chain transparency, materials traceability and data-based environmental impact measurement, the non-profit argues that governments must explore incentives such as tax credits or duty reductions of imported components or finished products (Textile Exchange 2021). There are preferential tariff schemes such as the *EU Generalised Scheme of Preferences* (GSP) which grant preferential access to the EU market if developing countries meet certain criteria on human rights and environmental protection. Bilateral trade agreements, such as the **EU-Bangladesh Cooperation Agreement** from 2001 or the **Cooperation Agreement** between EU and Pakistan from 2004 are built around GSP (Bangladesh) or GSP+ (Pakistan). These agreements include the ratification and implementation of international conventions (Wijayasiri), while the implementation progress is monitored by the EU regularly. In general, countries can lose preferential access in case of grave systematic violations. Discussions are underway to extend the negative conditionality to other conventions that are more concerned with environmental and climate change issues in the new period from 2024 to 2034, as they have been largely ignored in the past period (European Commission n.d.b). Depending on how the EU GSP reconciles trade and environmental issues in the next period and how producer countries deal with it, this could have an impact on the cost-benefit distribution in supply chains.

To illustrate that there is also need for action in the producing regions, it is useful to take a closer look at the relevant **regional trade agreements and policies** that have an impact on the sector. With regard to South Asia (including India, Pakistan, Bangladesh and Sri Lanka) as the most important region for cotton production (Voora et al. 2023b), there are **regional trade agreements**, such as the **South Asian Association for Regional Cooperation (SAARC)**, which establish common goals and fields of cooperation in agriculture, environment and trade. Free trade agreements, such as the agreement on the **South Asian Free Trade Area (SAFTA)**, are considered an instrument for implementing the 2030 Agenda and reconciling trade and the environment. Topics such as the availability and affordability of genetically modified seeds are addressed, however, without critically reflecting on the environmental impact (SAWTEE 2016). According to Voora et al. (2023b), there are several public initiatives to encourage intraregional integration and jointly promote sustainable cotton production and consumption (e.g. **Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation - BIMSTEC** - and SAARC). These initiatives mostly focus on agricultural practices and, with that, on cotton cultivation/production, while regional attempts to address cotton textiles are not known. The SAARC Agriculture Centre (SAC) is a focal point for regional cooperation and shares its knowledge on the use of agrochemicals, water management and farmer incomes in South Asia (Voora et al. 2023b). According to the International Institute for Sustainable Development, regulatory frameworks, good practices, incentives for sustainable practices and recommendations for policymakers were discussed more than once, however, with no particular focus on cotton (e.g. water management, eco-fertilisers) (Voora et al. 2023b). This is supported by other research institutes and non-profit organisations, which argue that the current trade agreements do not provide for concrete commitments on sustainable production practices in the cotton sector and thus are unlikely to reduce negative environmental impacts (Lanfranchi and Cline 2021; Textile Exchange 2021).

### Transparency issues

Markets for cotton and cotton-based products are partially protected, generally not very sustainable and lack clarity about prices (WTO 2021). This lack of transparency in the cotton supply chain particularly affects smallholder farmers in developing countries who do not have access to market price information, which impacts their business operations and decision-making (Truscott et al. 2021).

In cotton-producing African countries, generally seed-cotton prices are fixed by governmental agencies in the beginning of a season (WTO 2021). The global downturn during the COVID-19 pandemic prompted many farmers to switch to less price-volatile food crops as cotton prices continued to decline in 2020/21. The current cotton supply chain is characterised by prices being squeezed downwards, while little is known about actual production costs and the level of payments to farmers. Trade models for organic cotton discuss the need to consider quality aspects as much as environmental and social costs (Truscott et al. 2021). In practice, however, the market is not always open to pay a price premium for the added value of environmentally friendly (i.e. organic) cotton, and the benefits are not passed on to farmers (Truscott et al. 2021). The current business model of the mass market does not empower suppliers (manufacturers, farmers) to incorporate the cost of being certified into their pricing. Sustainability is assumed to be cost-neutral, which means that suppliers end up bypassing best practices and harming the environment. When it comes to transparency in the cotton supply chain, data sharing is crucial. In addition to buying and supplying companies, other key stakeholders that need to provide access to reliable data are voluntary supply chain standards, certification bodies, industry associations, and governmental agencies, among others (Truscott et al. 2021; Textile Exchange 2022). Non-profit organisations in the textile and cotton sector, such as Textile Exchange, advocate for more integrated supply networks that rely on good practices, such as greater integration, transparency and engagement with partner organisations along the entire supply chain. Sharing risks, responsibilities and opportunities can only be achieved through closer and longer-term business relationships (Truscott et al. 2021).



### 3 Sustainable supply chain management approaches and instruments

This chapter is an excerpt of the report “Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains - Business approaches and instruments of sustainable supply chain management” (Grüning et al. 2024). The chapter shows which approaches and instruments for SSCM are used in the cotton-garment supply chain and to what extent. The information is based on desktop research, interviews with industry experts and consultation with an Expert Advisory Board comprising individuals from business, civil society and academia. The chapter concludes with a matrix in which the observed and described SSCM approaches and instruments are categorised.

#### 3.1 Main environmental impacts in the cotton-garment supply chain

The cotton-garment supply chain creates pressure on the environment along the entire supply chain, from cultivation to assembly. Table 5 highlights the negative impacts based on a review of relevant literature. The water footprint of the cotton-garment supply chain is particularly large, as cotton fields are irrigated in areas where cotton does not naturally occur (or where global warming has altered the climatic conditions) and conventional cotton is grown (Pal et al. 2021b). The wet processes in textile processing (e.g. washing, bleaching, dyeing, printing) also consume high amounts of water, which is often inefficiently used; in addition, wastewater is not treated appropriately (Zietlow et al. 2017). Energy-intensive process steps, such as spinning, knitting, weaving, drying and finishing, often use fossil fuels (e.g. coal) and are a major source of greenhouse gas (GHG) emissions. Energy consumption is also high where cultivation is mechanised (e.g. for planting, irrigation, fertilisation, harvesting). The use of chemicals such as fertilisers, insecticides and herbicides in conventional cotton cultivation affects soil health and emits pollutants into water and the air (Pal et al. 2021a). Process chemicals, such as detergents, wetting agents or stabilisers, and performance chemicals, such as dyes or finishing agents, are used in wet processing, i.e. during bleaching, dyeing, washing or finishing. These chemicals can be harmful to humans and the environment if they are substances of concern according to the EU REACH regulation, are not handled properly during processing, or are not treated correctly during wastewater treatment. Soil compaction is an immediate negative effect of the use of heavy machinery during planting and harvesting particularly in areas where large farms dominate. The use of fertilisers, pesticides and other chemicals during cultivation result in degrading soil quality (EOS Data Analytics 2023). Organic cotton is usually grown less densely in order to promote the growth of cotton and other crops growing alongside it, which, while decreasing productivity, increases the amount of land used compared to conventional cotton (Textile Exchange 2016). Air emissions occur along the entire supply chain. Dust emissions are mostly produced during the manufacture of fabrics, singeing or during cutting and sewing/stitching (Roth et al. 2023). Other air emissions include volatile organic compounds (VOC) and formaldehyde (e.g. coating, finishing, printing, thermal treatment), ammonia (printing, coating, thermal treatment), waste gases from incineration to generate energy or steam (Roth et al. 2023). Solid waste is generated in different processes from cultivation (e.g. organic matter including hazardous substances, such as cotton stalk and cotton gin waste) to textile processing (e.g. sludges containing hazardous/non-hazardous substances, offcuts) and garment manufacturing (e.g. cutting/sewing waste) (CISL 2016; Roth et al. 2023). Depending on the region, the best-available techniques are used to reduce the amount of waste sent for disposal (e.g. EU) or disposed of in landfills, while wastewater often ends up untreated or inadequately treated in bodies of water (Hasan et al. 2018). Effluents may contain high loads of pollutants if they are not properly treated.

**Table 5: Main environmental impacts along the cotton-garment supply chain**

	Fibre production			Yarn and fabric production		Textile production	
	Cultivation	Raw material processing	Fibre preparation	Yarn preparation (spinning)	Weaving / knitting / bonding	Bleaching / dyeing / finishing	Assembly
Water	Water depletion through irrigation					Inefficient water use; high consumption	
Land use/Soil	Soil compaction by machinery; soil degradation due to high use of fertilisers and pesticides (e.g. eutrophication)		Fibre waste / trimming to landfill				Textile scrap to landfill
Energy	If mechanised, machinery for planting, fertilising, irrigation and harvesting			High consumption of energy, often fossil fuel-based			
Chemicals	Use of fertilisers, insecticides, herbicides in conventional and sustainable cultivation				Use of hazardous process and performance chemicals		
Air	Air emissions from use of pesticides and fertilisers			Air emissions from incineration to generate energy or steam (boiler)			
Waste		Seeds and trash removed from cotton lint	Fibre scrap / trimming to landfill		Fibre waste	Polluted effluent, sludge	Cutting waste, emission to air (e.g. dust)

Source: own illustration (adelphi), adapted from Petrie 2023; Roth et al. 2023 and Singh et al. 2018

To manage these impacts, the industry has a range of approaches and tools for sustainable supply chain management (SSCM) at its disposal.

### 3.2 Sustainable supply chain management approaches and instruments used in the cotton-garment supply chain

Companies in the cotton-garment supply chain predominantly use **buyer-individual voluntary approaches**, such as audits and certifications, to manage risk in their supply base. Audits and certifications are key instruments of the coercive strategy, in which the roles of buyers (requesting sustainability data) and suppliers (providing sustainability data) are clearly divided. The distribution of cost and benefit varies with the business model, but is often perceived as unevenly distributed by suppliers (see Chapter 4 on distributional fairness). The **auction-based system** takes a very competitive approach as the number of collections (from 2 to 3) and thus styles have increased substantially over the years, while prices have remained stable or even decreased (Ljarja et al. 2023). Short lead times at a very competitive price while meeting sustainability requirements are an indication of the coercive strategy and are increasingly becoming a “must have” to gain a foothold in highly competitive markets such as the European fast fashion market. When taking on new suppliers, it is common practice for companies to subject them to internal (second-party) audits of social and environmental standards, before engaging a third party, which is usually paid for by the supplier. Interviews with **specialty brands/retailers** suggest that the approach with key/strategic suppliers is less rigorous and more collaborative and trust-based, which is reflected in supplier visits and second-party audits, thanks to their long-term business relationship (often more than 10-15 years). Here, the costs are borne by the buyer, who is sending a team of in-house experts to inspect the facilities. Occasional suppliers, i.e. suppliers with whom there is not yet an established partnership, are subject to third-party audits in order to verify that specifications are met. In this case, the audit cost would have to be covered by the supplier. Interviews confirm that well-performing suppliers are rewarded with further orders, increased quantities and training – i.e. a more cooperative approach to overcoming negative impacts is built in (Dreismann 2019). As confirmed by a major specialist brand/retailer, key/strategic suppliers benefit from **training (buyer individual/collective voluntary instrument)**, usually provided free of charge either by the brand/retailer or by the development programme in which the brand/retailer is involved. Sometimes training is organised for a cluster of nominated suppliers. This may be accompanied by a range of support measures, such as an advisory process, a feasibility study or matchmaking events with machine suppliers on the use of proven high-efficiency and/or environmentally friendly technologies (e.g. water/energy saving; solar roof-top). According to the interviewed specialist brand/retailer, the investment in the hardware must be borne by the suppliers, while the **brand/retailer commits to placing more orders** for products manufactured with this technology, if it is applied. This incentive mechanism, if built into the contract, is quite effective for large key/strategic suppliers who have the necessary investment capacity – a prerequisite for being nominated as a supplier – but would not work for (M)SMEs.

Buyers can also request **certifications** to assure “the origin, specifications, level of quality or conformity of a product according to production, social and environmental standards” (ReSOURCE 2021), covering the entire chain from certified materials (e.g. Better Cotton, Organic Cotton Standard) to products (e.g. OEKO-Tex Standard 100) and processes at the facility level (e.g. ISO 9001 for quality management, ISO 14001 for environmental management, STeP by OEKO-TEX®). If the certification process requires third-party verification, the cost is usually borne by the supplier, which is indicative of a coercive approach to SSCM. Depending on the certification and the size of the facility, the complexity of the product or the process, the costs

can amount to several thousand euros. In addition to the direct costs, audits and certifications tie up considerable human resources for the necessary preparatory and follow-up work. In general, the supplier alone is responsible for remedying any non-compliances and passing the audit, which is why larger suppliers are more likely to be considered as nominated suppliers, since they have the financial means to make investments in equipment (e.g. machine safety, functionality of water and effluent treatment plant) or structural changes (e.g. building safety). In addition to individual approaches, companies increasingly join sustainability and/or MSIs (MSIs), such as Textile Exchange, the Zero Discharge of Hazardous Chemicals (ZDHC) initiative, the Higg Index, the Social & Labor Convergence Program (SLCP) or the apparel impact institute (aii), which offer tools and standards to address environmental impacts in the textile supply chain (**buyer-collective voluntary approaches**). These tools and standards provide guidance for companies and suppliers to understand and improve their sustainability performance, usually at the expense of suppliers. For example, the Higg Index by Cascale (formerly Sustainable Apparel Coalition) comprises a set of tools that enable brands, retailers and suppliers of all sizes to measure and assess the sustainability performance of a company or a product (e.g. Brand & Retail Module, Factory Environment Module, Material Sustainability Index). Once the results have been verified by an approved auditing firm (third party), they can be shared on an online platform that is recognised by other (Cascale) members, which in turn offers suppliers the advantage of presenting themselves as a supplier with robust management systems in place. Resource materials and improvement programmes are available for implementation at different stages of the supply chain. These initiatives and approaches focus on establishing a management system, while making incremental improvements in different areas. The Higg Factory Environment Module (FEM), for instance, covers management system, energy use and GHG emissions, water use, wastewater, air emissions, waste management, and chemical management. The Higg FEM score only can be published if the facilities, i.e. the suppliers, give their permission. Although (mostly large) suppliers are increasingly part of MSIs and sustainability initiatives, these tools are used by brands and retailers to manage risk in the supply chain. However, the requirements, i.e. the processes to be implemented, are often quite demanding for suppliers and not easy to fulfil – especially for SMEs, as they often lack the financial resources. Some of the tools (Material Sustainability Index, Product Module) have been criticised for not being fully aligned with ISO standards and for providing misleading information on product labels about impact (Bierling 2022).

The **cooperative business model** advocated by the Fair Wear Foundation (FWF) follows the collaboration strategy, which seeks to implement **shared responsibility** principles within the **buyer-collective voluntary approach**, where brand members bear the costs of the audit carried out by FWF itself. Audits, audit costs and reports can be shared with other FWF members sourcing from the same factory; sharing the corrective action plan is mandatory. This relieves suppliers of the burden of having to provide personnel for the audit process multiple times and provides a clear financial incentive. The Fair Wear audit helps to identify, assess and monitor risks and identify improvements where necessary, with a focus on human rights due diligence. Despite positive attempts in considering preventive measures (e.g. responsible purchasing practices), the Fair Wear approach can only have a limited impact, as it is restricted to human rights, labour and social aspects and only covers tier 1 suppliers. Similar collaborative approaches to assessing environmental performance and environmental management systems at the supplier level are not known.

**Traceability tools** in the cotton-garment sector are primarily used to identify and mitigate risks in the supply chain, with the buyer usually taking the initiative and implementing them with key suppliers (**buyer-individual approach**). Among the most important technologies used to confirm the origin or the content of the cotton are DNA-traceability solutions, Radio Frequency



Identification (RFID), fibre tracing tools using pigments and blockchain-based technology (TÜV SÜD AG 2023). RFID tags are increasingly deployed by luxury fashion brands to prevent counterfeiting (Buckulcikova et al. 2022). The blockchain technology stores information on the origin, ownership and lifecycle on a digital record of each good, which allows it to be tracked throughout the product life cycle (Freitag and Weber 2018; Köppe and Finkeldei 2022). It has reportedly been used by various brands and retailers of the garment industry, such as Walmart, adidas, Nike, Puma or Prada (Cuc 2023). The blockchain technology can have various positive effects if it enables the tracking of inputs as they are transformed to outputs. Use cases for blockchain technology aim for high impacts on transparency, sustainability and efficiency (Berger 2022). The most evident cases were the registry of legal (including audit) documents and the measurement of environmental parameters (e.g. water consumption, pH value, temperature, humidity, dust), which, enabled by a tamper-proof Internet of Things (IoT) device, could initiate automated processes via self-executing smart contracts. Assessing other environmental values (e.g. phosphate, ammonium) would require photometric equipment. Companies may realise an increase in efficiency levels, as blockchain seeks to reduce the work in progress, provide more information about the social and environmental sustainability claims of a product, and create a transparent register for documents such as audit reports, contracts or wage data (Berger 2022). Köppe and Finkeldei (2022) present several state-of-the-art blockchain technology solutions that trace each textile product back to its origin (e.g. my-trace by Remei; The Seedtrace Platform, Textile Genesis). According to an interview with a large specialist/retailer, the blockchain technology has been used for the purpose of traceability, which is a huge challenge in the cotton supply chain<sup>10</sup>. Textile Genesis, a blockchain-based traceability platform, claims to provide fibre traceability solutions that can trace sustainable and certified materials from the raw material to consumption. Several companies (e.g. Lensing, ArmedAngels, H&M Group), standard organisations (e.g. Textile Exchange) and textile suppliers have conducted or started pilots that focus on various standards, such as the Organic Cotton Standard (OCS), the Global Recycled Standard (GRS) and the Recycled Claim Standard (RCS), all focusing on the origin of the material composition (TextileGenesis 2023). Consortia like “texCHAINge”, comprising the discount retailer KiK, the Bremer Baumwollbörse and ITA Academy GmbH, among others, have started promoting the development of an ecosystem for digital supply chain management in the German textile and clothing industry (Köppe and Finkeldei 2022). According to one major specialist brand/retailer who sources from different regions (e.g. USA, Pakistan, Australia), blockchain is not seen as a solution that can be deployed at scale, as cotton farming in some geographies is entirely dependent on smallholders picking the crop by hand. It can be assumed that due to the challenges of cost, communication, scalability and correct data entry (Freitag and Weber 2018; UNECE and UN/CEFACT 2021; Köppe and Finkeldei 2022), the adoption of blockchain technologies by smallholders and SMEs in the Global South, which still make up the vast majority of the supply base, is unlikely in the near future.

**Smart contracts** are automated, self-executing transactions that can (but do not have to) be based on blockchain technology. In smart contracts, agreements between buyers and suppliers are encoded and stored on the blockchain, and are executed automatically when certain conditions are met – for example, payment is approved when the quality of the ordered goods is met or the audit is passed (Cuc 2023). In terms of a collaboration strategy, the mechanism is

<sup>10</sup> After spinning, cotton usually cannot be traced back to cultivation. The mass balance system used by Better Cotton is implemented from the ginning plant onwards. Between farm and gin, Better Cotton seed cotton and lint bales must be separated from conventional cotton. After ginning, the Better Cotton mass balance chain of custody is applied, meaning that Better Cotton can be replaced by or mixed with conventional cotton, as long as the volume (mass) is recorded and does not differ (Better Cotton 2020).

therefore designed to incentivise good behaviour and sanction bad behaviour. According to Cuc, several fashion brands like adidas, Puma or Nike are using the Ethereum platform to facilitate smart contracts, although the implementation in practice and how costs are distributed could not be verified. The complexity of the contract determines the cost for designing and using it, which may range from \$500 to \$5000 (Davis 2023). The size of the bytecode, the gas price, or grid congestion can all add significantly to the cost (Davis 2023). Smart contracts facilitate the secure and automatised information exchange between buyers and sellers and make sure that each party fulfils its obligations. They can also be used to pass information to secondary systems, such as certification systems. The benefits for both parties are a higher level of trust, transparency and efficiency, as physical documentation (e.g. authenticated documents such as bill of lading) is significantly reduced, resulting in cost savings. Questions remain as to the extent of reliability, scalability and governance. The decentralised network structure of blockchain-based smart contracts reduce the dependence of single entities (e.g. banks), but also raise the question as to ownership and responsibility. The main barrier to making smart contracts a scalable solution is the complex and time-consuming process of setting up a secure contract and ensuring tamper-proof data entry. Even though smart contracts are expected to be secure, they do not have any legal validity yet, which may affect their adoption in the market.

It is known that in organic cotton trading models, as part of a **collaboration strategy (buyer-individual voluntary instrument)**, suppliers are granted **price premia**, also called organic differentials (Truscott et al. 2021). In-conversion and organically farmed plantations yield positive outcomes for biodiversity, reduce costs for inputs (e.g. chemical fertilisers, irrigation) and improve the farmers profitability. Typically, organic differentials are calculated by taking the price of conventional cotton and adding a percentage to cover the organic value addition, which includes the costs for production, audit, certification, inspection, any yield losses, training and other extension services. The quality of the fibre or the material can also play a role. According to Fairtrade International, there is only an incentive for farmers to grow organic cotton if the market and governmental support prices do not exceed the Fairtrade minimum price (Fairtrade International 2021). Shifting farming methods from conventional to sustainable also has a positive impact on the environment and thus reduces costs for society. However, farmers producing cotton according to the Better Cotton standards are not paid a price premium (Voora et al. 2023). This standard only allows farmers to realise higher prices if the quality of the cotton and efficiency have increased. At the brand/retailer-tier 1 link, a repeated complaint voiced by suppliers is that their efforts to improve social compliance and environmental performance is not rewarded by their customers. In general, no price premium is paid, which is an indication of a coercive SSCM strategy; instead, sustainability is incorporated into the customer requirements. *“Buyers say point blank that they are not going to increase the price, other factories then take the order. ‘You didn’t do it, he (i.e. the other supplier) did’”* (interview with supplier BM2). The same supplier is increasingly faced with buyer requirements to use recycled content for packaging – which, however, is not rewarded. According to this supplier, the whole concept of sustainability only works if there is partnership between brands and suppliers. The literature widely recognises that value creation (i.e. environmental upgrading) does not necessarily result in value capture for suppliers (profit). Instead, buyers maintain prices while sustainability requirements are passed down the supply chain, building a competitive supply base (Khattak et al. 2015) (Khan et al. 2019). When, during the first lockdown, buyers cancelled their orders and pulled out of the market, leading to a significant drop in prices, many suppliers were compelled to sell below the cost of production. Sustainability requirements were the first areas to be compromised (e.g. late payments, cancellation of orders, no remediation of safety issues indicated by the RMG Sustainability Council in Bangladesh) (Ljarja et al. 2023).

**Sustainability financing:** access to finance is a challenge for both buyers and suppliers when it comes to investing in measures to reduce the environmental impact of their operations. Companies have several options to finance projects with high sustainability impact.

- Sustainability-linked bonds and green bonds have experienced a sharp increase over the past decade (Nguyen 2022). The issuance of green bonds enables companies to raise funding for environmentally friendly investments such as renewable energy, energy efficiency, circular products, green buildings, or sustainable water and wastewater management (ICMA 2021). Fashion brands and retailers like H&M, VF Corporation, adidas and Walmart, among others, have issued green bonds to finance specific projects. H&M, for instance, has adopted the Green Bond Principles (GBP) of the International Capital Market Association (ICMA), but has not yet selected and implemented any projects as of December 2023. Annual reports on how funds have been allocated and what impact has been generated are mandatory.
- Sustainability-linked finance schemes that follow ICMA's Sustainability-Linked Bond Principles (SLBP) issue sustainability-linked bonds or grant loans as an incentive to meet previously defined sustainability performance indicators. H&M issued a €500 million sustainability-linked bond in 2021 and linked it to three targets that are to be achieved by 2025: i) to increase the share of recycled materials to 30%; ii) reduce scope 1 and 2 GHG emissions by 20%; and iii) reduce scope 3 GHG emissions by 10%. If the targets are not met, the company would not only suffer reputational damage, but bond interest rates would also rise (Eggerstedt 2021). Consequently, the instrument's inherent incentivising and penalising effects balance each other out. In general, this is an opportunity for investors to incentivise bond issuers to improve on sustainability. However, with H&M's base year set at 2017, when the market and absolute numbers were smaller, and relatively low target numbers, there is reason to doubt the ambitiousness of these targets (Nguyen 2022).
- Suppliers in the Global South have the option to get loans from commercial banks or apply for funding from public development banks or green refinancing instruments of central banks (United Nations Inter-agency Task Force on Financing for Development 2023). Loans from commercial banks do not always offer favourable conditions (e.g. high interest rates) or cannot be accessed as buyer orders are often given only informally by email and are not supported by contract documents. However, even when the funds are available and interest rates are acceptable, access is limited because of the bureaucratic application process involved. The Green Transformation Fund issued by Bangladesh Bank is a refinancing instrument that allows banks to give long-term loans to export-oriented industries for environmentally friendly equipment. Despite a comparatively low interest rate (5%), uptake has been slow due to an extremely bureaucratic application process, which was confirmed in supplier interviews: *"it doesn't make any sense [to apply for], it's just too cumbersome"*.

Linking finance schemes to specific conditions and targets can improve environmental performance. The question here is – and there is a lack of transparency in reporting – to what extent the supply chain benefits from the investments made through sustainable financing. The industry's current focus is on meeting climate targets, while other challenges (e.g. water consumption, hazardous chemicals) are lower down on the agenda; these issues would also benefit from such solutions.

**Voluntary sustainability initiatives and commitments/pledges:** several buyer-collective voluntary sustainability initiatives have committed to achieving net zero by 2050 (e.g.,

Sustainable Apparel Coalition, Textile Exchange, Global Fashion Agenda), setting climate targets to reduce GHG emissions in line with the 1.5°C pathway on all scopes. In practice, few companies have actually presented tangible results to date. Sustainability claims are used to portray a company as green or sustainable, which usually is to the company's advantage, but can increase reputational risk if they are not substantiated. The EU Green Claims Directive aims to regulate false claims made about products. Interviews with country representatives have shown that brands communicate their targets to their supply chain, for instance, in supplier days or direct communication, but rarely accompany them with appropriate measures, such as sustainable finance tools. Suppliers complain that they lack guidance on which data need to be collected and how they are expected to contribute to reducing their customers' scope 3 emissions. Other environmental impact areas are often addressed through capacity development programmes – which, however, normally only benefit key suppliers.

**Emerging approaches** of SSCM shift towards more proactive and collaborative buyer-supplier relationships and shared responsibility. The business model followed by FWF and its member brands seeks to strengthen cooperation among brands and take on a more **collaborative approach** with their supply chain by establishing **responsible purchasing practices** (Ethical Trading Initiative et al. 2022; Fair Wear Foundation n.d.). Companies are assessed on how due diligence is managed, taking into account their sourcing strategy and purchasing practices. An effective way to engage suppliers to minimise risk in their supply chain is for buyers to commit to long-term relationships and practice shared forecasting to improve production planning. **Shared audits** with other customers of the production site help streamline cooperation and reduce costs for suppliers. These are tangible benefits that reduce the number of corrective action plans (CAP) significantly and speed up documentation and reporting. As the aim is to establish fair practices rather than third-party verification of non-compliances, FWF members are expected to engage in remediation through guidance, but not financially. Continuous improvement, while recognising limitations of buyer influence, is central to this risk-based approach. A major constraint to this approach is that FWF has focused on tier 1 factories, ignoring the deeper supply chain. Only now are brands requesting to include tier 2 and 3 suppliers as they are increasingly required to provide data on the environmental impact further down the supply chain (e.g. scope 3 emissions).

**Responsible contracting:** Unfair trading practices are often rooted in contractual terms and conditions where risk is shifted from the buyer, usually the stronger party, to the supplier, who is weaker. Power imbalances in the cotton-garment industry are often reflected in late payments, prices that do not cover production costs, unrealistic lead times and clauses that allow buyers to cancel contracts in the event of force majeure, as happened during the Covid-19 lockdowns (Ljarja et al. 2023). Responsible contracting is a practice initiated by the not-for-profit organisations The Responsible Contracting Project (RCP) and The Chancery Lane Project (TCLP), in collaboration with other industry stakeholders like GIZ and the Sustainable Terms of Trade Initiative (STTI), which seeks to establish shared responsibility between buyers and suppliers to ensure human rights and environmental due diligence. Both organisations have developed Model Contract Clauses (MCC) that can be incorporated in contracts and purchase orders, setting out for both buyers and sellers their obligations to ensure human rights (RCP) and environmental due diligence (TCLP). This means buyers and suppliers are collaboratively responsible for establishing a due diligence process and defining means of resolution as well as of cost responsibility, if necessary. They explicitly move away from supplier-only responsibility to shared responsibility to ensure due diligence. In this context, both parties agree that the supplier is rewarded if, for instance, contractual climate obligations (e.g. reduction of carbon emissions) are fulfilled (The Chancery Lane Project 2024). MCC are sector-agnostic and should be adjusted by legal counsellors. While RCP started out on the US American market, a



consultation version of the European Model Clauses (EMC) have been published in late 2023 (Responsible Contracting Project 2023). Zeeman textielSupers BV, a Dutch discount chain store and member of the FWF, is acknowledged to have started introducing responsible elements in its purchasing practices, such as payment within 14 days (including during the pandemic), sharing audit results with other buyers, early order placement, limited sampling or not changing contract terms (Fair Wear Foundation 2022). Other issues, such as buying prices still not being linked to wage levels, a key requirement of the FWF's Fair Price approach, have not yet been addressed.

**Integrated supply networks** refer to collaborative ways of working in supply chains. Textile Exchange has identified several organic cotton trading models that achieve leverage through a partnership approach with supply chain actors (Truscott et al. 2021):

**Direct sourcing:** brands (e.g. People Tree) want to have more control of the raw material in terms of quality, price or sustainability (e.g. organic content) and buy directly from spinners, fibre growers or corresponding initiatives (e.g. Organic Cotton Accelerator). They negotiate fair prices for the yarn and the production costs for a certain timeframe (e.g. 3-6 months) and make sure their business partners source from nominated suppliers. This gives them control over the product (e.g. organic content).

**Joint entities:** companies pursuing a common goal, which is, for instance, to source organic cotton at fair prices, set up a joint venture to source cotton directly from farmers or ginneries, thereby bypassing costly middlemen. The companies contribute a certain amount of equity and finance the rest through financial institutions. While it can be a useful mechanism to ensure stably supply/demand, it is costly to set up and involves certain risk-taking. The Cotton Sourcing Company Limited (COCSO) is an example.

**Cluster partnerships:** public (local/national governments) and private stakeholders (farmers, manufacturers, brands, business associations, financial institutions) jointly develop mechanisms to improve the sector. Funding commitment from both public and private sector is required (e.g. South African Sustainable Cotton Cluster).

**Collaborative communities:** companies, usually SMEs, that pursue a common purpose aim for shared value by joining forces with like-minded organisations and promoting sustainability through their coalition.

For these models to be effective, that is to ensure stable prices and a secure supply, several attributes need to be fulfilled, such as price transparency (e.g. open book costing, including a premium for sustainability efforts, also for the farmers), agreed prices and quality at the beginning of the commitment, long-term buying commitment, risk and reward sharing, KPI data collection and monitoring, and leveraging access to financial services, among others (Truscott et al. 2021).

**Collaborative financing:** green loan programmes can make funds available to suppliers to address negative environmental impacts. The H&M Group joined forces with the Singapore-based DBS bank to set up a collaborative finance tool that enables suppliers to finance decarbonising measures in various areas (H&M Group 2023). Along with access to direct funding, technical support is provided. While this is a promising first step towards joint

solutions<sup>11</sup>, questions remain as to the terms and conditions of the loans and the financial commitment of the buyers<sup>12</sup>. Further details are required to show potential impact areas.

**Circular business models** are increasingly gaining traction in textile and garment industry (Salmi and Kaipia 2022) and have the capacity to fundamentally change buyer-supplier relationships. While the linear business is dominated by speed, scale and cost, circular business models require more collaboration between supply chain partners. To become circular, buyers and suppliers need to closely work on joint solutions and coordinate their operations transparently. Manufacturers need to invest in new technologies and change their practices, which comes with costs and risks. An effective institutional environment (e.g. regulatory and policy framework, technical) and incentive schemes are crucial for a successful transition of linear business models to circular solutions. However, despite a few initiatives from clothing brands to invest in a collaborative partnership with their suppliers, incentive and reward systems are still lacking in the fashion industry (Loh et al. 2020; Schmid 2023). MSIs, like circular.fashion are increasingly bringing together supply chain partners to develop joint solutions. Schmid (Schmid 2023) portrays various forms of collaborations, from sharing knowledge, technology and other resources to product and material development. More details are needed to show potential impact areas.

#### **Matrix of SSCM approaches and instruments**

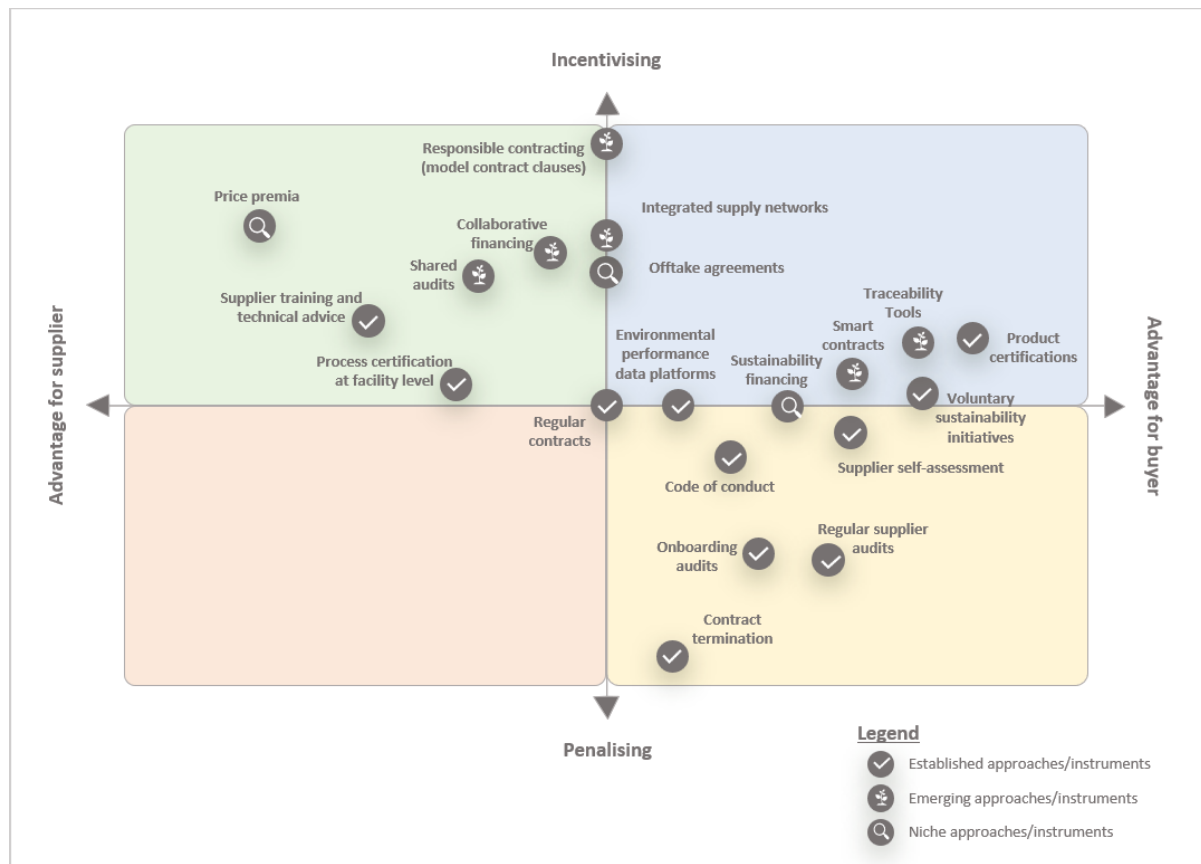
Placing the described business approaches and instruments observed in the cotton-garment industry in a matrix, according to the definition of (perceived) distributional fairness (advantage for supplier/advantage for buyer) and approach to influence the desirability of the requested changes for the business partner (incentivising/penalising) presented in this Chapter, the following pattern emerges:

---

11 In the green loan programme, which was only launched in November 2023, one project (solar panels, energy-efficient motors, water conservation technologies) has been financed with an Indian supplier (ESG News 2023).

12 No information on terms and conditions of the loans have been made available (07.12.2023).

**Figure 10: Matrix of instruments and approaches in the cotton-garment supply chain**



Source: own illustration (adelphi)

As illustrated in Figure 10, the approaches that are primarily based on sanctions tend to result in a perceived advantage for the buyer, while incentive and reward-based instruments are associated with more (perceived) advantages for suppliers. We use the term “perceived” because calculating the total costs would be very complex, especially as the data is often not available and suppliers often feel disadvantaged. Most established instruments favour the buyer side, as they were not designed to redress the power imbalance between buyers and suppliers. Although niche instruments (e.g. price premia, sustainability financing, offtake agreements) are known in the market and have been around for some time, they have not been able to establish themselves for wider use for different reasons (e.g. contested market, tight margins, certain level of trust as a prerequisite). Incentive-based instruments that benefit suppliers are extremely rare, due in large part to the power imbalance in the cotton-garment supply chain. Process certifications of facilities are often not rewarded appropriately, but are now considered a “must have” in the market. Shared responsibility approaches and instruments that aim to involve both parties gravitate towards the centre of the x-axis, where buyers and suppliers benefit equally (e.g. carbon emission reduction against offtake agreements). They are among the emerging instruments that are intended either to compensate for power imbalances or to utilise new technologies (e.g. traceability solutions). It should be noted that this is a highly simplified representation only of those instruments and approaches that are used predominantly. It always depends on how both parties actually apply them or interpret their functionality in practice.

## 4 Roadmap for the cotton-garment supply chain

This chapter is an excerpt of the report “Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains - Roadmaps for the implementation of sustainable supply chain management approaches and instruments” (Grüning et al. 2025). It presents an exemplary roadmap for the implementation of supply chain management instruments to improve the cost-benefit sharing and sharing of environmental information in the cotton-garment supply chain. The roadmap can assist companies in the sector and other stakeholders in advancing the environmental performance of suppliers and sub-suppliers primarily through incentives and cooperation. The roadmap includes a description of the environmental upgrading target, tailored sustainable supply chain management instruments, key actors for implementation, interactions between the instruments, and necessary framework conditions.

### 4.1 Environmental target and background

Water is a key topic in the cotton-garment industry, as it is widely and intensively used throughout the supply chain. Its relevance has increased even more over the past years due to the exacerbation of extreme weather events, such as droughts and floods (e.g. Pakistan 2022), and steadily increasing water scarcity in various places, such as China, Pakistan, northern India, Egypt and the Mediterranean (Mann 2022). Although the water footprint of cotton is contested and depends a lot on the farming methods (Transformers Foundation 2021), in some geographical areas large quantities of water are required for the irrigation and processing of cotton. According to Morgan et al. (2022) cotton farming (Tier 4 of the cotton supply chain) accounts for the largest share of water consumption (65%), while raw material processing (Tier 3) consumes 12%, fabric production (Tier 2) 6% and assembly (Tier 1) 5%.

In 2022, only 24% of the total cotton production was covered by one of the preferred sustainability programmes<sup>13</sup>, while only 1% of the global cotton is organic (Voora et al. 2023); (Textile Exchange 2022). The most important voluntary sustainability standards differentiate between certified sustainable sources for the origin of the cotton raw material, like sustainable cotton such as Better Cotton or Cotton Made in Africa (CMiA), organic cotton such as Global Organic Textile Standard (GOTS), Organic Cotton Standard (OCS), or recycled cotton such as the Global Recycled Standard (GRS) and the Recycled Claim Standard (RCS). In terms of sustainable cotton, these standards certify and ensure that sustainable (Better Cotton, CMiA) or organic (e.g. GOTS, OCS) agricultural practices have been used. In terms of recycled content, the relevant standards (GRS, RCS) ensure the origin and composition of recycled cotton. Initiatives like Zero Discharge of Hazardous Chemicals (ZDHC) and process certifications, such as bluesign, Cradle to Cradle Certified™, STeP by OEKO-TEX, OEKO-TEX Eco Passport or Made in Green by OEKO-TEX and product certifications such as OEKO-TEX Standard 100 promote safe chemical use and sustainable practices particularly between Tier 3 and Tier 1. In addition to these process and product certifications, some of those certifications that cover the entire supply chain (e.g. GOTS, OEKO-TEX Standard 100) emphasise strict standards for approved chemicals and processes in the relevant wet processes. Even though they do not specifically require adherence to a specific standard, their principles are compatible with the requirements of chemical management schemes as suggested by ZDHC or bluesign (bluesign 2020; Global Organic Textile Standard 2023; ZDHC 2024a).

<sup>13</sup> Textile Exchange uses the term “preferred sustainability programmes” to refer to a range of initiatives, certifications and standards that align with Textile Exchange’s definition of preferred fibres and materials that offer improved environmental and social outcomes compared to conventional alternatives (Textile Exchange 2023).

Wastewater is one of the main sustainability concerns in the textile and fashion industry due to several significant environmental and health impacts. Wastewater is produced when textile factories engage in wet processes such as pre-treatment, dyeing and finishing (e.g. mostly in Tier 2; minimal in Tier 1). After the use of a significant amount of chemicals (Fashion For Good 2023), the effluents are discharged to treatment plants and surface waters, often leading to pollution if inadequately treated. As wet processes have considerable impact on water quality determined by chemical, (e.g. oxygen, nitrogen), physical (e.g. temperature) and biological parameters (e.g. biological oxygen demand), water – as a public resource – requires improved governance and management for it to benefit both industrial users and household consumers.

The textile industry's lax water governance over many years led to the founding of the Greenpeace Detox My Fashion campaign and the ZDHC initiative in 2011 (Greenpeace 2020). Today, ZDHC is known in the sector for providing guidelines for chemical and wastewater management; however, according to interviews, adoption rate varies with the specific requirements and the capabilities of the factories to meet those. The ZDHC Wastewater Guidelines specify limit values for conventional wastewater parameters (e.g. BOD, COD, temperature, pH level), heavy metals (e.g. antimony) and chemicals listed in the ZDHC Manufacturing Restricted Substances List (MRSL) (ZDHC 2024b).

Based on this along with key informant interviews and a review of sustainability reports, we focus this cotton roadmap on water pollution in wet processing units (WPU) at Tier 1 (product manufacturing<sup>14</sup>) and Tier 2 (fabric production). This focus is also owed in large part to the fact that brands/retailers have more direct relationships with Tier 1 in particular, increasingly also with Tier 2, and thus have a greater influence here than on spinners (Tier 3) or the cotton farming (Tier 4). Cotton supplies at Tier 4 are often intermediated by traders or sustainability initiatives such as Organic Cotton Accelerator (OCA) or Better Cotton.

Studies and corporate sustainability reports have shown that many fashion companies have been slow, not very ambitious and rather vague in setting and achieving targets to reduce water consumption and pollution throughout the supply chain. The targets and goals are usually set for water management, chemical management and wastewater treatment during pretreatment, dyeing, washing and finishing (H&M Group 2023; Inditex 2023). However, the reports do not consistently specify the tiers included, but generally speak of relevant wet processes, which typically fall under Tier 2 suppliers, sometimes of suppliers and business partners, and sometimes of Tier 1 and Tier 2 supplier factories when discussing their water stewardship approach.

Based on several workshops and interviews with a wide range of actors (companies, suppliers, sustainability initiatives, MSI, banks and investors, business associations), we selected a target that was considered as relevant and ambitious to develop a roadmap for the cotton supply chain. The roadmap was developed and discussed in detail with a focal company and validated through further discussions and desk research. The following targets were defined on this basis:

#### Short-term environmental upgrade target – cotton

Within three years, all high-volume WPUs<sup>15</sup> show at least 80% ZDHC MRSL conformance of their input chemicals and their wastewater quality complies with the highest level of the ZDHC Wastewater Guidelines.

<sup>14</sup> Tier 1 involves garment assembly but can also include dyeing and washing processes. Most of the wet processes take place in Tier 2, such as pretreatment, dyeing, printing, and finishing.

<sup>15</sup> High-volume WPUs make in total around 80% of the order volume of the focal company.

### Mid-term environmental upgrade target – cotton

Within six years, all high-volume WPU's show 100% ZDHC MRSI conformance of their input chemicals.

The focal company is a European retail chain that is known for its wide range of consumer goods, including textiles and fashion. The company focuses on sustainability clothing collections, uses sustainable materials like organic cotton, and participates in MSIs to improve social and environmental standards in its supply chain.

Like any other European brand/retailer in the textile and fashion industry, the focal company is embedded within a complex regulatory framework that includes international agreements, supra-national (e.g. European Union (EU) directives and regulations) and national regulations (e.g. EU member state level). Relevant international regulations and standards encompass e.g. the United Nations Guiding Principles for Business and Human Rights and the Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises on Responsible Business Conduct, which provide global guidelines for preventing and addressing the risk of adverse impacts of business activities on human rights. The International Labour Organisation core conventions do not specifically address chemical, water and wastewater management. The Occupational Safety and Health (OSH) Convention (No. 155) promotes safe and healthy working conditions, which can include aspects of chemical, water, and wastewater management.

At the supranational level, the **Corporate Sustainability Reporting Directive (CSRD)** and its European Sustainability Reporting Standard (ESRS) E3 "Water and marine resources" requires obliged companies to disclose information in its policies, targets and actions related to water consumption in the value chain, particularly if it is taking place in geographical areas with high water-related quality, quantity, regulatory or reputational risks. According to ESRS E2 "Pollution", companies are obliged to disclose their pollutant emissions to air, water and soil and their use of substances of very high concern and a larger group of chemicals classified as substances of concern. Reference is also made to the **EU REACH regulation** (Registration, Evaluation, Authorisation and Restriction of Chemicals), which regulates the production and use of chemical substances to ensure environmental and human health protection (EFRAG 2022; EC 2024c). REACH requires companies to identify and manage the risks associated with the chemicals they manufacture and market in the EU and to provide actors in the supply chain appropriate safety information.

Starting from July 2026, the **Corporate Sustainability Due Diligence Directive (CSDDD)** will oblige large EU companies, including the focal company for this study, to conduct business while respecting human rights and the environment. The CSDDD requires companies and other organisations to assess their entire "chain of activities" (European Union 2024), i.e. the upstream value chain and the distribution, transport and storage of their products for potential negative human rights and environmental impacts and address these impacts by passing on relevant information and support (e.g. on restricted substances) to their supply chain partners. Obligated companies need to conduct due diligence when, for instance, activities of upstream business partners like not continuously using an effluent treatment plant lead to environmental degradation affecting specific human rights, such as the right to food, health or water.

At the national level, the **German Supply Chain Due Diligence Act (LkSG)** obliges large companies, including the focal company, to implement comprehensive human rights-related due diligence obligations and selected environmental due diligence obligations. The protected legal positions according to § 2 (2) No. 9 LkSG include environmental damage to soil, water, and air,



noise emissions and excessive water consumption that results in a violation of human rights, such as denying a person access to safe and clean drinking water (Bundestag 2021). This means that, following a due diligence process, they must assess the risks in their supply chain with regard to water pollution and associated human rights violations, which may occur in Tier 1, but very often also occur further down the cotton-garment supply chain (Tiers 4 to 2), and take appropriate action to address them.

## 4.2 Description of the roadmap

This roadmap presented includes the results of research and findings from interviews and workshops with various actors from companies (brands/retailers, suppliers), civil society, academia, service providers and technical experts. In two workshops, a smart mix of supply chain management instruments and approaches, especially incentive-based, was developed and analysed by a wide range of actors of the cotton-garment supply chain. This mix of instruments was then discussed with a representative of the focal company and translated into a roadmap that identifies and describes which instruments need to be implemented by which actors and by when in order to effectively address the environmental upgrade targets defined above. This approach ensures that broader lessons from the project, beyond the experience of the individual focal company, are incorporated into the roadmap, which will also require other actors in the cotton-garment supply chain to contribute to its effective implementation. The roadmap highlights only the most effective instruments, starting with those identified as most relevant to the focal company, which, through its involvement in relevant industry collaborations (e.g. Partnership for Sustainable Textiles), provides a realistic example for similar buying companies in the cotton-garment supply chain. Some may be of particular importance to the focal company as for other buyers, such as a corporate code of conduct (CoC), while their impact is critically discussed in the literature. They have been critically considered and adapted through timely recommendations (e.g. environmental performance clauses), which often have not been implemented at scale.

Figure 11 shows that most instruments are initiated by buyers and accompanied by collective initiatives in the supply chain, such as sustainability initiatives (e.g. water stewardship programme) or MSIs<sup>16</sup> to achieve the environmental target of reduced water pollution in general, and improved conformance with ZDHC requirements in particular. The individual and collective measures span over a timeframe of six years to achieve the environmental target, which is in line with similar targets set by other companies and industry initiatives (e.g. Partnership for Sustainable Textiles). Not every instrument is implemented from the outset. For instance, the foundation for cooperation between buyers and their suppliers is a CoC to which suppliers are expected to commit throughout the entire business relationship. However, CoCs rarely set specific environmental targets. Only after the sustainability performance of suppliers is understood and trust is built, are buyers willing to go deeper (e.g. direct sourcing), trade on responsible terms (e.g. RPP) and offer more incentivised instruments (e.g. offtake agreements, collaborative financing) to achieve their corporate targets.

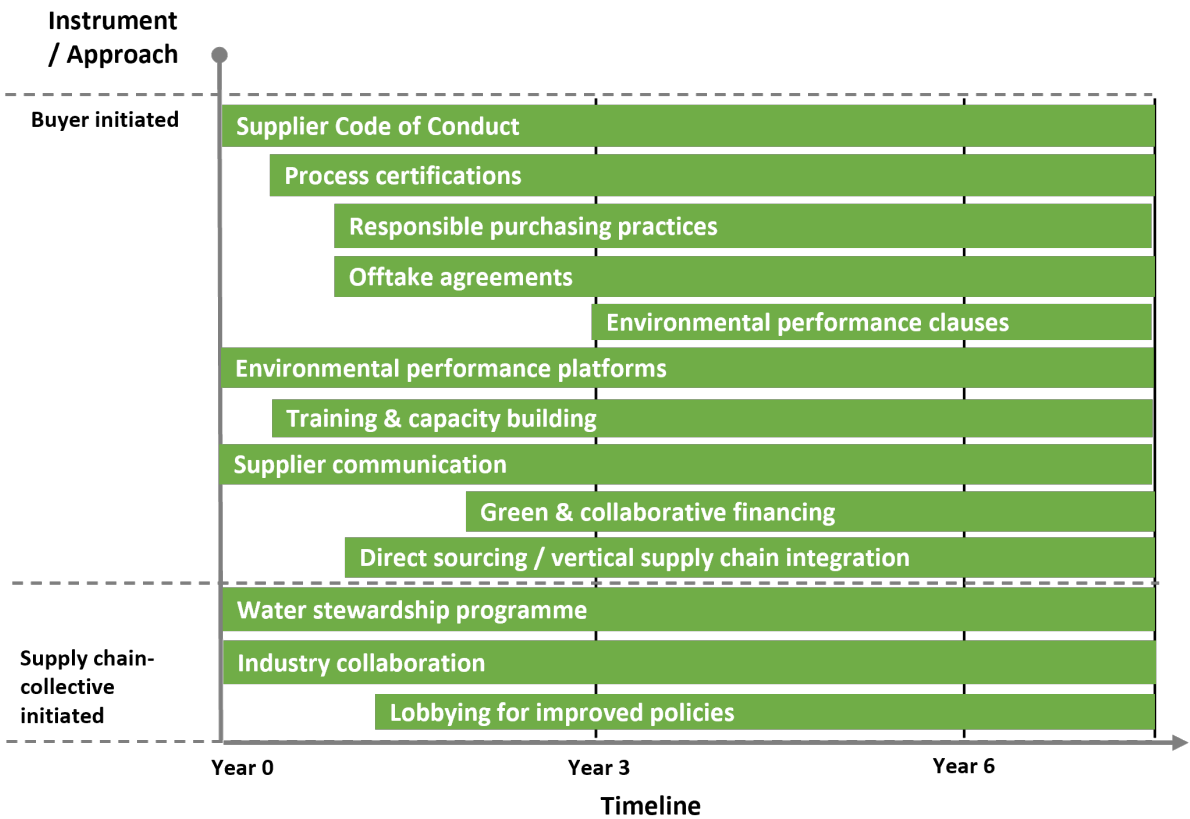
Each instrument and the measures recommended for the respective actors will be explained in detail in section 4.2.1 to 4.2.11.

---

<sup>16</sup> For more information on the categorisation of the instruments, see Grüning et al. (2024).



**Figure 11: Roadmap for improved environmental performance in the cotton-garment supply chain**



Source: own illustration (adelphi research gGmbH)

#### 4.2.1 Instrument 1: Water stewardship programme

Textile brands and retailers often report that they embed their water management measures into a water stewardship/management programme, which can focus on specific tiers (e.g. wet processes in Tier 2) or, ideally, extends back to the level of raw material cultivation (Inditex 2023; World Business Council for Sustainable Development 2024). The overall goal is to improve water management practices in order to increase water efficiency and reduce water pollution. The focal company has such a programme in place, but concentrates its measures primarily on the wet processes in Tier 2, preferring the greater dynamics in these tiers and the higher leverage effect. One of the main objectives of a water stewardship programme for WPU is to reduce water consumption and minimise the environmental impact from hazardous chemicals and untreated or not sufficiently treated effluents. Such a programme can provide guidance to ensure compliance with local and international regulations, thereby reducing legal and reputation risks associated with water pollution. It can explore industry benchmarks for technologies and processes to optimise water use and reduce water and wastewater treatment costs. Water stewardship programmes work towards resource conservation, ensuring long-term availability for both industrial and communal use (UN 2024). These programmes typically adopt a multi-stakeholder approach to identify and disseminate solutions to comprehensively improve the water use and minimise the supply chain (H&M Group 2023; Inditex 2023; UNEP 2023).

Given the priority placed by the focal company on wet processes at Tier 2 (pretreatment, dyeing, finishing), and given the limited scope and space of this roadmap, water-intensive processes at

the raw material production level will be excluded from the analysis. There is a broad range of actors involved driving the initiative of a water stewardship programme:

**Table 6: Key actors and actions for implementing a water stewardship programme**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- In general, join environmental performance programmes (e.g. platforms, initiatives, certifications) that aim to improve the water footprint along the supply chain.</li> <li>- In particular, develop a strategy to improve the use and consumption of water and chemicals in WPU.</li> <li>- Define guidelines and standards for chemical and water management in the supply chain.</li> <li>- Eliminate harmful substances right from the beginning of the manufacturing process by providing access to chemicals conformant with ZDHC requirements.</li> <li>- Communicate to direct (Tier 1) and indirect suppliers (WPUs) to comply with the ZDHC MRSL and the ZDHC Wastewater Guidelines or similar requirements (e.g. bluesign, STeP by OEKO-TEX) and compensate for the additional cost.</li> <li>- Work closely with suppliers to ensure compliance with ZDHC (or equivalent) requirements.</li> </ul>
Direct suppliers	<ul style="list-style-type: none"> <li>- Make sure that WPUs adapt their processes in water and chemical management practices as follows below.</li> </ul>
WPUs	<ul style="list-style-type: none"> <li>- Adopt and implement the ZDHC MRSL to ensure that restricted chemicals are not used in the manufacturing process.</li> <li>- Maintain a detailed inventory of all chemicals (chemical management) and ensure that all chemicals comply with the ZDHC MRSL.</li> <li>- Work closely with chemical suppliers to source safe alternatives that are compliant with ZDHC (or equivalent) requirements.</li> <li>- Conduct regular training sessions for relevant employees (e.g. sustainability/production/OSH/chemical managers) to increase awareness of chemical safety and ZDHC compliance requirements.</li> <li>- Optimise processes to reduce chemical use and hazardous waste and implement best practices for chemical handling and storage.</li> <li>- Follow the ZDHC Wastewater Guidelines to monitor and manage the wastewater quality.</li> <li>- Regularly test effluents to ensure it meets ZDHC requirements.</li> <li>- Document and report purchase, use and disposal of chemicals.</li> <li>- Register at the ZDHC Gateway for auditors to upload ZDHC wastewater reports (e.g. ZDHC ClearStream).</li> <li>- Regularly review and update chemical and water management practices to align with the latest standards.</li> </ul>
Sustainability initiatives/MSIs	<ul style="list-style-type: none"> <li>- Provide comprehensive guidelines and resources that contain best practices for chemical and water management and compliance with ZDHC (and equivalent) requirements.</li> <li>- Organise capacity building for relevant staff of brands/retailers, suppliers/WPUs and chemical suppliers on ZDHC requirements, chemical safety and sustainable practices.</li> <li>- Facilitate platforms for collaboration and information exchange among brands, suppliers, and chemical manufacturers to share knowledge and solutions (e.g. Partnership of Sustainable Textiles, Cascale).</li> <li>- Develop tools and frameworks for self-assessment to help facilitate and evaluate their compliance status and identify areas for improvement (e.g.</li> </ul>

Key Actors	Actions for Implementation
	Higg FEM). ZDHC is an initiative that collaborates with brands and facilities to recognise those achieving high compliance through its ZDHC Gateway, which tracks and shares progress of textile facilities. Cascale also provides tools like the Higg Index that allow brands and facilities to measure and score their sustainability performance, offering recognition to those with high scores.
Certification bodies/third-party auditors	<ul style="list-style-type: none"> <li>- Assess compliance with ZDHC requirements, identify areas for improvement and upload wastewater reports at the ZDHC Gateway.</li> <li>- Organisations like OEKOTEX (e.g. STeP by OEKOTEX) and bluesign offer certifications to facilities that meet specific environmental requirements, including management.</li> </ul>
International organisations	<ul style="list-style-type: none"> <li>- Provide technical expertise for and capacity building in chemical, water and wastewater management e.g. through national or international consultants.</li> </ul>
Industry associations	<ul style="list-style-type: none"> <li>- Facilitate access for sustainability initiatives and development organisations to manufacturers and encourage peer-learning among the members.</li> <li>- Introduce and roll out key requirements for improved water and chemical management among the members.</li> </ul>

Governmental and regulatory bodies in producing countries need to be involved if the programme touches upon local regulations (e.g. inspection and enforcement). Engaging local communities and civil society organisations (CSO) ensures that the community's water needs are taken into account.

#### 4.2.2 Instrument 2: Codes of Conduct vs. Environmental Performance Clauses

Companies in the textile and fashion industry typically impose unilateral codes of conduct (CoC) onto their suppliers for several reasons (Grüning et al. 2024) – these, however, rarely refer to actual performance targets. A CoC typically addresses sustainability concerns, as pressure from CSOs, consumers and regulation to become more sustainable increases. While specific performance targets are rarely mentioned, suppliers are expected to commit to monitoring and reporting on their social and environmental impacts. CoCs are also intended to help manage both economic and non-economic (environmental and social) risks through SSCM.

Brands/retailers often dictate the contents and leave the responsibility (and cost) for sustainability audits to the suppliers themselves (Hoek 2023). However, for buyers and suppliers to engage in equal partnerships, it is important that contracts are not one-sided, imposing requirements and expectations on suppliers, without sharing responsibility for the way the goods are produced. Instead, contracts should be designed to incentivise suppliers to meet or exceed environmental (and social) standards as suggested by the Responsible Contracting Project and The Chancery Lane Project (RCP 2023; The Chancery Lane Project 2023; Dadush et al. 2023). According to interviews, the textile and fashion industry has not adopted these practices yet. The focal company interviewed for this study also has no contracts based on sustainability performance. Their contracts with strategic suppliers only stipulate that both brand/retailer and supplier work on the topic of sustainability, without any further details.

Instead, contracts should be designed in such a way that both buyers and suppliers improve their sustainability performance, adding specific sustainability criteria and environmental performance metrics to the contracts. Brands/retailers could further incentivise compliant suppliers to receive preferred (nominated) status or join a tiered supplier programme depending on their environmental performance score, which would pave the way for more business opportunities and longer-term contracts.

**Table 7: Key actors and actions for implementing environmental performance clauses**

Key Actors	Actions for Implementation
Brands/retailers together with suppliers	<ul style="list-style-type: none"> <li>- Develop clear and detailed contracts that outline expectations, responsibilities, and environmental performance metrics.</li> <li>- Include clauses that provide incentives for meeting environmental performance targets and penalties for non-compliance, such as financial rewards (e.g. bonuses or discounts on future contracts), a preferred supplier status to those who meet or exceed the targets in future contract opportunities, or access to resources (e.g. technical assistance, training). Penalties could include imposing fines or requiring payments to an environmental fund if targets are not met, excluding non-compliant suppliers from bidding on future contracts or reducing their contract volume.</li> <li>- Incorporate environmental performance metrics in the environmental performance clauses that address chemical, water and wastewater management. These may include reducing water consumption (e.g. by a certain percentage in 2025), meeting the ZDHC MRSL and complying with the ZDHC Wastewater Guidelines.</li> <li>- Design these incentives and consequences in such a way that they drive positive environmental outcomes.</li> <li>- Conduct an initial baseline of the supplier's performance in the environmental target areas to understand the current performance.</li> <li>- Set realistic and achievable targets (SMART) for improvement over the duration of the contract.</li> <li>- Link financial (e.g. price premiums) or other incentives (e.g. offtake agreements; 30 days-LC) for achieving the environmental performance targets.</li> <li>- Implement penalties or a reduction payment for failing to meet the sustainability criteria that were agreed upon.</li> <li>- Set up a system that enables suppliers to regularly (e.g. quarterly) monitor and report their environmental performance.</li> <li>- Pay for third-party audits to verify compliance and accuracy of the reported data.</li> <li>- Provide support (e.g. technical assistance, training, access to resources, tools and guidelines) to suppliers to help them achieve the environmental performance targets.</li> <li>- Encourage continuous improvement by setting progressively higher targets over time.</li> <li>- If financially feasible, use traceability tools (e.g. blockchain-based) and platforms (e.g. Higg Index) to track the environmental performance of suppliers.</li> </ul>
Suppliers/WPUs	<ul style="list-style-type: none"> <li>- Align environmental performance targets with customers and work together to achieve them, following the principle of shared responsibility.</li> <li>- Evaluate technology and processes available to meet these targets and invest in upgrades if necessary.</li> <li>- Reach out to customers to discuss sustainable and/or collaborative financing options.</li> <li>- Commit to continuous improvement practices in the specific performance areas to demonstrate willingness to improve.</li> <li>- Participate in industry initiatives that advocate for responsible business conduct and sustainable practices.</li> <li>- Only engage in robust contracts with customers that foster long-term partnerships. Set up incentive-based business relationships and contracts with own suppliers (e.g. material and/or chemical suppliers).</li> </ul>

These clauses ensure fair treatment, promote sustainability, and foster long-term partnerships built on shared responsibility. To be more effective, environmental performance clauses should

be linked to RPP to ensure that contracts explicitly refer to sustainability requirements that suppliers must meet.

### 4.2.3 Instrument 3: Responsible purchasing practices

The Common Framework for Responsible Purchasing Practices (CFRPP) provides a structured approach to incentivise suppliers to improve their overall sustainability performance through RPP. Five elements are key to establishing RPP between buyers and suppliers in the textile and fashion industry: integration and reporting, equal partnership, collaborative production planning, fair payment terms and sustainable costing (Ethical Trading Initiative et al. 2022). By aligning purchasing practices with environmental performance targets, the CFRPP can help create the conditions that value and reward improved environmental performance, encouraging suppliers to adopt and maintain sustainable practices. Some of these recommendations are partially implemented between brands/retailers and their strategic suppliers, but not comprehensively. This approach is seen as too costly and time-consuming for occasional suppliers, who, according to various interview partners, usually account for 80% of suppliers, but only cover 20% of production volume. In general, buyers argue that they have more leverage with their strategic suppliers and therefore focus sustainability measures on them.

**Table 8: Key actors and actions for implementing responsible purchasing practices**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- Integrate RPP into corporate strategy and decision-making process.</li> <li>- Build long-term sourcing relationships with suppliers and pursue win-win situations, sharing responsibility to improve in specific performance areas (e.g. chemical, water and wastewater management).</li> <li>- Collaboratively plan production with suppliers, reducing samples, increasing forecasting accuracy, and balancing orders, among other things, and ensure that changes are agreed upon mutually.</li> <li>- Ensure that suppliers are paid in a timely manner and at fair prices (e.g. Letter of Credit (LC) at sight or LC 30 days) that provides them with the financial stability they need to invest in improved environmental performance (fair payment terms).</li> <li>- Agree with suppliers on reasonable penalties (see above).</li> <li>- Make sure prices cover all production costs and enable responsible business conduct. To make this happen, long-term partnerships provide suppliers with the stability needed to invest in sustainable practices.</li> <li>- Work closely with suppliers on production schedules to avoid last-minute changes, which can increase waste and inefficiencies (collaborative production planning).</li> <li>- Encourage suppliers to regularly report on their environmental performance (integration &amp; reporting).</li> <li>- Consider using the data to recognise and reward suppliers who demonstrate significant improvements.</li> <li>- Implement costing models that account for environmental impacts to incentivise suppliers to improve their chemical, water and wastewater management (sustainable costing).</li> <li>- Treat suppliers as equal partners where both parties are invested in pursuing improved environmental performance (equal partnership).</li> </ul>
Suppliers/WPUs	<ul style="list-style-type: none"> <li>- Engage in transparent communication with brands/retailers, maintaining open lines of communication with customers to discuss expectations, challenges, and opportunities for improvement.</li> </ul>

Key Actors	Actions for Implementation
	<ul style="list-style-type: none"> <li>- Provide regular updates on production status, potential delays, and any issues that may affect delivery timelines.</li> <li>- Negotiate fair payment terms and reasonable lead times that allow for sustainable production without excessive pressure.</li> <li>- Work with customers to develop accurate forecasts, preventing overproduction and waste.</li> <li>- Share information about production capacity and constraints to align expectations and avoid unrealistic demands.</li> <li>- Implement sustainable practices, monitor progress and communicate proactively.</li> <li>- Meet relevant requirements (e.g. ZDHC) and obtain relevant certifications (e.g. OEKO-TEX, bluesign) to demonstrate commitment to RPP.</li> </ul>

#### 4.2.4 Instrument 4: Offtake agreements

Brands/retailers in the fashion industry can make use of offtake agreements in several ways to incentivise suppliers to enhance their environmental performance, such as the conformance with ZDHC requirements. According to interviews with industry actors, offtake agreements with suppliers are used to secure stable supply of materials or products. By providing a long-term purchasing commitment, offtake agreements can offer suppliers the financial stability needed to invest in, for instance, water-saving technologies and other environmentally friendly practices related to the target. This assurance can reduce the risk associated with making such investments. Agreeing to purchase a specific volume of products can encourage suppliers to optimise their production processes, leading to more efficient use of resources (water, energy, chemicals) and reduced waste. If suppliers know they have consistent demand, they might be more willing to implement environmentally friendly practices and purchase chemicals that are safe, sustainable and conformant with the ZDHC requirements. Linking offtake agreements to environmental performance metrics related to chemicals, water and wastewater could provide an incentive for suppliers to improve their performance in the environmental target areas (FasterCapital 2024a; FasterCapital 2024b). Offtake agreements can also include clauses that offer higher prices for products that meet certain environmental standards, such as 100% conformance with the ZDHC MRSL or any other water/chemical-related requirements. This financial incentive can motivate suppliers to adopt environmentally friendly practices to qualify for the premium.

**Table 9: Key actors and actions for implementing offtake agreements**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- Commit to purchasing a specified quantity of goods over a set period of time, providing suppliers with financial stability and predictability.</li> <li>- Arrange agreements that lock in prices, protecting both parties from market fluctuations and ensuring cost predictability.</li> <li>- Include options that i) incorporate clauses that adjust prices based on inflation indices, allowing for periodic price reviews and adjustments, ii) implement flexible pricing models that account for changes in raw material costs, labour and other inflation-related expenses, iii) establish cost-sharing agreements, where both parties share the increased cost, or iv) schedule regular negotiations to reassess and adjust prices based on current market conditions and inflation rates.</li> <li>- Include environmental performance metrics focusing on chemical, water and wastewater management.</li> </ul>



Key Actors	Actions for Implementation
	<ul style="list-style-type: none"> <li>- Include clauses that reward suppliers for consistently meeting sustainability benchmarks in the areas of water, wastewater and chemical management.</li> <li>- Encourage suppliers to develop new materials or processes by offering rewards for successful innovations in terms of water efficiency and chemical safety.</li> </ul>
Suppliers/WPUs	<ul style="list-style-type: none"> <li>- Use the guaranteed revenue from offtake agreements to invest in environmentally friendly technology upgrades, among other things, to meet the demand and improve the environmental performance in terms of chemical, water and wastewater management.</li> </ul>

#### 4.2.5 Instrument 5: Process certifications

Process certifications in the textile and fashion industry can significantly enhance supplier performance in chemical, water and effluent management by setting clear standards and providing frameworks for best practices. In the absence of mandatory regulatory requirements, voluntary sustainability standards and certifications can provide a framework for a performance-based approach and provide information about the supplier's capabilities (Botta and Forbicini 2023; Strasser et al. 2024). The following non-exhaustive list of certifications encourages continuous improvement, compliance with regulations, and adoption of best practices, ultimately leading to better chemical, water and wastewater management. Some of these certifications like bluesign or STeP by OEKO-TEX provide a systematic approach for textile manufacturers to manage chemicals responsibly and reduce environmental impact. As they are also aligned with the ZDHC requirements, companies prefer to work with/onboard factories that are certified and thus have already established some sort of management system. ZDHC itself is not a certification but provides guidelines and tools for managing hazardous substances, helping suppliers improve towards industry best practices (ZDHC 2024a; ZDHC 2024b).

- **bluesign** is primarily a business-to-business certification system verified by a third-party audit. It provides a chemical management system that enables manufacturers to select and use safe chemicals. Bluesign-approved chemicals meet stringent safety criteria that align with the ZDHC objective to eliminate harmful chemicals from the textile supply chain. Products that meet the stringent bluesign standards can carry the consumer-oriented bluesign label.
- **STeP by OEKO-TEX** is a certification system aimed at promoting sustainable manufacturing processes in the textile and leather industries. It evaluates production facilities based on six performance areas: chemical management, environmental performance, environmental management, social responsibility, quality management, and health and safety. The STeP by OEKO-TEX requirements align well with the environmental target set by the focal company for this roadmap. It ensures chemical safety and effective resource management through several measures, such as the implementation of a chemical management system, the evaluation and improvement of the environmental performance, effective waste management, continuous improvement by setting targets and monitoring progress, training of relevant staff, and certification and auditing (OEKOTEX 2023).
- **ISO 14001** encourages the continuous improvement of environmental performance through the establishment of an Environmental Management Systems (EMS), which is based on a continuous Plan-Do-Check-Act (PDCA) cycle. The environmental performance and the function of the management system are regularly monitored and measured based on targets and performance indicators, internal audits and management reviews (ISO 2021; ISO 2023).



While ISO 14001 does not explicitly reference ZDHC, companies already certified as ISO 14001 might find it easier to integrate ZDHC requirements into their management systems. Adopting best practices for chemical management and ensuring conformance with e.g. the ZDHC MRSL can also complement the environmental management objectives of ISO 14001.

**Table 10: Key actors and actions for implementing process certifications**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- Only onboard suppliers with certifications that cover chemical and water management or who are registered with ZDHC or equivalent schemes.</li> <li>- Set high standards for both environmental and social requirements. If suppliers do not have the required certifications, brands/retailers may refuse to work with them.</li> <li>- Check which certifications integrate or align with other industry standards to prevent suppliers from complying with differing requirements. Ensure that certifications (e.g. STeP by OEKO-TEX) provide access to industry-wide environmental performance platforms (e.g. ZDHC Gateway, Higg Index), so that wastewater testing results automatically translate into a ZDHC ClearStream report, which simplifies the overall process and reduces cost. This access can help suppliers improve their sustainability practices and increase their readiness for certification.</li> <li>- Provide incentives to suppliers for obtaining relevant certifications related to chemical and water management, such as ZDHC, bluesign or equivalent requirements.</li> </ul>
Tier 1 suppliers	<ul style="list-style-type: none"> <li>- Make sure to only source from WPU's that meet ZDHC requirements or have a certification that is aligned with ZDHC requirements.</li> <li>- Advocate to their customers that WPU's with which they preferably work, but which are not yet on the customer's nomination list, are included in the water stewardship programme.</li> <li>- Closely engage with preferred WPU's to meet the entry barriers (e.g. ZDHC conformance, social and environmental standards) for the water stewardship programme.</li> <li>- Offer bonuses to WPU's for meeting the required standards, certifications and requirements.</li> <li>- Negotiate long-term contracts with customers in return for purchasing from reliable, certified sources.</li> </ul>
WPU's	<ul style="list-style-type: none"> <li>- Adopt the ZDHC MRSL to ensure that only approved chemicals are used in the manufacturing process.</li> <li>- Implement a comprehensive chemical management system with a detailed inventory of all chemicals that meet ZDHC (or equivalent) specifications.</li> <li>- Work closely with chemical suppliers to make sure that they source chemicals that are compliant with the ZDHC requirements.</li> <li>- Conduct regular training for their employees to use and handle chemicals safely and meet the ZDHC requirements.</li> <li>- Optimise processes to reduce chemical use and improve efficiency, minimising environmental impact.</li> <li>- Follow the ZDHC Wastewater Guidelines to monitor and manage wastewater quality, ensuring it meets the ZDHC requirements.</li> </ul>
Standard setting organisations (e.g. ISO, OEKO-TEX, GOTS)	<ul style="list-style-type: none"> <li>- Build standards on relevant sustainability requirements that have been increasingly adopted by the industry (e.g. ZDHC MRSL, ZDHC Wastewater Guidelines, Greenpeace Detox). For instance, OEKO-TEX® DETOX TO ZERO was developed to proactively work towards achieving Greenpeace Detox goals that are similar to the ZDHC goals.</li> </ul>

Key Actors	Actions for Implementation
	<ul style="list-style-type: none"> <li>- If possible, work closely with other standards and sustainability initiatives to harmonise requirements and create a unified approach to environmental performance.</li> <li>- Engage a diverse range of stakeholders (e.g. manufacturers, CSOs, researchers) in the standard development process to ensure that the standards are comprehensive and practical.</li> <li>- Include detailed guidelines for chemical and wastewater management across the supply chain.</li> </ul>
Conformance assessment bodies/certification bodies	<ul style="list-style-type: none"> <li>- Conduct third-party audits to verify compliance with relevant environmental standards. Provide factories with detailed feedback on areas for improvement.</li> <li>- Provide feedback to standard setting organisations for improving standardised processes for environmental management, data collection, and reporting.</li> <li>- Offer training programmes to brands/retailers and supplier factories to understand and implement environmental management standards</li> </ul>

#### 4.2.6 Instrument 6: Environmental performance platforms

Continuous monitoring of supplier performance in environmental performance areas can best be achieved by joining environmental performance platforms. Here, suppliers record and upload data from different performance areas, such as chemical use or water and energy consumption. Environmental performance platforms like ZDHC and Higg Index/Worldly provide comprehensive assessment tools to improve the sustainability performance, facilitating data sharing and benchmarking, offering training and capacity building, and fostering collaboration across the industry (Cascale 2024; ZDHC 2024b).

- The **ZDHC Gateway** is an online platform that is designed to promote safer and more sustainable practices in the textile, apparel, leather, and footwear industries (Stichting ZDHC Foundation 2023b; Stichting ZDHC Foundation 2023d). It consists of two modules: chemical and wastewater. The Chemical Module is a comprehensive database of safer chemistry for the industry. It allows suppliers and manufacturers to register their chemical products and make public their ZDHC MRSL conformance levels. The website also offers complete safety and sustainability information on registered chemicals (ZDHC Gateway 2018). The Wastewater Module allows suppliers to share verified wastewater data and demonstrate their performance to customers (Stichting ZDHC Foundation 2023c). It provides guidance on opportunities for improvement and generates wastewater reports (ZDHC ClearStream Report) that were verified by ZDHC Accepted Laboratories. Additional tools and reports help ensure supply chain transparency and promote the use of safer chemicals. The ZDHC ChemCheck Report serves as a chemical formulation product passport that confirms compliance with the ZDHC MRSL (Stichting ZDHC Foundation 2023a). The Performance InCheck Report provides an overall score of conformance with the ZDHC MRSL (ZDHC 2020).
- The **Higg FEM** (Facility Environmental Module) provides a comprehensive framework for facilities to assess their environmental performance across several key areas, including energy use and greenhouse gas (GHG) emissions, water use, wastewater, emissions to air, waste management, and chemical use and management. Following a self-assessment, the accuracy and credibility of the data provided is verified by an accredited third party. The scores generated from the verified data allow facilities to benchmark their performance

against industry standards. The scoring system helps facilities identify where they stand in terms of environmental performance and highlights areas for improvement. Based on the assessment results, facilities can develop and implement improvement plans. The Higg FEM provides guidance on best practices and strategies to improve environmental performance in specific areas.

**Table 11: Key actors and actions for using environmental performance platforms**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- Set clear standards, such as the ZDHC MRSL and the most recent ZDHC Wastewater Guidelines, which define specific criteria and expectations for chemical, water and wastewater management that suppliers must meet.</li> <li>- Jointly implement with suppliers/WPUs monitoring technologies that enable WPUs to track water usage and chemical discharges in real-time and communicate them to their clients.</li> <li>- Regularly verify the performance through internal and/or third-party audits that also identify areas for improvement. Give regular performance feedback to strategic suppliers and offer technical assistance for implementing corrective measures and best practices.</li> <li>- Have strategic suppliers join platforms for sharing data and insights into relevant reports (e.g. ZDHC ClearStream).</li> <li>- Include specific clauses in supplier contracts that mandate the use of Higg FEM and conformance with ZDHC requirements. Stipulate the expectations, timelines and consequences for non-compliance.</li> <li>- Offer training programmes and technical assistance to help suppliers use the Higg FEM and meet the ZDHC requirements. Work together with strategic suppliers to address the identified issues and implement best practices, building a trust-based long-term relationship.</li> <li>- Offer financial incentives, such as bonuses or discounts on future orders, for suppliers who successfully implement these requirements and meet the environmental performance targets.</li> <li>- Establish financial support programmes to help suppliers with the initial cost of implementing necessary changes.</li> <li>- Pay for regular third-party audits to verify that suppliers are meeting the requirements.</li> <li>- Require suppliers to share their Higg FEM scores and ZDHC conformance data. Maintain regular communication with suppliers to discuss their progress, challenges, and any support they might need. Integrate the use of Higg FEM and ZDHC conformance with other sustainability initiatives and certifications (e.g., OEKO-TEX, bluesign, ISO 14001) to ensure that all relevant sustainability aspects are addressed.</li> </ul>
Suppliers/WPUs	<ul style="list-style-type: none"> <li>- Install sensors and automated monitoring systems (e.g. smart water meters, chemical inventory trackers, wastewater monitoring solutions, environmental monitoring systems to track emissions) to track water usage, chemical inputs, and emissions in real-time.</li> <li>- Regularly collect data and develop management systems to analyse and report on environmental performance.</li> <li>- Use the monitoring data to implement continuous improvement processes, optimise the resource use and reduce waste (e.g. chemicals, water), thereby saving cost.</li> <li>- Upload the data to relevant platforms that can be accessed by customers (brands/retailers).</li> <li>- Collaborate with brands/retailers and align monitoring practices with their sustainability goals and reporting requirements.</li> </ul>

Key Actors	Actions for Implementation
	<ul style="list-style-type: none"> <li>- Use the assessment results to identify improvement areas, particularly in chemicals, water and wastewater. Implement, for instance, the Higg FEM best practice guidelines and resources for each area of assessment. Use the resources to implement more sustainable practices, such as water-saving measures or chemical management systems.</li> <li>- Conduct periodic assessments to track progress and make adjustments to the improvement plans.</li> <li>- Share verified environmental performance data with customers through the Higg Index platform, where brands/retailers can access the results.</li> </ul>

#### 4.2.7 Instrument 7: Green and collaborative financing

Green financing programmes can significantly enhance the environmental performance of textile and fashion suppliers by providing the financial resources and incentives needed to implement sustainable practices. This may include upgrading machinery and equipment to more efficient models, installing water treatment systems, or adopting closed-loop systems that minimise chemical emissions. Financial support can come either from brands/retailers through supplier financing programmes or collaborative funding mechanisms, from international organisations (e.g. grants) or from international or national financial institutions (Ahi and Searcy 2015; Khurana and Ricchetti 2016; Köksal et al. 2017; IFC 2021). Many green financing programmes offer incentives such as lower interest rates or grants for companies that meet certain sustainability criteria. This encourages suppliers to adopt practices that reduce chemical use and water pollution. Very often, however, the focus is still on the transition to a low-carbon textile industry (H&M Group 2024). Green financing can also be used to reduce the use of hazardous chemicals and/or switch to water-saving and energy efficient alternatives, such as enzymes (Juniper Policy Consulting (Pvt.) Limited 2024). This involves changing processes and using improved technology.

**Table 12: Key actors and actions for implementing green and collaborative financing**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- Set up supplier financing programmes that offer preferential loan terms or lower interest rates for suppliers who invest in environmentally friendly technologies and practices (e.g. water-saving technologies, new processes for sustainable chemical substitutes).</li> <li>- Reward suppliers that achieve their environmental performance targets, such as improved water efficiency, less water pollution, or full conformance with ZDHC requirements.</li> <li>- Collaborate with banks or financial institutions to create dedicated financing lines for suppliers and secure better financing terms for suppliers.</li> <li>- Offer long-term contracts or guaranteed order volumes to provide suppliers with the financial stability needed to invest in improved environmental performance.</li> <li>- Provide technical assistance and capacity building to support suppliers on relevant environmentally friendly practices and technologies. This could include workshops, access to technical experts, or guidance on achieving relevant certifications/requirements.</li> <li>- Set up partnerships with sustainability initiatives or MSIs (e.g. Cascale, Textile Exchange), suppliers and non-governmental organisations (NGOs) to co-fund environmental performance programmes. This could help reduce risk and lower the entry barriers for suppliers to participate.</li> </ul>

Key Actors	Actions for Implementation
Suppliers/WPUs	<ul style="list-style-type: none"> <li>- Implement EMS to set the groundwork for improved environmental performance.</li> <li>- Participate in self-assessment tools/programmes, such as the Higg Index, to increase transparency and improve reporting.</li> <li>- Actively engage with customers by communicating environmental performance goals and progress to customers.</li> <li>- Create detailed plans for environmental performance improvements.</li> <li>- Clearly outline the expected environmental and financial benefit.</li> <li>- Demonstrate how the project aligns with the customer's environmental performance goals.</li> <li>- Implement digital tools for better data collection and reporting.</li> </ul>
Financial institutions	<ul style="list-style-type: none"> <li>- Provide green loans specifically designed for improving environmental performance with favourable terms, such as lower interest rates, longer repayment periods or deferred payments, to encourage investments in the key areas.</li> <li>- Provide sustainability-linked loans; these are loans with interest rates linked to the borrower's sustainability performance. If the supplier meets predefined environmental performance targets, they benefit from reduced interest rates.</li> <li>- Implement financing models where repayment terms are linked to the achievement of specific environmental outcomes. This ensures that suppliers are incentivised to meet performance targets.</li> <li>- Require suppliers to provide regular reports on their environmental performance as a condition of financing. This ensures transparency and accountability.</li> </ul>
International organisations	<ul style="list-style-type: none"> <li>- Collaborate with governmental agencies and financial institutions to provide grants for environmental projects to help suppliers cover the initial cost or get funding at affordable interest rates.</li> <li>- Offer advisory services to help suppliers understand the benefits of their investments (e.g. business cases, feasibility studies, cost-benefit analyses).</li> <li>- Provide guarantees to reduce the risk for lenders (e.g. local banks).</li> <li>- Collaborate with industry initiatives like ZDHC and Cascale/Higg to ensure that financed projects align with industry standards and certifications.</li> </ul>

#### 4.2.8 Instrument 8: Training/capacity building

Capacity building, training and education are crucial for suppliers to develop their employees in focus areas that determine their sustainability performance (e.g. data collection, monitoring, chemical inventory, etc.). While brands can offer capacity building and training to their suppliers, sustainability initiatives and MSIs also play an important role since: i) they bring together diverse perspectives and expertise from different actors, ii) they can leverage their extensive networks and reach a larger audience through their members, increasing impact, iii) and they may foster collaboration among actors, enabling sharing knowledge, resources and solutions, and fostering peer learning.

**Table 13: Key actors and actions for implementing training and capacity building**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- Brands/retailers provide technical assistance, training and resources to help suppliers improve their environmental practices and meet</li> </ul>

Key Actors	Actions for Implementation
	compliance with e.g. ZDHC requirements. This technical assistance could be linked to a 'preferred supplier programme' where compliant suppliers receive preferred status, leading to more business opportunities as well as better and more long-term contracts.
Suppliers/WPUs	<ul style="list-style-type: none"> <li>- Conduct a thorough needs assessment to identify the specific training and capacity-building needs within the facility and employees. Use surveys, interviews, and audits to understand the current state and areas needing improvement.</li> <li>- Develop training content that is tailored to the specific needs and challenges of the facility. Partner with sustainability experts, industry associations, and certification bodies to develop and deliver high-quality training programmes.</li> <li>- Ensure that effective training methods (e.g. interactive, in-person, peer-learning) are used to engage participants and enhance the outcome.</li> <li>- Ensure access to resources, such as manuals, guidelines and best practice documents that employees can use.</li> <li>- Establish key performance indicators (KPIs) to monitor the effectiveness of the training programmes, regularly assess the impact of the training programme and consider third-party verification to ensure the accuracy and credibility of the performance data.</li> <li>- Align training with organisational goals and secure top management commitment.</li> </ul>
MSIs/sustainability initiatives	<ul style="list-style-type: none"> <li>- Develop comprehensive training modules on chemical, water and wastewater management. This training should be tailored to the specific needs of the suppliers and ensure hands-on experience.</li> <li>- Create and distribute educational materials, such as guidelines, case studies, and best practice documents. These materials can serve as reference points for suppliers.</li> <li>- Engage with digital platforms to provide access to webinars and interactive tools. Platforms like the ZDHC Academy offer specialised training in sustainable chemical management.</li> <li>- Organise workshops, roundtables and conferences where both brands/retailers and suppliers can learn from industry experts and share experiences with peers.</li> <li>- Develop certification programmes that recognise suppliers who have successfully completed training and implemented sustainable practices.</li> <li>- Collaborate with international organisations and financial institutions to offer grants and subsidies for training and capacity building.</li> <li>- Offer technical assistance to help suppliers implement the knowledge gained from training and educational programmes.</li> <li>- Implement monitoring and evaluation systems to track the progress of the suppliers.</li> </ul>
National/international organisations	<ul style="list-style-type: none"> <li>- Offer impact-oriented training programmes, workshops and webinars to educate suppliers on best practices in chemical, water and wastewater management.</li> <li>- Provide technical assistance and resources to help suppliers implement sustainable practices and technologies.</li> </ul>

While sustainability initiatives and MSIs can play an important role in providing guidelines, resources and training, their impact often has been criticised as limited and intransparent (MSI Integrity 2020). MSIs often rely on voluntary compliance and lack the enforcement and monitoring mechanisms needed to ensure that all participants adhere to agreed standards and



practices. One criticism is that improvements in human rights and the environment on the ground with rights holders have been scarce, as capacity-building measures often only focussed on output, instead of outcome or even impact level (MSI Integrity 2020).

#### 4.2.9 Instrument 9: Improved supplier/factory communication

Effective communication between buyers and suppliers is key to enhancing sustainability performance. Brands/retailers and their suppliers (Tier 1, WPU) need to engage in proactive, structured communication to foster a collaborative environment that drives improvement in chemical, water and wastewater management.

**Table 14: Key actors and actions for improved communication between brands/retailers and suppliers/factories**

Key Actors	Actions for Implementation
Brands/retailers	<ul style="list-style-type: none"> <li>- Clearly communicate sustainability standards, guidelines, and performance expectations regarding chemical, water, and wastewater management right from the beginning of the business relationship, when initiating the contact.</li> <li>- Offer training programmes, resources, and technical support to help suppliers understand and implement monitoring that allows for constructive feedback on the suppliers' performance, identifying areas for improvement.</li> <li>- Encourage open and transparent communication channels where suppliers can discuss challenges, share progress, and seek guidance without fear of repercussions (e.g. sanctions, contract termination).</li> <li>- Work collaboratively with suppliers to develop and implement solutions to any identified issues, leveraging expertise from both sides.</li> <li>- Create incentives for suppliers/WPU that meet or exceed sustainability performance targets, such as preferred supplier status or financial rewards.</li> </ul>
Suppliers/WPU	<ul style="list-style-type: none"> <li>- Ensure a thorough understanding of the brand/retailer sustainability expectations and align internal processes accordingly.</li> <li>- Provide regular, transparent reports on chemical usage, water consumption, and wastewater management practices, including any challenges faced.</li> <li>- Implement industry best practices and technologies to improve chemical, water and wastewater management.</li> <li>- Provide space for employees to participate in training, workshops and capacity-building activities offered by brands/retailers, MSIs, national and international organisations.</li> <li>- Proactively communicate with customers. Work closely with brands/retailers to develop and implement effective solutions to challenges in chemical, water and wastewater management, sharing insights and innovations.</li> </ul>

#### 4.2.10 Instrument 10: Direct sourcing/vertical supply chain integration

Direct sourcing and vertical supply chain integration can provide companies with greater control and transparency in implementing sustainable chemical, water, and wastewater management practices in the textile and fashion industry. Sourcing from composite units (e.g. Tier 1-2 or Tier 1-3, in few geographies even Tier 1-4 is possible, like in China or Pakistan) allows brands/retailers to have greater control over multiple stages of the production process. This also improves the negotiating position of suppliers, diminishing power imbalances between brands/retailers and suppliers.

**Table 15: Key actors and actions for direct sourcing/vertical supply chain integration**

Key Actors	Actions for Implementation
- Brands/retailers	<ul style="list-style-type: none"> <li>- Source from composite units that address sustainability issues, such as chemical use, water consumption and wastewater discharge.</li> <li>- Ask for chemical, water and wastewater data from composite units and make decisions based on their resource use and their chemical, water and wastewater management.</li> <li>- If composite units are not available, build business relationships with WPUs, testing their sustainability performance and nominating them as preferred fabric suppliers. Incentivise Tier 1 suppliers to only source from nominated/preferred WPUs.</li> </ul>
- Tier 1 supplier	<ul style="list-style-type: none"> <li>- Expand into areas like textile production, knitting/weaving, and dyeing if financially feasible. If that is not possible, establish multi-tier supplier collaboration with WPUs/Tier 2 fabric suppliers.</li> <li>- Coordinate and plan between internal departments and WPUs to ensure optimised supply chain flow, following sustainability performance requirements.</li> <li>- Collaborate with WPUs to develop and agree on common sustainability standards and best practices for chemical, water and wastewater management.</li> <li>- Join training programmes and workshops to ensure both tiers are aligned on the latest best practices and regulatory requirements.</li> <li>- Establish agreements with WPUs for sharing relevant data on chemical usage, water consumption, and wastewater treatment processes.</li> <li>- Engage external experts and consultants to provide guidance and support for implementing advanced sustainability practices in chemical, water and wastewater management.</li> </ul>
- WPUs	<ul style="list-style-type: none"> <li>- Engage in multi-tiered supplier collaboration with Tier 1 factories (see above).</li> <li>- Participate with chemical suppliers and other actors in industry-wide sustainability initiatives and multi-stakeholder platforms to stay informed about emerging trends in chemical, water and wastewater management.</li> </ul>

For more information on multi-tiered supplier collaboration, see Sabri (Sabri 2023).

#### 4.2.11 Instrument 11: Policymaking/lobbying

Drawing on interviews with the focal company and other experts, actors in the textile and fashion industry should advocate for improved policymaking regarding chemical, water, and wastewater management through multiple strategic actions:

**Table 16: Key actors and actions for policymaking/lobbying**

Key Actor	Actions for Implementation
- Brands/retailers + suppliers	<ul style="list-style-type: none"> <li>- Actively lobby for stricter regulations and policies that promote safer chemicals (e.g. the phase-out of hazardous chemicals) and improve water and wastewater management standards in regions where cotton is produced, and the textiles are being processed.</li> <li>- Engage actively in MSIs that support sustainable practices in chemical, water and wastewater management.</li> </ul>

Key Actor	Actions for Implementation
	<ul style="list-style-type: none"> <li>- Form partnerships with NGOs and environmental organisations that have expertise in chemical, water and wastewater management.</li> <li>- Publish detailed sustainability reports that showcase the brand's/retailer's actual results in chemical, water and wastewater management across the supply chain.</li> <li>- Clearly demonstrate sustainability performance with strategic and occasional suppliers, providing transparency.</li> </ul>
- MSIs	<ul style="list-style-type: none"> <li>- Develop in collaboration with other actors (e.g. industry associations, international organisations, governmental organisations in producer countries) and submit policy proposals to government agencies and regulatory bodies, outlining specific measures and standards for sustainable chemical, water and wastewater management.</li> <li>- Participate in public consultations and hearings on environmental regulations, providing expert knowledge and data to support more stringent policies. Give constructive feedback on policies.</li> <li>- Organise and participate in industry forums and conferences that focus on sustainability and regulatory improvements in chemical, water and wastewater management.</li> </ul>
- National/International organisations	<ul style="list-style-type: none"> <li>- Work with industry associations or umbrella initiatives (e.g. STAR Network) to advocate for sustainable practices and improved regulations on chemical, water and wastewater management.</li> <li>- Launch public awareness campaigns to educate consumers and actors about the importance of sustainable chemical, water, and wastewater management.</li> </ul>

For more information on the STAR Network (Sustainable Textiles of the Asian Region), see Asia Garment Hub (Asia Garment Hub 2024).

### 4.3 Other instruments

Some instruments were not considered by the focal company as suitable for the target to increase the compliance with ZDHC requirements and reduce water pollution. However, they may be in use for other environmental targets (e.g. carbon emission reductions):

- **Price premiums:** are already used by the focal company to pay the organic differential and for certified facilities. For chemicals and wastewater, the company admits that pressure by civil society and consumer awareness are not high enough to justify increased prices.
- **Collaborative financing:** an instrument that could be used for larger investments, mostly in topics such as carbon emission reductions where political pressure is higher and conversion to different fuels or more environmentally friendly technology (e.g. 'clean' boilers) is imminent.
- **Shared audits:** according to the focal company, this instrument is not very common for environmental topics; for wastewater and chemical targets, environmental performance platforms like ZDHC or Higg Index are more relevant.

## 4.4 Discussion of the roadmap for the cotton-garment supply chain

The key instruments presented in the roadmap are intended to overcome some of the challenges that companies and their supply chain partners face in reducing water pollution and improving chemical management. The roadmap includes only those instruments that the focal company and relevant stakeholders believe have the greatest leverage and does not represent a comprehensive guide to implementing SSCM to reduce water pollution.

According to interviews with the focal company and other relevant stakeholders, supplier codes of conduct are key for brands/retailers to start a business relationship with suppliers, stating guidelines and expectations and ensuring that suppliers adhere to sustainable practices. To make this instrument more effective in terms of environmental performance, comprehensive codes of conduct eventually would need to be integrated into contractual agreements between buyers and their suppliers.

In order to achieve environmental performance targets, in particular chemical, water and wastewater management targets, brands/retailers prefer onboarding and sourcing from suppliers that carry relevant process certifications (e.g. STeP by OEKO-TEX, bluesign) or meet sector-specific key requirements, such as the ZDHC MRSL or the ZDHC Wastewater Guidelines.

Once the quality of the product and a basic level of sustainability have been assured, brands/retailers enter into contract negotiations. Contracts that integrate sustainability-linked offtake agreements, environmental performance clauses and RPP ensure that sustainability is at the core of the business relationship. These measures should start early, but not at the outset, as there is a need to establish trust first. Although contracts are binding, power imbalances in the sector mean that they are sometimes not honoured in the event of force majeure, as was the case during the COVID-19 pandemic.

Setting environmental performance targets and defining rewards and sanctions in contracts means assigning responsibilities and timelines and working towards them. Investments in technology and infrastructure are needed to meet these requirements. This includes, for example, upgrading machinery and/or implementing new effluent treatment systems, but also the adoption of cleaner production processes and general process improvements. Access to finance is essential for suppliers aiming to achieve ambitious environmental performance targets. The process of obtaining certifications and ensuring compliance with ZDHC requirements can involve significant costs, including fees for audits, testing, and documentation. Buyers and international organisations (e.g. multi-lateral banks) have opportunities to support key suppliers with funding to initiate the necessary actions. Green financing instruments, such as green loans or sustainability-linked loans, and collaborative financing schemes can help the focal company and their key/strategic suppliers to set long-term goals and achieve greater improvements through significant investment in environmentally friendly technologies and processes. Such measures are typically only offered to trusted suppliers.

Supplier capacity building and transparent communication can be effective tools to overcome challenges and improve in relevant performance areas (chemical, water and wastewater management) – if adequately designed.

Environmental performance platforms can play a crucial role in enhancing the effectiveness of offtake agreements and model contract clauses (MCC), as they provide the necessary tools and resources for suppliers to regularly monitor data and manage and improve specific performance areas (e.g. water consumption, energy efficiency, conformance with specific MRSL).

Sourcing from composite units (e.g. Tier 1-2, Tier 1-3) is not always possible but when it is, it can give the focal company greater control over the resources used and the overall sustainability performance.

Supply-chain collective initiatives, such as water stewardship programmes, ensure that all relevant actors are involved in water, chemical and wastewater management activities in certain segments of the supply chain. Challenges are often systemic and can only be addressed through concerted action by key stakeholders. Industry collaboration is vital to improving sustainability performance in the textile and fashion industry and achieving the environmental targets. It enables companies to share knowledge from the outset, align practices with regulatory requirements, and create a culture of innovation to tackle the challenges in the industry.

Policymaking in both consumer and producer countries of the cotton-garment supply chain is crucial for achieving improved environmental performance. Effective policies can establish clear environmental standards and regulations that guide the industry towards sustainable practices. This includes setting limits on emissions, waste, and resource use. Very often, these standards and regulations are not in place in producer countries or are not effectively enforced due to a lack of inspection capacity (Strasser et al. 2024). To bring about change, MSIs, brands/retailers and suppliers need to actively advocate for improved policies that enhance chemical, water and wastewater management (e.g. phasing-out hazardous substances; testing for strict limits of pollutants), creating a level-playing field. Policymaking can provide financial incentives, such as tax breaks or subsidies, for companies that invest in sustainable technologies and practices. This encourages innovation and adoption of environmentally friendly methods. In this context, it is important that policies in producer countries are aligned with international environmental standards and agreements (e.g. the Stockholm Convention) to ensure that their industries remain competitive in the global market.

## List of references

This report is a compilation of content from the following research reports. The literature cited in this report is accessible in the list of references of the respective reports.

Grüning, C., Jüde, J., Martin, K., Strasser, J., Tran, C., Grabs, J. (2025): *Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains. Roadmaps for the implementation of sustainable supply chain management approaches and instruments*. German Environment Agency (Hrsg.). Texte 04/2025. <https://doi.org/10.60810/openumwelt-7704>

Grüning, C., Jüde, J., Martin, K., Strasser, J., Tran, C., Hofstetter, J. (2024): *Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains. Business approaches and instruments of sustainable supply chain management*. German Environment Agency (Hrsg.). Texte 161/2024. <https://doi.org/10.60810/openumwelt-7629>

Strasser, J., Garcia, B., Grüning, C., Tran, C., Martin, K., Hannak, J., Jüde, J., Becker, M., Grabs, J., Hofstetter, J. (2024): *Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains. Analysis of the cotton, tin, natural rubber, coffee and iron ore supply chains*. German Environment Agency (Hrsg.). Texte 06/2024. <https://doi.org/10.60810/openumwelt-6390>

Strasser, J., Grüning, C., Martin, K., Tran, C., & Jüde, J. (2025). *Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains - Recommendations for selected incentive mechanisms*. German Environment Agency (Hrsg.). Texte 73/2025. <https://doi.org/10.60810/openumwelt-7752>