Accelerating action | Investing for impact

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# Implementation Programme

## *"Industry Engagement and Action along Value Chains"*

## *Workstream on Private Sector Financing and Investment*

*Chemical use in textile value chains: Cotton clothing*

*Phase 2 of 2 towards ascertaining financial flows and financial needs in Chemicals Value Chains*

Working paper

November 2026

Chronos Sustainability Ltd produced Phases 1 & 2 of this study for UNEP Finance Initiative, with contributions from UNEP Finance Initiative and results prepared by Dr Rory Sullivan and Tanya Cox of Chronos Sustainability Ltd.

The financial needs modelling approach was collated by UNEP Finance Initiative, informed by the findings of the Chronos Phase 1 & Phase 2 reports and builds upon the levers for change identified during Phase 1 and verified by stakeholders in Phase 2. The modelling approach and its documentation are presented in the companion report *Estimating financial needs for the cotton textile value chain transition: From hazardous chemicals to safer alternatives* (GFC, 2026b).

**NOTE**

This paper presents results from Phase 2 of a two-phase study towards ascertaining current financial flows and future financial needs to align sector-specific value chains with the strategic objectives and targets of the Global Framework on Chemicals. It follows the Phase 1 report which was submitted as an Information Document to the first meeting of the Open-Ended Working Group of the Global Framework on Chemicals in Punta del Este, Uruguay, 24-27th June, 2025 (UNEP, 2025).

The International Conference working document UNEP/GFC/IC.1/8 describes the analytical work as three components: the Phase 1 report, this Phase 2 report, and a fully documented financial needs modelling approach aiming to quantify the cost of transitioning the global cotton clothing value chain away from hazardous chemicals (Global Framework on Chemicals Secretariat, 2026).

The Phase 1 and Phase 2 reports and the modelling approach documentation are designed to be read together.

The present note has not been formally edited or designed.

**POSITIONING STATEMENT**

This report has benefited from collaborative, multi-stakeholder input. The views expressed in this publication are those of the authors and do not necessarily reflect the views of contributing or convening organisations. Particularly, case studies included within the publication reflect the views of their contributors, and their inclusion should not imply endorsement or directed, collective action. Where current practices and relevant barriers are reported, this content does not aim to be prescriptive as to actions or decisions to be taken by individual financial organisations.

About Chronos

Chronos Sustainability Ltd is a UK-based sustainability consultancy specialising in corporate responsibility, responsible investment and multistakeholder initiatives. Chronos works with and builds strong relationships with a broad range of clients and partners to deliver transformative change at scale in the social and environmental performance of key industry sectors. To find out more, visit www.chronossustainability.com

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## Report Contents


**Acronyms** ..... **6**
**Glossary** ..... **7**

***Executive Summary*** ..... ***8***

***Introduction*** ..... ***10***

**Background and project purpose** ..... **10**
**Project methodology & audience** ..... **11**

***An overview of the Phase 1 Study*** ..... ***13***

**Rationale for focusing on cotton clothing value chains** ..... **13**
**Defining the cotton clothing value chain** ..... **13**
**Chemical use in the cotton clothing value chain** ..... **15**
**Barriers to aligning the cotton value chain with GFC targets** ..... **17**
**Levers for change: Opportunities to accelerate action** ..... **18**
Improving chemical use in fibre production ..... 19
Improving chemical use in textile and garment manufacturing ..... 20
Policy, voluntary and financial measures ..... 21

***Phase 2: Points of influence and priority actions*** ..... ***23***

**Priority stakeholders & key points of influence** ..... **23**
**Priority actions** ..... **29**
**Evaluating costs and sources of finance for implementing priority actions** ..... **31**
From priority actions to cost lines ..... 33
Sources of finance for the priority actions ..... 35
Data gaps identified in Phases 1 and 2 ..... 37
Limitations of the financial needs modelling approach ..... 38
**Exploring the role of the finance sector** ..... **39**
Current investor practice ..... 41
Financial institution roles and model cost lines ..... 41

***Conclusions*** ..... ***42***

**Recommended next steps** ..... **43**

***List of Appendices*** ..... ***45***

**Appendix 1 – Phase 1 Report** ..... **46**
**Appendix 2 – Cotton clothing value chain stakeholders** ..... **47**
**Appendix 3: Consolidated list of identified barriers and levers for change for specific stages of the cotton clothing value chain** ..... **49**

**Appendix 4: Identified opportunities (levers for change) for governments & policymakers and intergovernmental agencies to align the cotton clothing value chain with the GFC targets and objectives ..... 53**

***References ..... 55***

Table 1. An overview of the four most chemical dependent stages of the cotton value chain and the use of chemicals ..... 16

Table 2. Key opportunities (levers) for change ..... 22

Table 3. Priority actions ..... 30

Table 4. Overview of preliminary approach to estimate business-as-usual financial flows Source: GFC (2026b) ..... 32

Table 5. Phase 1 value-chain stages and financial needs modelling approach components. Source: UNEP (2026a). ..... 33

Table 6. Phase 1 levers and corresponding modelling approach cost lines. Sources: Sullivan and Cox (2025); GFC (2026b). ..... 34

Table 7. Identified priority actions and their treatment in the financial needs modelling approach. Source: GFC (2026b), Priority Actions sheet. ..... 35

Table 8. Indicative public share and financing channels by cost line. Source: GFC (2026b) ..... 36

Table 9. Instrument types by cost line. ..... 37

## Acronyms

**BAU** Business as usual

**CAPEX** Capital expenditure

**DFI** Development finance institution

**EHS** Environmental Health and Safety

**EPR** Extended producer responsibility

**EU** European Union

**FAO** Food and Agriculture Organization

**FIs** Financial Institutions

**FFS** Farmer field school

**FTAs** Free Trade Agreements

**GBF** Kunming-Montreal Global Biodiversity Framework

**GFC** Global Framework on Chemicals

**HA** Hectare

**HHP** Highly Hazardous Pesticide

**ICAC** International Cotton Advisory Committee

**IFWG** Informal Finance Working Group

**IPM** Integrated Pest Management

**Kg** Kilogram

**LMICs** Low- and Middle-income countries

**MDB** Multilateral development bank

**MMCF** Manmade Cellulosic Fibres

**MRSL** Manufactured Restricted Substances List

**NGOs** Non-Governmental Organisations

**OPEX** Operating expenditure

**PAN** Pesticide Action Network

**PFAS** Per- and polyfluoroalkyl substances

**PPE** Personal protective equipment

**R&D** Research and development

**RSL** Restricted Substances List

**SMEs** Small and Medium Sized Enterprises

**USA** United States of America

**USD** United States Dollars

**USDA** United States Department of Agriculture

**WHO** World Health Organization

**WTO** World Trade Organisation

**ZDHC** Zero Discharge of Hazardous Chemicals

## Glossary

**ACTIVE INGREDIENT** – means the part of the product that provides the pesticidal action.

**EXPOSURE** – to pesticides means any contact between a living organism and one or more pesticides. Routes of exposure include inhalation, ingestion, adsorption and injection.

**FORMULATION –** means the combination of various ingredients designed to render the product useful and effective for the purpose claimed and for the envisaged mode of application.

**HAZARD** – means the inherent property of a substance, agent or situation having the potential to cause undesirable consequences (e.g. properties that can cause adverse effects or damage to health, the environment or property). Hazards may be acute or chronic. Hazard = toxicity + potential for exposure.

**HIGHLY HAZARDOUS PESTICIDE (HHP)** – pesticides that are acknowledged to present particularly high levels of acute or chronic hazards to health or environment according to internationally accepted classification systems such as WHO or GHS or their listing in relevant binding international agreements or conventions. In addition, pesticides that appear to cause severe or irreversible harm to health or the environment under conditions of use in a country may be and treated as highly hazardous. Note: herbicides, insecticides and fungicides (as types of pesticide) can also be considered highly hazardous.

**INTEGRATED PEST MANAGEMENT** – a low or no chemical approach to managing pests, diseases or weeds in farming by utilising a combination of different control methods, based on good crop husbandry (cultural and agronomic practices), physical, plant breeding or biological control methods, underpinned by effective pest, weed and disease monitoring strategies.

**ORGANIC COTTON** – Organic cotton is cotton that is produced, and certified, according to organic agriculture standards.

**PESTICIDES** – Pesticides are products used in agriculture to control pests that can harm crops. They can be categorised into herbicides (targeting weeds), insecticides (targeting insects) and fungicides (targeting diseases).

**RISK –** is the probability and severity of an adverse health or environmental effect occurring as a function of a hazard and the likelihood and the extent of exposure to a pesticide. Quantification of risk considers all possible routes of exposure and requires establishment of dose-effect and dose-response relationships. Risk = Hazard x Exposure.

**TOXICITY** – is a measure of the degree to which something is toxic or poisonous. Toxicity can refer to the effect on a whole organism, such as a human or a bacterium or a plant, or to a substructure, such as the liver. Toxicity is a function of the size of the dose (concentration and/or volume) and the level of Exposure.

# Executive Summary

**Mandate.** At the fifth session of the International Conference on Chemicals Management (ICCM5), the secretariat was requested to assess the existing financial and investment flows and the financial needs associated with implementing the Framework (GFC Resolution V/3, adopted at ICCM5). Owing to the significant resources, data availability, and methodological constraints of a comprehensive global assessment, a stepwise approach was adopted, starting with the cotton clothing value chain, a sector prioritised under the Implementation Programme on industry engagement and action along value chains (Global Framework on Chemicals Secretariat, 2026).

**Phase 1 findings.** Phase 1 defined a nine-stage cotton clothing value chain and identified four stages where chemical use and exposure concentrate: cotton farming, textile production, garment finishing and textile recycling (Sullivan & Cox, 2025). It found that most stakeholders are small and medium-sized enterprises (SMEs) in low- and middle-income countries, that data on the quantities, combinations and costs of chemicals in use across the value chain and across the life cycle are largely missing. The study identified key barriers and levers for change (opportunities) at each of the highly chemical-dependent stages of the value chain. The identified levers included policy, voluntary and financial measures, each of which require different types and sources of finance (public and private) at differing scales. The study concluded that voluntary measures alone are unlikely to achieve a system-wide alignment with the objectives and strategic targets of the Global Framework on Chemicals (GFC).

**Phase 2 findings.** A series of stakeholder consultation meetings and two expert workshops, with members of the GFC Textile Industry Sector Programme and of the GFC Private Sector Financing and Investment Workstream, under the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) Implementation Programme on industry engagement and action along value chains (IP2) were held to further refine the Phase 1 results. This process produced four results:

**Priority actions.** Eighteen targeted actions were prioritised from the long list identified in Phase 1. These consisted of six actions for governments and policymakers, and six voluntary actions each for agrichemical companies and for brands and retailers.

- **Key points of influence to effect system change.** The priority actions were considered against the long list of stakeholders identified in Phase 1, to identify where in the system lies the greatest potential to implement the identified actions. The cotton value chain can be described as a system of two halves: Agrichemical companies hold the greatest direct influence upstream; brands and retailers hold the greatest influence downstream, from the point of textile processing through to end-of-life management. Governments and policymakers have potential to influence every stage of the value chain; and financial institutions (FIs) are important stakeholders at every stage as a source of capital and a source of influence.

- **Roles of financial institutions.** In addition to acting as a source of capital, the consultations highlighted that financial institutions have two distinct roles: Responsible Stewardship directed at policymakers and Active Ownership directed at the two key points of influence.
- **Data gaps.** Missing data prevent all stakeholders from assessing the full extent and financial materiality of chemical pollution in the value chain, in terms of impacts, dependencies, risks and opportunities, making it particularly challenging to quantify financial needs to align sectoral value chains with GFC targets with a high degree of confidence.

**A preliminary approach to quantifying sectoral financial needs.** Recognising that the data gaps identified in Phase 1 and verified in Phase 2 rule out a bottom-up costing of stakeholders' future financial needs, a top-down investment-gap preliminary modelling approach was developed to cost the priority actions (GFC, 2026b). The modelling approach is structured around the value-chain stages and priority levers identified in Phases 1 and 2 and assigns prices to the priority actions identified in Phase 2.

**Sources of finance.** Redirected costs can be mobilised mainly through demand-side policy: standards, procurement rules, import requirements and eco-modulated fees. Additional costs generally call for public funds, concessional and blended finance, and research and development (R&D) grants (GFC, 2026b). Governance, extension and extended producer responsibility (EPR) administration are largely public functions; chemical substitution, CAPEX and OPEX costs and traceability systems are largely private.

**Next steps.** The draft resolution on Investing for Impact: Finance and Investment included in the working document for the first International Conference proposes to request UNEP, in collaboration with IOMC and all relevant stakeholders, to continue developing the modelling approach and to replicate it in other sectors or value chains and to encourage Member States to adopt similar national-level approaches (UNEP, 2026b). The modelling approach documentation recommends expert review of the modelling approach parameters, regional parameter datasets for the main cotton producing and processing countries, including end-of-life management, as well as a structured assessment of current financial flows, to help strengthen estimates for future financial needs.

Additionally, the mapping exercise can support ongoing efforts to drive forward the implementation of the GFC, including by establishing criteria for and scaling effective low-chemical outcomes across the value chain to ensure long-term environmental, social and economic benefits; identifying the most harmful chemicals used across the value chain for prohibition and phase out and establishing clear criteria for safer chemicals that align with GFC targets, and monitoring protocols to verify the transition to safer chemistry which appeal to public and private investors.

# Introduction

## Background and project purpose

The adoption of the Global Framework on Chemicals (GFC) in Bonn, Germany in 2023 was a significant milestone in global efforts to "*prevent, or where prevention is not possible, minimise harm from chemicals and waste to protect the environment and human health*" (UNEP, 2023).

To fund the transition to a safer, more sustainable chemicals future that aligns with the strategic objectives and targets of the Framework, GFC Resolution V/3 recognises that there is a need for greater clarity on the status of financial flows and investment needs and opportunities across the value chain. To this end, Chronos Sustainability Ltd was commissioned by UNEP FI to undertake desk-based research and consultations to produce a decision-useful analysis of the status of financial and investment flows across the global chemicals value chain and to identify future financial needs associated with the implementation of the GFC.

In resolution V/8, the Conference invited the IOMC and its participating organizations to *develop* implementation programmes (IPs), in close collaboration with stakeholders, *for consideration* by the first International Conference in 2026 (UNEP, 2023). IP2, the industry value-chain programme under strategic objective D and Target D6, includes a private-sector financing and investment workstream. The workstream is convened by UNEP FI and works through three tracks: awareness raising, transitioning value chains (with a first focus on textiles, focused on cotton clothing), and practical guidance and implementation support. Track 2 maps hotspots and priority interventions, identifies financing gaps and the policy levers and actors to engage, develops methodologies to assess transition costs, and considers innovative finance including blended finance and de-risking tools. The Cotton value chain study forms part of Track 2 and has been completed by Chronos Sustainability in two phases:

**Phase 1** involved a landscape review of the global chemicals industry, and a detailed mapping of sector-specific value chains including key stakeholders, the types of chemicals currently being used and opportunities for innovation. Results presented to the first meeting of the Open-Ended Working Group of the Global Framework on Chemicals in Punta del Este, Uruguay, in June 2025 defined the global chemicals value chain, identified highly chemical-dependent sectoral value chains and priority substances of concern under a business-as-usual scenario. The cotton clothing value chain was selected for in-depth analysis as a chemical-dependent value chain associated with significant use of substances of concern whilst also facing circularity pressures. Phase 1 outputs offered a sectoral approach to implementing the GFC's strategic objectives and targets.

**Phase 2** builds on the results from the Phase 1 analysis and identifies the key points of influence in the value chain, prioritises actions to be taken by key stakeholders and sets out the role of financial institutions to help transition this chemical-dependent value chain to align with the GFC targets. Through consultation with experts from across the textile industry and the finance sector, Phase 2 analysis included a review of: current financial flows to different parts of the value chain,

as defined in Phase 1; perceived barriers to accessing or issuing finance; and the most appropriate sources of finance (public, private, blended) to implement priority actions. Phase 2 work identified the key data gaps that prevent accurate quantification of the future financial needs to transition the cotton clothing value chain to a GFC aligned value chain.

A preliminary financial needs modelling approach was subsequently developed by UNEP FI based on the outcomes of Phases 1 and 2 to estimate current financial flows and future financial needs, by assigning costs to the priority actions over ten years using a top-down investment-gap method (GFC, 2026b). Combined, Phases 1 and 2 of this study and the preliminary financial needs modelling approach set out how sector-specific financial needs could be identified in three clear steps:

- Understand the system by mapping key value chains to identify stakeholders, chemical dependencies and barriers and levers for change, including identifying key points of leverage within the system to accelerate alignment with GFC targets;
- Consult stakeholders to understand current financial needs and future needs to implement priority levers for change, including the most appropriate types and sources of finance and the costs of externalities in the system; and
- Use the modelling approach to establish indicative costs of GFC alignment, timelines and barriers, including remaining data gaps.

## Project methodology & audience

Research for Phase 1 of this study took the form of desk-based literature review and was supplemented with virtual interviews and facilitated workshops with identified experts. Phase 2 combined four elements:

- a desk-based literature review covering financial flows, the costs of chemical pollution and financial-sector practice;
- a virtual workshop held in November 2025 with some members of the GFC Textiles Workstream under the GFC Implementation Programme on industry engagement and action along value chains (IP2) (e.g. standards and certification companies, NGOs), UNEP FI and the UNEP Textiles programme. The workshop included a review of Phase 1 findings and two breakout groups (one focused on fibre production; and one focused on textile production, garment manufacturing and recycling) provided feedback and validation on the conclusions presented in Phase 1, helping to prioritise key stakeholders and the most impactful levers for change;
- a virtual workshop with the GFC Private Sector Financing and Investment Workstream under the GFC Implementation Programme on industry engagement and action along value chains, on the role of financial institutions, held in January 2026 with representatives from industry, banks, institutional investors and NGOs. Again, two virtual breakout groups were established that focused on the types and sources of finance most appropriate for supporting priority actions upstream (cotton farming) and downstream (textile production, garment finishing and end-of-life management). Discussions also focused on key barriers to issuing finance;

- preliminary financial needs modelling approach to cost the priority actions. The modelling approach uses global sector-level quantities (cotton area, production, textile chemicals market, installed machinery base, post-consumer waste, workforce), applies unit costs, cost differentials and adoption shares for each transition activity, and aggregates costs over ten years with Low, Central and High parameter ranges. All assumptions sit in a single Parameters sheet so that they can be inspected, challenged and adjusted (GFC, 2026b).

**Audience.** The Phase 1 and Phase 2 reports together with the modelling approach report are intended for GFC stakeholders, the members of the Textiles Industry Sector Programme and of the Private Sector Financing and Investment Workstream, and financial institutions considering their role in the transition of chemicals-dependent value chains.

A full copy of the Phase 1 report including all references can be accessed from the link included in Appendix 1. Please refer to the original Phase 1 publication – entitled UNEP/GFC/OEWG.1/INF/3/Rev.1 – for the original study and detailed analysis including data sources and references.

To put the results of Phase 2 analysis into context in the present report, a condensed summary of Phase 1 findings is presented herein.

# An overview of the Phase 1 Study

The Phase 1 study introduces global chemical value chains and highlights the geographic and regional differences in regulatory frameworks that exist in both the control of chemical use and in the handling of waste including chemicals at end-of-life stages and the large data gaps that exist relating to the types, volumes and fate of chemicals produced and used in different geographies, sectors and value chains on a global level. These factors provide the context and rationale for adopting a sectoral approach to understanding the type and scale of finance required by different actors across global chemicals value chains to support the implementation of the strategic objectives and targets of the GFC and the transition to a safer, more sustainable chemical industry.

## Rationale for focusing on cotton clothing value chains

In 2019, the United Nations Environment Programme (UNEP) published the Global Chemicals Outlook II report which identified six highly chemical dependent value chains – one of which is textiles. Valued at approximately USD 1 trillion, textile manufacturing is an economically significant, resource intensive sector with distinct socio-environmental impacts including high greenhouse gas emissions, water and land use and significantly contributes to air and water pollution (Norarmi et al. 2022). Resource use issues driven by fast fashion and environmental contamination associated with largely linear apparel value chains means that the textile sector is facing pressure to become more circular, creating a timely opportunity to align textile value chains with the strategic objectives and targets of the GFC. Prior to the adoption of the Global Framework on Chemicals, its predecessor – the Strategic Approach for International Chemicals Management (SAICM) – identified several priority issues that needed addressing by the GFC.[1] Cotton value chains are associated with a number of these priority issues.

## Defining the cotton clothing value chain

Cotton is grown in 85 countries around the world, 31% of which are classed as least developed countries (van Heck & Poonyth, 2023). Over 190 million people earn a living from their involvement in the cotton production sector (FAO, 2023). Cotton, as a fibre, represents approximately 20% of all fibres produced for textiles (UNEP, 2025) and 80% of the cotton produced is destined for apparel (FAO, 2026). Less than 1% of end-of-life cotton is recycled and incorporated back into value chains Ellen MacArthur Foundation, 2017. Cotton farming is heavily reliant on pesticide application to protect yields and the processing of cotton into textiles and garments requires the application of chemicals in the form of dyes, process chemicals and chemical finishing treatments. Over 8,000 chemicals are reportedly used across textile value

[1] These included: Chemicals in products; Endocrine Disrupting Chemicals (EDCs); Environmentally persistent pharmaceutical pollutants (EPPPs); Hazardous Substances in life cycle of electrical and electronic products (HSLEEP); Highly Hazardous Pesticides (HHPs); Perfluorinated Chemicals (e.g. PFASs); Lead in paint; Nanomaterials;

chains (UNEP, 2025), with estimates of over 0.58Kg of chemicals needed to produce every 1Kg of textiles (Ellen MacArthur Foundation, 2017).

In 2022/23, 24.4 million tonnes of cotton fibre were produced (Sullivan & Cox, 2025) on just 2% of global arable land (Fairtrade Foundation, 2020) and the global cotton market was valued at approximately USD 41.8 billion (Research and Markets, 2025). Although most cotton produced is derived from virgin fibre, in 2022, 300,000 tonnes of recycled cotton fibre was produced (equivalent to approximately 1% of the virgin fibre produced that year) (Recover, 2024).

For the purposes of this study, Chronos Sustainability defined a nine-stage, cradle-to-cradle cotton clothing value chain (from 'field to frock'). Chemicals are used throughout the entire life cycle, both directly and indirectly, to meet performance, aesthetic, and functional needs of cotton apparel but the use and exposure to chemicals is highest at four distinct stages of the cotton clothing value chain: during fibre production (cotton farming), textile production (spinning and weaving of cotton fibre), garment manufacturing and finishing and during recycling. These four stages (highlighted in red in Figure 1) became the focus of the Phase 1 study.

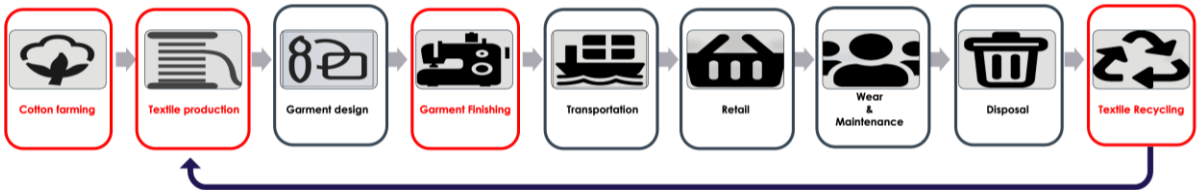



*Figure 1. The global cotton (apparel) value chain. Image Source: UNEP, 2025*

## Chemical use in the cotton clothing value chain

Different types of chemicals are used for different purposes at each of the highly chemical-dependent stages of the cotton apparel life cycle. Many of the chemicals used on cotton apparel are known to be harmful or hazardous to both human health (Hoppin et al., 2017; Hu et al., 2015) and to the environment. Globally, approximately 402 to 433 million cases of unintentional acute pesticide poisoning occur each year, including around 11,413 deaths, and about 46% of the world's farmers are poisoned each year (Boedeker et al., 2026). This reassessment replaces the earlier estimate of 385 million cases cited in the Phase 1 appendices, which was retracted in 2024 (Boedeker et al., 2024). PAN UK reports that 42% of cotton farmers surveyed in Benin, India and Tanzania reported incidents of acute pesticide poisoning and 12% reported severe incidents (Claydon, 2022). Illness (short- and long-term) associated with chemical exposure has economic impacts for workers due to reduced working time: 33% of cotton farmers who felt unwell after using pesticides took time off work (Claydon, 2022).

Weighted by ecotoxicity, total applied toxicity rose between 2013 and 2019 for six of eight species groups. Cotton is among the crops with the highest toxicity-weighted application per hectare, mainly from acetochlor and imidacloprid, and its contribution to national applied toxicity in Brazil, China, India and Nigeria is disproportionately high relative to its cultivated area. It is estimated that without intervention, only one of the 65 countries assessed (Chile) will meet the GBF Target 7 goal of halving pesticide risk by 2030 (Wolfram et al., 2026).

Cotton textile producers and garment manufacturers are also exposed to a wide variety of health-harming chemicals and particulate matter (e.g. PM2.5) in cotton mills and factories, but a paucity of data prevents a clear overview of the true scale of impact across the world. Published literature revealed that a proportion of the dyes, process chemicals and chemical treatments used at these stages of the value chain include substances of concern (SoC) and substances of very high concern (SvHc) including persistent ‘forever’ chemicals (e.g. PFASs/PFOSs), endocrine disrupting chemicals and carcinogenic, mutagenic and reprotoxic chemicals (CMRs). The textile industry accounts for about 20% of global industrial wastewater, primarily from dyeing and textile treatment (UNEP, 2026b). One case study reviewed by the OECD identified 466 g of chemicals used per kilogram of textile in wet processing (Brown & Börkey, 2024).

Table 1 summarises the geographic spread of key stages of the cotton clothing value chain and includes examples of the types of chemicals applied to cotton at each stage of the life cycle.

*Table 1. An overview of the four most chemical dependent stages of the cotton value chain and the use of chemicals*

| Stage: | Overview |
|---|---|
| Cotton farming | Key cotton producing countries (2022 FAOSTAT Data[2]; van Heck & Poonyth, 2023): China (19% of global total), India (17%), USA (10%) and Brazil (8%). Cotton farming is the fourth heaviest user of agrichemicals, including highly hazardous pesticides (Fairtrade Foundation, 2020) - 4.7% of all pesticides produced annually are sprayed on cotton (Better Cotton Initiative, n.d.) (110,675 tonnes of pesticides, 47% of which are herbicides) in 2022/2023 (International Cotton Advisory Committee, 2023). Between 13-70% of pesticides used are considered to be HHPs : 13% under ICAC criteria, which exclude FAO/WHO Criterion 8, and 70% when PAN criteria are applied to the same list (Sullivan & Cox, 2025). Global pesticide sales by the 20 largest agrichemical companies, across all crops, reached USD 73.8 billion in 2023 – nearly 60% of global sales are made by four large, vertically integrated agrichemical companies (Syngenta, Bayer CropScience, BASF and Corteva). Major pesticide users (by volume) are: Brazil (31.2% of total), USA (23.6%), India (11.8%) and China (10.3%) (Sullivan & Cox, 2025). In terms of pesticide application per Kg of cotton produced, the highest users are Brazil, Malawi, Benin, USA and Burkina Faso. |
| Textile production | At spinning mills, cotton fibre is spun into yarn and then woven or knitted into textiles. Process chemicals are used for fibre preparation, bleaching, colour, texture, performance. Key countries producing (Cotton) textiles are: China, India, Vietnam, Bangladesh. Collectively, these countries imported 5.4 million tonnes of ginned lint with a combined value of USD 12 billion in 2023. This stage of the value chain is largely dominated by small- and medium-sized enterprises (SMEs) The chemicals used for textile production may be organic (derived from plants or minerals) or inorganic chemicals (synthetically produced) and chemical processes can be wet (requiring water input) or dry. Additional auxiliary chemicals are required to facilitate each process (indirect chemical use). A higher proportion of chemical treatments are applied to cotton fabric post-weaving or knitting in 'wet-processing' facilities (Greenpeace Germany, 2021). |
| Garment finishing | Garment finishing is the final stage of garment manufacturing where dyes and chemical treatments are applied to enhance a garment's appearance, performance, or functionality. These chemical treatments can include: antimicrobial treatments, flame retardancy, stain-proofing, waterproofing, and wrinkle-proofing (Commercial Standardisation of Instrument Testing of Cotton [CSITC], n.d.). Stakeholders and operations at this stage of the value chain include high numbers of highly diverse SMEs distributed across developed and emerging economies. Facilities typically operate where labour costs are low to maximise already small profit margins driven by 'price squeeze' from buyers. It is estimated that spinning and garment manufacturing processes represent 15-40% of the total final value of the garment. Key countries manufacturing & |

[2] Most recent FAOSTAT data from 2023, shows China (24% of global total), India (22%), USA (11%) and Brazil (12%) – date accessed 2026/11/02.

| | |
|---|---|
| | finishing cotton garments in 2023 were: China (30.06% of total global apparel exports), Bangladesh (8.65%), Vietnam (5.65%) and Italy (5.52%). Significant data gaps exist for this section of the value chain with respect to the types and volumes of chemicals applied to different garments (UNEP, 2025). |
| Textile recycling | 87% of apparel is currently landfilled or incinerated at end of life (Ellen MacArthur Foundation, 2017), with approximately 1% of global cotton production (300,000 tonnes in 2022) being recycled (Recover, 2024). Mechanical recycling uses low/no chemicals but results in low quality recyclate that requires input of virgin materials when creating new apparel clothing and the lower quality fibres may require additional chemical treatments, to stabilise/strengthen/colour fabrics dependent on final performance requirements. Chemical recycling is an emerging technology that uses high amounts of energy and chemical inputs to breakdown textile waste into pulp (manmade cellulosic fibre, note cotton pulp) and creates smaller volumes of higher quality recyclate. It is unclear which countries are primarily responsible for recycling cotton and what types/volumes of chemicals are used in chemical recycling. This is a notable data gap. |

## Barriers to aligning the cotton value chain with GFC targets

During Phase 1, the following key challenges and barriers to change were identified (see Appendix 2 for details):

- **Fragmented chemical policies and frameworks** on a global scale which result in inconsistent elimination and phase out of the most harmful substances. This, coupled with **weak regulatory and licencing frameworks** mean harmful substances are readily available for use, at low costs.
- **High numbers of diverse stakeholders** in predominantly low- and middle-income countries (LMICs) are associated with cotton production, sale and manufacturing. **Low profit margins** do not incentivise change in practices (because of perceived risk of higher cost) and create **investment risks**.
- **Lack of consistent disclosure and reporting standards** across the value chain has resulted in significant data gaps relating to the quantities and combinations of chemical substances used across the life cycle of cotton apparel. This includes lack of data on revenues derived from the sale of chemicals – particularly in post-fibre production stages of the value chain, including end-of-life management.
- **Low transparency and traceability** of chemical use across this fragmented value chain amplifies the risk of worker and community exposure to chemicals across the value chain.
- Cotton as a crop is susceptible to pests and disease and vulnerable to changing climatic conditions. Farmers **rely heavily on synthetic pesticides** to protect crops but there is **limited awareness of the risks** associated with the use and exposure to harmful and hazardous chemicals in pesticides.

- Together, data gaps and transparency and traceability issues have prevented the full **extent and monetary costs of the socio-environmental impacts** of cotton chemicals from being systematically assessed under a business-as-usual scenario[3].
- Market dominance of a relatively small number of major chemical manufacturers and suppliers – notably relating to crop protection – limits incentives and capacity for innovation and transition to safer chemical use.
- **The absence of clear criteria or indicators established for 'GFC-aligned' safer chemical alternatives** and lack of globally agreed assessment methodology or measurement of impact reduces the ability of downstream stakeholders to effect change.

Without intervention, the identified barriers will either prevent or reduce the speed at which safer chemicals management could be deployed across the cotton clothing value chain to drive alignment with the strategic objectives and targets of the GFC.

## Levers for change: Opportunities to accelerate action

Phase 1 analysis identified multiple opportunities to implement safer and more sustainable chemicals management at each chemically dependent stage of the value chain. These opportunities – or levers for change – could drive a value chain-wide change in practice that could help the sector align more closely with the strategic objectives and targets of the GFC. Appendix 3 includes a list of identified opportunities and highlights which barriers the opportunities could help overcome.

Policymakers and regulators can create an important enabling environment by introducing strong policy commitments that facilitate a fair and just transition for all stakeholders towards value-chain alignment with the GFC. Clear and ambitious targets and public policy create a more predictable regulatory environment and long-term market signals which in turn, build confidence and buy in from vested stakeholders at all stages of the value chain, creating attractive opportunities for financial investments.

The private sector should continue to innovate while applying the principles of green and sustainable chemistry in a systemic change towards transparent and traceable processes and safer chemicals alternatives. Adopting a precautionary, hazard-based approach in future chemicals policies - following the mitigation hierarchy can help avoid regrettable substitutions and 'no data, no market' rules could greatly increase transparency in chemical use and reduce risks across product life cycles.

The following sections highlight the key levers specific to chemically dependent stages of the value chain that were identified during Phase 1 research.

[3] Impacts include direct impacts on worker health and the natural environment and indirect impacts on communities and nearby watercourses and agricultural land

## Improving chemical use in fibre production

A growing number of initiatives seek to improve cotton production by reducing or omitting (in the case of organic cotton) reliance on HHPs and chemical fertilisers and pesticides. Organic cotton farming offers the greatest potential to reduce impact and exposure to harmful and hazardous chemicals during the fibre production stage of the value chain but today, organically produced cotton represents just 2.3% of the total cotton fibre produced each year (Textile Exchange, 2024). Obtaining organic certification can be perceived by farmers as a costly and time-consuming challenge which is a reported barrier to scaling organic cotton. The process requires an estimated three-year transition period during which farmers' livelihoods and yields may be jeopardised, putting additional pressure on farmers where operating margins are already low and crop susceptibility to pests and climate changes is high.

Agroecology and Integrated Pest Management principles, when properly implemented in cotton farming have been proven to successfully reduce reliance on synthetic fertilisers, genetically modified crops and synthetic pesticides (FAO & WHO, 2014). A number of sustainability standards exist that promote low, or no pesticide use in cotton production. Better Cotton accounts for about 22% of global cotton fibre production, Cotton made in Africa for 2.1% and Fairtrade Cotton for 0.1% (Textile Exchange, 2024). Farmers in Better Cotton's India programme cut HHP use from 64% to 10% between the 2014/15 and 2021/22 seasons (Better Cotton Initiative, 2023). Some examples of programme evidence on IPM and farmer field schools (FFS) show what these levers can achieve and where they fall short:

- Across 85 IPM projects in 24 countries in Asia and Africa, yields rose by a mean of 40.9% and pesticide use fell to 30.7% of baseline (Pretty & Bharucha, 2015);
- Cotton farmers in Mali who took part in FFS reduced pesticide use by just over 90% compared with pre-FFS use and a control group (Settle et al., 2014);
- In Benin, PAN UK's organic cotton project reports 8,870 farmers trained and 7,114 certified organic (June 2025); farmer field school training in organic pest management cut input costs by more than two-thirds with no yield loss, and each GBP 1 spent in 2024 returned an additional GBP 21.23 in farm income. The project's earlier work contributed to a national ban on the HHP endosulfan in 2008 (Claydon, 2025);
- In the FAO integrated production and pest management programme in Sahelian West Africa, FFS cost USD 24 per farmer and generated net benefits of USD 264 per participating farmer (Pretty & Bharucha, 2015);
- A 2025 meta-analysis of IPM adoption in low- and middle-income countries found gains in yield and income but concluded that "adoption of IPM practices does not directly lead to behavioural change among farmers in reducing synthetic pesticide use" (Kondo et al., 2025). Training alone is therefore unlikely to remove HHPs; it is more likely to do so when combined with regulation, supply of registered alternatives and conditional finance.

**Box 1:** Upstream, key levers for eliminating the use of and exposure to harmful and hazardous chemicals to align the cotton value chain with GFC targets are:

- Prioritise elimination of HHP use in major cotton producing countries;
- Transition to low chemical, integrated pest management farming practices;
- Hasten identification and commercialisation of pest-resistant cotton species;
- Develop and transition to safer chemistry pesticides and safer pesticide application and management (adopting green and benign by design pest management);
- Eliminate pesticide and synthetic fertiliser use (organic, fairtrade cotton farming);
- Capacity building through on-site training, access to appropriate personal protective equipment.

Specific activities include:

1. Increase R&D into cotton specific biocontrols
2. Establish (domestic) biocontrol production capacity
3. Facilitate registration of new and imported cotton specific biocontrols
4. Build country to country, region to region biocontrol knowledge transfer
5. Provide support and finance for farmers to derisk their transition
6. Tax interventions that penalise HHPs and CoHCs and favour biocontrols.

## Improving chemical use in textile and garment manufacturing

Manufacturing Restricted Substance Lists (MRSLs) have been developed by companies to restrict the use of certain chemicals across textile value chains. MRSLs focus on restricting the use of harmful chemicals in textile processing and specify acceptable limits for other chemical uses. Restricted Substance Lists (RSLs) by comparison, focus on the application of chemicals to final (consumer-facing) products and are therefore relevant in garment finishing processes. MRSLs help regulate the individual substances that go into chemical formulations – thus improving safety – but do not control the final chemical formulation.

Brands and retailers develop and impose MRSLs on suppliers (top-down influence) and the emphasis is on suppliers to carry out due diligence with stakeholders at each tier of the supply chain. MRSLs help brands and companies to manage risks associated with manufacturing value chains and MRSL compliance improves transparency in practices. Note: MRSLs are voluntary in nature and not globally applicable/comprehensive. EU REACH is an example of regional legislation that restricts certain chemical substances, which may in turn be included in brands' MRSLs.

**Box 2:** Downstream, key levers for eliminating use of and exposure to harmful and hazardous chemical to align the cotton value chain with GFC targets are:Downstream, key levers for eliminating use of and exposure to harmful and hazardous chemical to align the cotton value chain with GFC targets are:

1. Adopt and implement global MRSLs that prioritise and eliminate the most harmful and hazardous dyes, chemical treatments and auxiliary chemicals used in the manufacture of cotton apparel
2. Adopt and implement global RSLs that prioritise and eliminate the most harmful and hazardous dyes, chemical treatments and auxiliary chemicals used in the manufacture of cotton apparel
3. Adopting and enforcing mandatory transparency measures such as 'no data no market' rules and building standardised digital product passports for cotton textiles
4. Develop international minimum standards and criteria for safer dyes and chemical treatments and process chemicals for use in apparel manufacturing, based on green chemistry and benign by design principles
5. Adopt market interventions and finance mechanisms to scale transition across the sector (e.g. greener procurement and price adjustments that put a premium on non-safe chemical use as opposed to a premium on greener production methods)
6. Capacity building through on-site training, access to appropriate personal protective equipment.

## Policy, voluntary and financial measures

To implement the opportunistic actions, a combination of policy, voluntary and financial measures spanning public and private finance will be required to facilitate the transition to a GFC-aligned cotton clothing value chain (Table 2). Identifying sector-specific financial needs for implementing and aligning with GFC targets for specific products used in key value chains can be supported by better integration of the finance sector in a thematic workstream or GFC Industry Sector Programme within the GFC Industry Implementation Programme. This would build capacity and better align investor expectations to fully support the implementation of the GFC targets and objectives.

*Table 2. Key opportunities (levers) for change*[4]

| | |
|---|---|
| **Policy measures** | • **Import restrictions** to control and reduce access to internationally identified harmful substances; |
| | • Implementation of **adequate filtration and effluent treatment systems** to prevent harmful emissions to air and water; |
| | • **International prioritisation and prohibition of the most hazardous substances in use**; |
| | • **Phased out use of substances of concern** and harmful chemicals via mandatory MRSL and RSL compliance; |
| | • **Traceability and disclosure schemes** for chemical use such as digital product passports; and |
| | • Effective, climate-appropriate ventilation and protective equipment to protect workers health. |
| **Voluntary measures** | • Scaling implementation of **sustainable chemical best practice measures** including third party certification; |
| | • **Improved transparency** about chemical usage, particularly during garmenting; |
| | • **Capacity building programmes** covering GFC-aligned chemical use, handling, use and disposal of chemicals across the value chain; |
| | • Provision of effective, climate-appropriate **personal protective equipment** to reduce exposure risks; |
| | • Investment to support transition to **safer**, more **circular technologies** and practices (e.g. pesticide delivery, closed loop fibre sourcing, dry-dye techniques, reusable yarn treatments): |
| | • Scale up adoption and implementation of consolidated, international **HHP, MRSL and RSL lists**. |
| **Financial measures** | • Financial incentives to support **safer chemical use and production methodology** across the value chain; |
| | • Requirement for third party certification to increase **compliance with MRSL/RSLs**; |
| | • **Longer-term procurement contracts** to support transition to more sustainable production; and |
| | • **De-risking and investments** to facilitate transition to GFC-aligned, circular textile industry. |

[4] Note: All measures must protect the livelihoods of upstream stakeholders who are most vulnerable to the changs to ensure a just transition to a more sustainable future value chain and should be developed with clear timelines and structured, multistakeholder implementation plans.

# Phase 2: Points of influence and priority actions

The final output from Phase 1 raised the following key questions which have subsequently been explored in Phase 2 of this study:

- Based on stakeholder mapping, where, in the system, is the biggest point of influence to effect change needed to align the value chain with the GFC targets to enable a safer, more sustainable future value chain?
- Of the identified actions, which will have the greatest impact and therefore, how should the actions be prioritised?
- Is it possible to identify the costs of taking these actions? What does a business-as-usual (BAU) scenario look like and what are the additional costs for implementing the priority actions?
- What is the role of different types of financial institutions in this system, both as a source of finance/capital and as a source of influence?
- What are the dependencies (needs) and barriers (data gaps) that enable or prevent financial institutions from supporting the transition to a GFC-aligned cotton value chain?

Phase 2 of the study commenced with two virtual workshops: the first of which included some members of the GFC Textile Industry Sector Programme under the IOMC Implementation Programme to foster representation from across the cotton value chain, with input from the UNEP Finance Initiative and the UNEP Textiles programme in November 2025 and a second workshop held in January 2026 with some members of the GFC Private Sector Financing and Investment Workstream. Both workshops sought to ensure representation from experts from across the life cycle of the cotton value chain including non-governmental organisations, industry representatives, standards and certification bodies and institutional investors. The workshops were designed to answer three critical questions:

1. Which of the identified stakeholders across the cotton clothing value chain have the most significant influence to effect change within the system?
2. Of the identified levers for change, which actions should be prioritised to accelerate the alignment of the value chain with the GFC targets?
3. What types (e.g. public or private), sources (e.g. banks, institutional investors) and scales of finance are needed to facilitate this transition?

The following discussion presents the outcome of the workshops and culminates with recommended next steps to support the assessment of financial flows and future financial needs to align the cotton clothing value chain with the strategic aims and objectives of the global framework on chemicals.

## Priority stakeholders & key points of influence

Prioritisation was essential because the cotton clothing value chain comprises a large and diverse network of stakeholders including individual farmers and SMEs (See Appendix 2). Rather

than seeking to engage all actors equally, the approach focused on identifying the key points of influence within the system – where particular stakeholders, decisions or interventions could create the greatest leverage and catalyse change across multiple stages of the value chain. Targeting these points of influence will be critical to directing engagement and resources towards the actors best placed to accelerate system-wide alignment with the GFC targets. Figure 2 depicts the outcome of the prioritisation exercise conducted during the expert workshops – with priority stakeholders highlighted as either Primary Stakeholders (with highest direct influence over effecting change) or Secondary stakeholders (important stakeholders that support or enable the required changes to be made) (see also Appendix 2).

Farmers and farming communities rank highly in importance, but their individual influence over the levers was judged low: the exercise ranked influence to effect change, not importance. Dye houses and wet-processing mills are the largest direct users of process chemicals; they are numerous and mostly SMEs, and the main points of influence over them are regulation and enforcement by governments and procurement requirements set by brands.

Governments and policymakers were also identified as an important point of influence at all stages of the value chain. It was acknowledged that effective public policy is the most direct way of effecting (influencing) change across the value chain as a whole. Regulatory requirements to restrict and eliminate the most harmful and hazardous substances in use in the cotton clothing value chain helps to create a level playing field and market certainty, reduce risk and drive compliance. Regulation introduced by governments and policymakers could also facilitate a fair and just transition to value chain alignment with the GFC. See Appendix 4 for details.

Financial institutions were also acknowledged as an important group of stakeholders. The role of the finance sector is dual fold, with stakeholders seen as both: enablers of change – providing a source of capital and de-risking investments (e.g. in the form of insurance) to support a transition to safer chemistry use across the value chain; and drivers of change – constructively influencing practices across the value chain by setting expectations, engaging with companies (and policymakers), driving alignment with recognised standards and frameworks and driving the implementation of prioritised actions. A discussion of the role of the finance sector is in the section titled: ‘Exploring the role of the Finance Sector’.

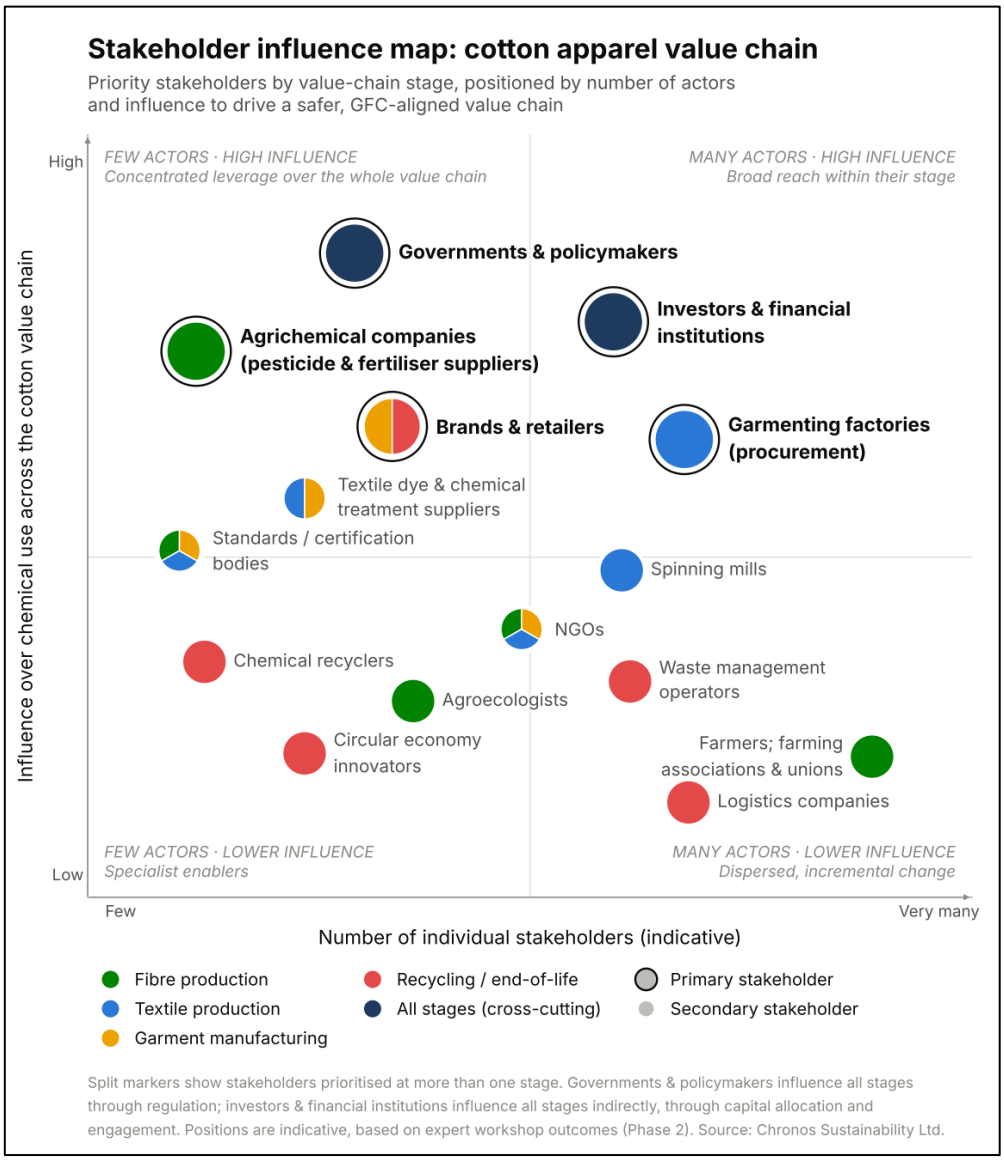



*Figure 2. Stakeholder influence map: cotton clothing value chain*[5]

Having identified key stakeholders across the value chain, and prioritised which stakeholders are crucial for enabling the transition to a safer, more sustainable future value chain, workshop participants were asked to reflect on the following question: of the priority stakeholders identified, where in the system lies the greatest influence to effect change?

[5] Workshop participants were asked to indicate which of the identified stakeholders in the cotton value chain have the greatest potential to effect system change. Note: The actions considered were voluntary actions, and therefore policymakers are not represented in this image. Similarly, Financial institutions (Banks, Investors, Insurance Companies) were identified as an important point of indirect influence at all stages of the value chain. Their role in implementing the identified actions was considered separately

This is an important question for delivering large-scale impact that supports a system change: high numbers of individual stakeholders making incremental changes in a relatively small part of the system (value chain) is less effective (bears lower influence) than smaller numbers of stakeholders making substantial changes that positively impacts a greater proportion of the value chain (demonstrating higher influence).

In the absence of (or in advance of) far-reaching policy reforms, workshop participants discussed the influence that the identified stakeholders could have across the value chain with a coordinated, voluntary effort to reduce use of harmful and hazardous chemicals.
Two key points of influence and sets of stakeholders were identified from this activity:

- **Upstream**, agrichemical companies were identified as the primary stakeholders with greatest influence over:
    - Eliminating production (and availability of) HHPs
    - Development (and distribution) of lower-hazard (safer chemistry) pesticides or biocides at affordable prices
    - Compliance with international standards and criteria for safer chemistry in pesticides and crop protection
    - Development of safer pesticide delivery mechanisms
    - Farmer capacity building via relationship with agroecologist and IPM specialists.

- **Downstream**, brands & retailers were identified as the primary stakeholders with greatest influence over:
    - The number and range of dyes and process chemicals restricted for use in garments (via RSL/MRSLs)
    - Demand for lower-hazard (safer chemistry) dyes and process chemicals from chemical suppliers, developed in line with green chemistry principles
    - Demand for recycled content, including content derived from certified safer (lower chemical hazard) end-of-life textiles
    - Demand for certified or in-transition[6] organic cotton

[6] In transition cotton is cotton grown without use of chemicals or synthetic fertilisers by farmers transitioning from conventional to organic cotton status but have not yet completed the transition period and obtained certification.

Adoption of internationally recognised standards for low/no chemical cotton

The outcome of the influence mapping exercise demonstrated that the cotton value chain should be viewed as a system of two halves. Agrichemical companies have direct influence over the availability of safer pesticides and cotton farming practices (fibre production) but this influence does not extend to downstream users of the cotton lint. Conversely, looking downstream, the influence of brands and retailers is greatest with garment manufacturers and garment finishers (Tier 1 suppliers) and with textile recyclers (demand-side influence) but these stakeholders have less direct influence over textile and fibre manufacturers (Tier 2 & 3 suppliers). The influence that brands and retailers have over pesticide application and farming practices (for conventional or Bt Cotton plants) is extremely limited. A notable exception to this pattern of influence relates to demand from brands and retailers for either organic cotton or cotton certified to a higher sustainability standard that assesses and restricts the application of certain chemicals. This pattern of influence is illustrated in Figure 3.

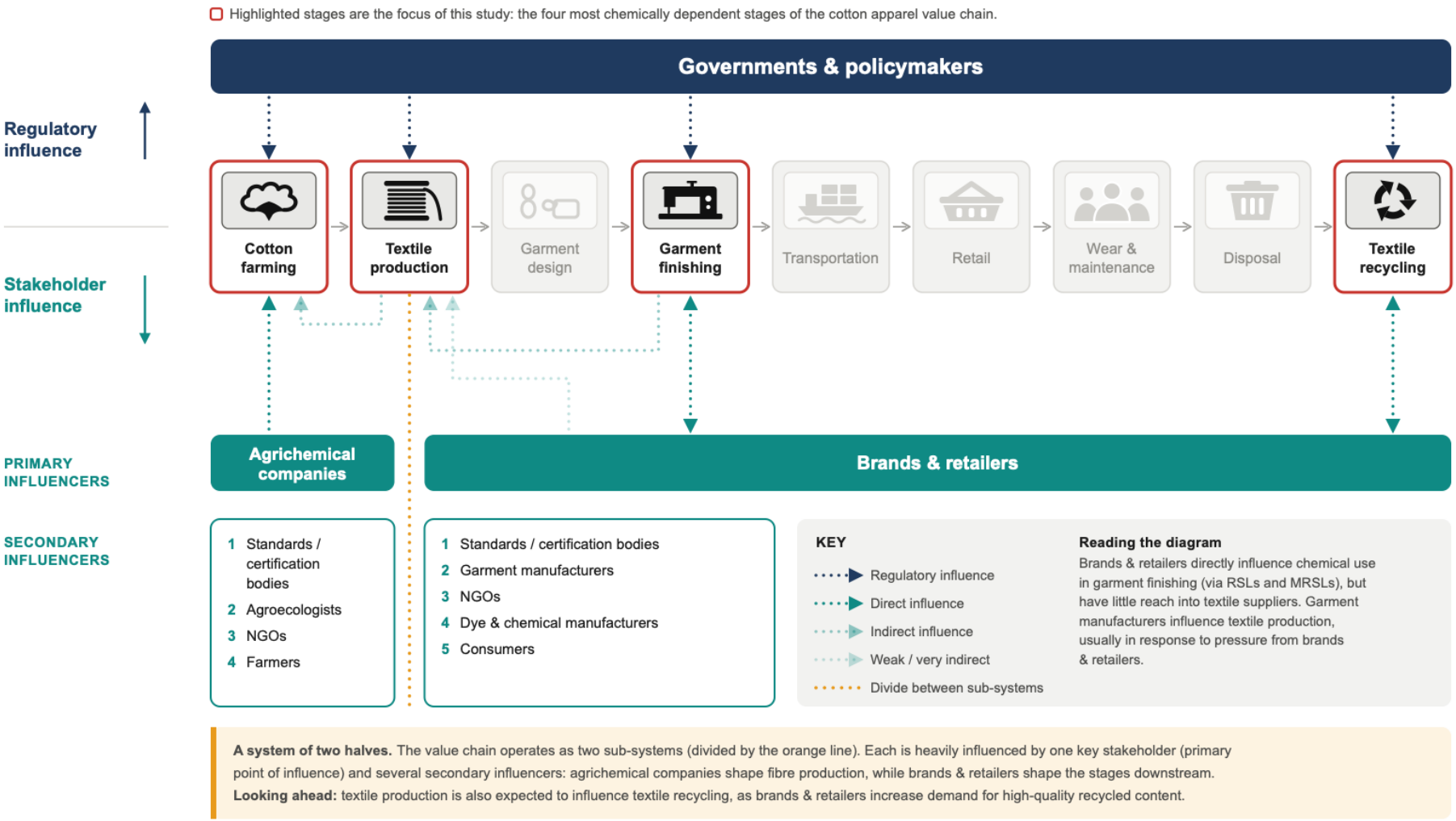



*Figure 3. Stakeholder influence mapped across the cotton clothing value chain. Image source: Chronos Sustainability Ltd.*

## Priority actions

To determine which of the identified levers for change will likely have the biggest impact in terms of reduced use and exposure to harmful and hazardous chemicals across the cotton clothing value chain, workshop participants reviewed and prioritised actions from the long list identified in Phase 1 (see Appendix 3). The workshop discussions focussed on the voluntary actions that primary points of influence (agrichemical companies, brands & retailers) can implement in advance of any mandatory measures that may be introduced by governments and policymakers. The possible priority actions for national governments and intergovernmental agencies identified in Phase 1 are included in Table 3 and mapped to relevant GFC targets in Appendix 4.

Workshop participants agreed that actions must address conditions at all stages of the value chain, and across the life cycle of cotton apparel, and should follow the mitigation hierarchy: elimination of the most hazardous substances first before timebound substitution of substances of concern, followed by improved transparency and traceability of substances used across the value chain (recognising that standards and certification play an important role here). As restrictions and phase out of harmful substances increases, participants recognised the need for greater R&D and an active transition to safer alternatives, whilst ensuring the protection of workers and the environment where exposure remain.

The outcome of this exercise is summarised in five overarching actions for both key points of influence (Agrichemical companies and Brands & Retailers). The outcome of this exercise is summarised in five overarching actions for both key points of influence (Agrichemical companies and Brands & Retailers). These are detailed in Table 3 and summarised as:

1. Identify and eliminate the most harmful and hazardous chemicals of concern currently in use at specific stages of the value chain.
2. Develop a time-bound action plan to identify and substitute all substances of concern and substances of very high concern across the value chain.
3. Improve the transparency and traceability of chemicals used in the cotton apparel value chain.
4. Foster the development of consistent international standards for safer chemistry and chemical use at different stages of the value chain.
5. Drive an active transition to safer chemistry use and application across the value chain, via research and development efforts and through financial mechanisms (e.g. capital

| Policy actions | |
|---|---|
| **Priority order:** | **Governments & Policymakers** |
| 1 | Identification, prioritisation & prohibition of the most hazardous substances internationally (adopting precautionary, hazard-based approach) |
| 2 | Import restrictions and control of internationally recognised harmful substances |
| 3 | Timebound elimination of substances of concern and harmful chemicals |
| 4 | Traceability & disclosure schemes for chemical use (e.g. digital product passports |
| 5 | Adequate filtration and effluent treatment systems to prevent emissions to air & water |
| 6 | Workplace safety measures including ventilation & personal protective equipment |

| Voluntary actions | | |
|---|---|---|
| **Priority order:** | **Agrichemical companies** | **Brands & Retailers** |
| 1 | Commitment to prioritise and eliminate of most hazardous chemicals from pesticides | Consolidate and implement international RSL & MRSL to eliminate most hazardous chemicals in use |
| 2 | Timebound elimination of all substances of concern and harmful chemicals in pesticides | Timebound elimination of all substances of concern and harmful chemicals in use, based on precautionary principle |
| 3 | Improved transparency, traceability and disclosure of chemicals in pesticides | Improved transparency, traceability and disclosure of chemicals used across garment life cycle |
| 4 | Development of and adherence to international standards for safer pesticides and pesticide management | Development and implementation of standards based on green and safe, circular chemical design principles, across life cycle |
| 5 | Active transition to safer chemistry in pesticides and pesticide delivery systems | Incentivise safer chemistry use through improved procurement policies (e.g. price adjustment, longer-terms) |
| 6 | Capacity building on safer pesticide development, use, application (e.g. with farmers) | Improve circularity and sustainability policies following waste hierarchy and build consumer awareness |

*Table 3. Priority actions*[7]

[7] Actions are indicated for key influencers: governments and policymakers (mandatory actions) and agrichemical companies and brands & retailers (voluntary actions)

## Evaluating costs and sources of finance for implementing priority actions

This part of the workshop was the most challenging question for the participants to answer with a high degree of confidence, recognising that needs will likely vary significantly within jurisdictions, and across the value chain, and will – in part – be driven by the policy and regulatory (enabling) environment and downstream demand. Possible roles for financial institutions (FIs) to influence the actions of the primary stakeholders (Agrichemical companies and brands & retailers) are explored in the section Exploring the role of the finance sector.

Phase 1 found significant data gaps on the quantities and combinations of chemicals used, particularly after fibre production, and on revenue from chemical sales and the costs of social and environmental impacts (Sullivan & Cox, 2025). These gaps rule out a bottom-up costing that adds up the investment needs of individual farms, mills and factories. A global map of financial flows to the cotton clothing value chain, and of the share of those flows supporting or undermining GFC alignment, is not possible with the data available.

Utilising insights from the workshops and the outcomes of the Phase 2 prioritisation exercises described above, a top-down investment-gap modelling approach was therefore developed to cost the priority actions identified: global sector-level quantities are multiplied by unit costs or cost differentials for each transition activity and aggregated over ten years (GFC, 2026b). The modelling approach seeks to provide a structure and an order-of-magnitude estimate that should be reviewed and refined and could be applied to other value chains.

The modelling approach seeks to make explicit a business-as-usual (BAU) baseline, based on the financial flows that can be quantified for identified priority actions across the value chain. Available data suggest an order of magnitude of about USD 205 billion business-as-usual flows over ten years. These are existing flows, not including transition cost. Table 4 gives an overview of the BAU baseline order of magnitude and the preliminary approach to assess transition costs. See Section ‘From priority actions to cost lines’ below and the report ‘Modelling Approach for Estimating Financial Needs for the Cotton Clothing Value Chain Transition: From Hazardous Chemicals to Safer Alternatives – A preliminary approach for review and refinement’ for further details (GFC, 2026b).

*Table 4. Overview of preliminary approach to estimate business-as-usual financial flows Source: GFC (2026b)*

| BAU flow | Approximate ten-year scale | Treatment in the modelling approach for transition financial needs assesment |
|---|---|---|
| Conventional crop protection on the transitioning area (USD 80 per hectare) | USD 15 billion | Only the USD 150 per hectare difference to IPM is counted |
| Cotton textile chemicals subject to substitution | USD 41 billion | Only the 20% green premium is counted |
| Routine wet-processing equipment replacement (10% of a USD 100 billion base a year) | USD 100 billion | Only the 15% premium on replacement equipment is counted |
| Textile chemicals R&D (about 3% of market, cotton share) | USD 2.5 billion | Only the gap to 5.5% intensity is counted |
| Agrichemical R&D (8.5% of market, cotton share) | USD 5 billion | Only the gap to 13% intensity is counted |
| Existing post-consumer collection (20% baseline) | Small | Only collection above the baseline is counted |

Two clear barriers to accessing and issuing finance were identified in Phases 1 and 2: textile production is dominated by SMEs operating on low margins with weak governance, characterised as high-risk factors for investment in the absence of protective measures (Sullivan & Cox, 2025); and short-term procurement contracts from brands and retailers limit manufacturers' ability to invest in more sustainable practices (Sullivan & Cox, 2025). Additional factors also include the absence of investment-useful standardised metrics and frameworks (GFC, 2026a). Green Loan Principles include pollution prevention and "climate smart farm inputs such as biological crop protection", but neither text names a pesticide, toxicity or chemical-load metric (Asia Pacific Loan Market Association et al., 2025a, 2025b). A review of 18 agricultural blended finance funds in 2026 highlighted the absence of agricultural pollution reduction measures or the transition away from hazardous pesticides as a primary investment thesis (Agricultural Blended Finance Funds, 2026).

Recycling ventures identified in Phase 1 were financed largely by institutional investors, corporate partners and investment banks, with some public grants; Renewcell filed for bankruptcy in 2024 due to insufficient funds (Sullivan & Cox, 2025). Sustainable-chemistry ventures attracted over USD 6.6 billion in venture capital in the first quarter of 2025 across 377 companies, according to American Chemical Society data (Perrott, 2026). In the textile sector, investor engagement through EOS at Federated Hermes reports that Adidas reached 67% of Tier 1 supplier chemical formulations at ZDHC MRSL Level 3 by 2023 and that H&M reached 97% ZDHC MRSL compliance across Tier 1 and Tier 2 factories in 2024 (GFC, 2026a).

## From priority actions to cost lines

### *A modelling approach*

The modelling approach's value-chain stages correspond to the chemical-dependent stages defined in Phase 1, with garment finishing merged into processing and a governance component added for costs that serve the whole value chain (Table 5). Several anchor values are shared with Phase 1: the 1.7% annual growth in cotton fibre consumption, used as the central growth rate; the 80% of cotton fibre destined for apparel (Sullivan & Cox, 2025).

*Table 5. Phase 1 value-chain stages and financial needs modelling approach components. Source: UNEP (2026a).*

| Phase 1 stage | Modelling approach component | Cost lines |
|---|---|---|
| Cotton farming | Agricultural production | Input cost differential (conventional to IPM); monitoring, extension and training; yield-risk buffer; biocontrol and agrichemical R&D |
| Textile production; garment finishing | Processing | Chemical substitution premium; equipment CAPEX premium; textile chemicals R&D; wastewater treatment (public share) |
| Textile recycling | End of life | Collection and sorting; fibre-to-fibre recycling CAPEX and OPEX; EPR scheme administration; recycling technology R&D |
| All stages | Value-chain governance | Traceability and chain of custody; institutional overheads (policy establishment, standards body, recurring overhead, import controls); worker health and PPE (public share) |

The modelling approach addresses two GFC targets directly. Target A7, on phasing out HHPs in agriculture by 2035, is represented by the share of cotton area requiring transition (80% central). Target D6, on sectoral strategies that "identify priority chemicals of concern" by 2030, is represented by the share of the cotton textile chemicals market requiring substitution (50% central, with low range 30% and high range value 70%.) (GFC, 2026b).

### *Phase 1 levers and modelling approach cost lines*

Table 6 shows how the levers for change identified in Phase 1 (Table 3) correspond to cost lines in the modelling approach.

| Phase 1 lever | Modelling approach cost line |
|---|---|
| Build farmer capacity through agroecological training and IPM | Monitoring, extension and training (FFS at 25% direct coverage) |
| Support and livelihood protection during the transition; crop-protection insurance | Yield-risk buffer (10% of revenue over a three-year biological reset) |
| Price premium or subsidy for low-chemical cotton; redirect existing farm support | Input cost differential (IPM versus conventional crop protection) |

| Phase 1 lever | Modelling approach cost line |
|---|---|
| Innovation in lower-hazard pesticides and biocides | Biocontrol and agrichemical R&D gap |
| International GFC-aligned MRSL and RSL; phase-out of substances of concern | Chemical substitution premium on 50% of cotton textile chemical spend; policy establishment; standards body |
| Investment in safer technologies (low-liquor dyeing, dry dyeing, closed-loop systems) | Equipment CAPEX premium at the point of routine replacement |
| Novel chemical treatments based on green and safe design principles | Textile chemicals R&D gap |
| Filtration and effluent treatment | Wastewater treatment (public share) |
| Transparency measures, "no data, no market" rules and digital product passports | Traceability and chain of custody (USD 80 per tonne of lint) |
| Licensing conditions and import restrictions | Import controls (set-up and recurring, as a share of cotton trade value) |
| PPE, ventilation and on-site training | Worker health and PPE (public share) |
| Near-infrared sorting and collection infrastructure | Collection and sorting |
| Recycling capacity and technology | Fibre-to-fibre recycling CAPEX and OPEX; recycling technology R&D |
| Extended producer responsibility | EPR scheme administration |

*Table 6. Phase 1 levers and corresponding modelling approach cost lines. Sources: Sullivan and Cox (2025); GFC (2026b).*

### *Coverage of the priority actions*

Of the 18 priority actions in Table 3, 10 have their own cost line in the modelling approach (Table 7). The modelling approach prices costs by value-chain stage rather than by actor; costs are allocated to the three stakeholder groups (GFC, 2026b).

| Stakeholder Group | Identified Priority action | Treatment in the modelling approach (central values) |
|---|---|---|
| Governments | 1. Identify, prioritise and prohibit the most hazardous substances | Policy establishment, one-off, 1% of annual average transition spend |
| Governments | 2. Import restrictions and controls | Import controls: 0.25% of cotton trade value (set-up) and 0.5% a year (recurring) |
| Governments | 3. Timebound elimination of substances of concern | Transition shares: 80% of cotton area; 50% of cotton textile chemical spend |
| Governments | 4. Traceability and disclosure schemes | Traceability at USD 80 per tonne of cotton for apparel |
| Governments | 5. Filtration and effluent treatment | Wastewater treatment, public share (placeholder) |
| Governments | 6. Workplace safety, ventilation and PPE | Worker health and PPE, public share (placeholder) |
| Agrichemical companies | 1. Commit to eliminate the most hazardous chemicals | Biocontrol and agrichemical R&D gap |
| Agrichemical companies | 2. Timebound elimination of substances of concern | Transition share of cotton area (80%) |

| Stakeholder Group | Identified Priority action | Treatment in the modelling approach (central values) |
|---|---|---|
| Agrichemical companies | 3. Transparency, traceability and disclosure | Not yet costed separately; within value-chain traceability |
| Agrichemical companies | 4. Standards for safer pesticides | Standards body establishment, one-off |
| Agrichemical companies | 5. Active transition to safer chemistry | Input cost differential; monitoring; training |
| Agrichemical companies | 6. Capacity building with farmers | FFS, 25% direct coverage at USD 80 per farmer |
| Brands and retailers | 1. Consolidate international RSLs and MRSLs | Within policy establishment and institutional overheads |
| Brands and retailers | 2. Timebound elimination of substances of concern | Chemical substitution premium (20%) on 50% of cotton textile chemical spend |
| Brands and retailers | 3. Transparency and traceability across the life cycle | Value-chain traceability |
| Brands and retailers | 4. Standards based on green, safe, circular design | Within standards body and institutional overheads |
| Brands and retailers | 5. Incentivise safer chemistry through procurement | Proxy proposed: certification costs; contract terms treated as a margin adjustment |
| Brands and retailers | 6. Circularity policies and consumer awareness | Within EPR administration; collection, sorting and recycling |

*Table 7. Identified priority actions and their treatment in the financial needs modelling approach. Source: GFC (2026b), Priority Actions sheet.*

## Sources of finance for the priority actions

The modelling approach assigns a public share to each cost line from published evidence on typical financing channels (Table 8) (GFC, 2026b). Governance, extension and EPR administration are largely public functions; chemical substitution, equipment, traceability and processing R&D are largely private.

| Cost line | Public share, central (range) | Typical financing channel | Priority actions served |
|---|---|---|---|
| Input cost differential | 20% (10–30%) | Farmer and buyer spending; subsidy or payments for ecosystem services; price premiums | Agrichemical 2, 5; Government 3 |
| Monitoring and training | 70% (55–85%) | Public extension; development finance; brand-funded programmes | Agrichemical 5, 6 |
| Yield-risk buffer | 50% (35–65%) | Blended finance; subsidised crop insurance | Agrichemical 5 |
| Biocontrol and agrichemical R&D | 30% (10–50%) | Corporate R&D; public research grants | Agrichemical 1 |
| Chemical substitution premium | 10% (5–15%) | Mill operating expenditure; cleaner-production grants | Brands 2; Government 3 |

| Cost line | Public share, central (range) | Typical financing channel | Priority actions served |
|---|---|---|---|
| Equipment CAPEX premium | 10% (5–20%) | Corporate CAPEX; bank lending; DFI blended facilities | Brands 2, 5 |
| Processing R&D | 70% (60–80%) | Chemical supplier R&D; cleaner-production grants | Brands 4 |
| Wastewater treatment (public share line) | 50% (30-70%) | Permitting, enforcement, public infrastructure | Government 5 |
| Collection and sorting | 40% (25–55%) | EPR fees; municipal systems | Brands 6 |
| Recycling CAPEX and OPEX | 30% (15–45%) | Private recyclers; venture and project finance; public grants for first-of-a-kind plants | Brands 6 |
| EPR administration | 80% (65–90%) | Regulator and producer responsibility organisations | Brands 6 |
| Recycling technology R&D | 50% (35–65%) | Public innovation funding; venture capital | Brands 6 |
| Traceability | 15% (5–25%) | Brands and mills; some public infrastructure | Government 4; Agrichemical 3; Brands 3 |
| Institutional overheads | 90% (75–95%) | Public budgets; GFC Fund; GEF; multilateral support | Government 1, 2; Agrichemical 4; Brands 1, 4 |
| Worker health and PPE | 50% (30-70%) | Employers; public regulation and inspection | Government 6 |

*Table 8. Indicative public share and financing channels by cost line. Source: GFC (2026b)*

**Financing sources shift as technologies mature:** venture capital, blended finance and strategic corporate investors through the demonstration and scale-up "valley of death"; commercial banks, project finance, private equity and green bonds at commercial deployment (Perrott, 2026). Public de-risking tools include for instance guarantees, partial credit and risk guarantees, currency hedging and structured finance (Perrott, 2026). Table 9 matches instrument types to cost lines.

| Instrument | Relevant cost lines | Example |
|---|---|---|
| Use-of-proceeds loans and bonds | Equipment CAPEX premium; recycling CAPEX; wastewater treatment | Green Loan Principles cover pollution prevention and control and biological crop protection, but name no chemical-load metric (Asia Pacific Loan Market Association et al., 2025a) |

| Instrument | Relevant cost lines | Example |
|---|---|---|
| Sustainability-linked loans | Input cost differential; chemical substitution; traceability | The principles require targets beyond business as usual and regulatory requirements, with post-signing verification (Asia Pacific Loan Market Association et al., 2025c); a KPI that only tracks a legally required HHP phase-out does not meet this test |
| Blended finance, guarantees, first-loss | Yield-risk buffer; recycling scale-up; SME equipment | AGRI3 targets a USD 190 million guarantee fund with a USD 15 million technical assistance facility (Agricultural Blended Finance Funds, 2026) |
| Cornerstone public capital | Recycling and safer-chemistry funds | A EUR 100 million European Investment Bank commitment anchored the EUR 300 million European Circular Bioeconomy Fund (ECBF, 2022) |
| Milestone-based textile circular-economy finance | Collection, sorting, fibre-to-fibre recycling | UNEP FI textile guidelines name use-of-proceeds finance for textile-to-textile recycling and tranches released on time-bound milestones of 12–24 months (UNEP, 2026d) |
| EPR fees and eco-modulation | Collection; EPR administration | EPR helps converting a diffuse externality into a balance-sheet liability (UNEP, 2026c) |
| Grants, GFC Fund, GEF | Institutional overheads; standards; extension | For example trade facilitation costs. |

*Table 9. Instrument types by cost line.*

The first International Conference working document on finance proposes a dedicated private-sector and catalytic finance window for the GFC Fund that could deploy "grants for investment preparation and demonstration, recoverable or conditional grants, concessional finance, guarantees or other de-risking instruments, and blended-finance approaches" (Global Framework on Chemicals Secretariat, 2026).

## Data gaps identified in Phases 1 and 2

The data gaps reported in Phase 1 remain: the quantities and combinations of chemicals used, particularly after fibre production; revenue from chemical sales by value-chain stage; and the monetary costs of social and environmental impacts (Sullivan & Cox, 2025). The financial needs modelling approach adds three parameter-level gaps: no published source provides a value-weighted split of the textile chemicals market into hazardous and non-hazardous substances; the installed base of wet-processing machinery is estimated; and costs of wastewater treatment and worker protection are placeholders (GFC, 2026b).

Toxicity-weighted indicators depend on national pesticide use data by active ingredient. Wolfram et al. (2026) found explicit national data for 65 countries and name the provision of national pesticide use data as one of the actions required to approach the GBF Target 7 goal.

The GFC Chemical Footprint Approaches workstream under GFC IP2 aims to strengthen the transparency, comparability, and global effectiveness of chemical footprint. It developed a terminology and methodological framework intended to inform the GFC first International Conference, while laying the foundation for a future international standard (GFC, 2026c). Preliminary GFC Private Sector Financing and Investment Workstream findings name as key barriers to safer and more sustainable chemicals financing the absence of standardised chemical hazard, use, emission or impact metrics; few mandatory corporate disclosure frameworks; and the lack of transition-planning frameworks for safe and sustainable chemistry).

## Limitations of the financial needs modelling approach

The modelling approach documentation lists the main limitations below (GFC, 2026b):

- The modelling approach is global and does not provide any regional or national disaggregation.
- Critical parameter values need reviewing.
- The proposed transition activities themselves require expert review.
- Not all chemicals currently used in the value chain are chemicals of concern, therefore the share targeted for substitution needs careful consideration.
- The cost of capital is not included.
- The modelling approach distinguishes between additional and redirected costs and assigns a public share and private share, which require validation. It does not represent specific financial instruments.
- The modelling approach incorporates a sector growth rate (1.7% CAGR, central).
- The modelling approach introduces recycling at the end-of-life stage. It does not model substitution for alternative textile fibres (synthetic, regenerated cellulosic, other naturals).
- System-level transaction costs are introduced through a dedicated value chain governance component.
- Disclosure and reporting costs are not priced.
- Placeholder estimates have been introduced for wastewater treatment (public share) and worker health and PPE (public share).
- Dynamic policy effects, technology breakthroughs and market shocks are not considered.
- Savings and co-benefits are not credited at this stage.
- Cost curves for “green premiums” are linear but could be modified to reflect front-loading of costs or non-linear trends.

See the report ‘Modelling Approach for Estimating Financial Needs for the Cotton Clothing Value Chain Transition: From Hazardous Chemicals to Safer Alternatives – Preliminary Approach for Review and Refinement’ for further details on limitations (GFC, 2026b).

## Exploring the role of the finance sector

All FIs have a role to play in influencing the successful implementation of the GFC and facilitating the transition to a safer, more sustainable chemicals future. There are opportunities for different types of FIs – e.g. banks, investors, development finance and insurance providers – to adopt different roles in this space. Banks, for example, are an important source of debt capital that allows companies to allocate capital expenditure (CapEx) to modernise equipment such as pesticide delivery systems or adopt novel technology such as closed-loop, waterless dyebaths in garmenting factories.

Financial institutions can drive corporate change by allocating capital and aligning portfolios with sustainable chemistry projects and operations through positive screening. In addition, institutional investors can influence the practices and priorities of the priority stakeholders (e.g. agrichemical companies and brands & retailers) through active ownership and stewardship (e.g. incorporating chemical pollution into climate and nature strategies and setting investor expectations). Insurance providers, development banks and sources of public finance – at the intersection between public and private finance – have an important role to play in de-risking investments that ultimately help mobilise the allocation of private finance at scale. Multilateral development banks are also an important source of capacity building and technical assistance at scale for high numbers of individual stakeholders across the value chain. This is important for helping increase farmers' resilience and building capacity, for example by improving understanding of the risks of unsustainable chemical use and the benefits of greener-safer chemistry.

Possible roles for financial institutions (FIs) to influence the actions of the primary stakeholders (Agrichemical companies and brands & retailers) were discussed and prioritised and are outlined below:

**Active ownership**: FIs can positively influence policies and practices of primary stakeholders (agrichemical companies, brands & retailers) by:

1 Developing strategies and programmes to incorporate sound management of chemicals and waste in finance approaches and business models, strengthening linkages and synergies with wider policies and approaches linked to climate change solutions, biodiversity conservation, human rights and health protection (e.g. GFC Targets: D3, E3, E6).
2 Strengthen accountability by requiring greater transparency, traceability and disclosure of chemical production, use and disposal across the value chain through engagement & disclosure (e.g. GFC Targets: D3, D4, D7).
3 Supporting the development and adoption of international reporting standards and disclosure frameworks for chemicals use that manage systemic risks and impacts and align with key metrics (e.g. TNFD, CSRD) (e.g. GFC Target D3)
4 Developing market interventions and finance mechanisms to scale safer chemistries based on green and safe chemical design principles (e.g. GFC Target D6)
5 Scaling investments sustainable solutions such as infrastructure and equipment needed to support the transition to safer chemistries and circularity (e.g. precision-application low-tox

pest management systems; waterless dye houses, ICT-powered waste management systems to improve collection, sorting and recycling) (e.g. GFC Target D4).

**Responsible Stewardship**: FIs can influence the development of effective public policy by engaging with governments and policy makers on topics such as:

1. Adopt and implement effective, GFC-aligned policies and enforcement mechanisms that prioritise a precautionary, hazard-based approach to chemical use across the life-cycle (e.g. GFC Targets A3, A7, B3, C1, E1)
2. Phase out subsidies and incentives for chemicals that undermine sustainable development (e.g. SDGs 3, 5, 6, 11, 12, 14, 15) and undermine nature (e.g. GBF Targets 7, 10; GFC Targets D1, D2, D4, D5, E5)
3. Demonstrate how increased value chain transparency, traceability and disclosure of chemicals improves decision-making and capital allocation, reducing the risks and impacts of unsustainable chemical use (e.g. GFC Targets: B1, B2, B3, B6, B7)
4. Advocate for international prioritisation and elimination of the most harmful and hazardous chemicals in use, based on globally agreed lists (e.g. GFC Target A1, A4, A7, C1)
5. Support adoption of independent, global minimum requirements for sector-specific safer chemistries (e.g. GFC Target A2, D6, E1, E2, E4)
6. Integrate safer chemistry and chemicals management into wider strategies and finance approaches, (e.g. climate, biodiversity, water, pollution) (e.g. GBF Targets 7, 10; GFC Targets A5, E3, E4)

Despite the widespread social and environmental impacts associated with chemical use across cotton clothing value chain as demonstrated in the Phase 1 report, the risks and opportunities associated with chemical pollution is poorly understood by most FIs. This is likely the result of several factors but in particular, the lack of transparent data about the risks and impacts associated with different types of chemicals. Furthermore, the cost of chemical pollution is regularly treated as an externality and therefore not accounted for. Access to data is very limited and systematic assessments of either chemical dependencies, impacts risks and opportunities for direct operations or throughout the value chain are not commonplace. In a 2026 survey of financial institutions, 24 of 30 respondents from banks, asset managers and other financial institutions identified the absence of standardised metrics as their most significant data gap, and only 2 considered existing frameworks adequate (GFC, 2026a).

The Kunming Montreal Global Biodiversity Framework includes a target on the reduction of pollution to levels that are not harmful to biodiversity (Target 7). Specifically, GBF Target 7 states (Convention on Biological Diversity, n.d.):

[Parties should] "Reduce pollution risks and the negative impact of pollution from all sources, by 2030, to levels that are not harmful to biodiversity and ecosystem functions and services, considering cumulative effects, including [...] reducing the overall risk from pesticides and highly hazardous chemicals by at least half including through integrated pest management, based on science, taking into account food security and livelihoods". (Convention on Biological Diversity, 2022)

In the GFC, Target A7 states:

"By 2035, stakeholders have taken effective measures to phase out highly hazardous pesticides in agriculture where the risks have not been managed and where safer and affordable alternatives are available, and to promote transition to and make available those alternatives."

These global targets – and the overlap between the 50% risk-reduction target by 2030 in the GBF[8] and the voluntary phase out of HHPs by 2035 in the GFC – creates an opportunity for FIs to direct capital and engage with companies, also taking into account that the environment and health-harming pollution from chemicals also manifests at downstream stages of the cotton value chain.

GFC Target D3 calls on the private sector, including financial institutions, to integrate sound chemicals management into business models and reporting by 2030; Target E3 calls for mobilising finance, including through blended finance; and Target E5 for internalising the costs of sound management (United Nations Environment Programme, 2023).

## Current investor practice

Investor coalitions on hazardous chemicals are growing, even though engagement on pesticides has produced limited results so far. A few examples include:

- The Investor Initiative on Hazardous Chemicals has grown to more than 80 investors with over USD 23 trillion under management or advice, asking chemical producers to disclose revenue and volume linked to hazardous products, publish time-bound plans to phase out persistent chemicals and increase investment in safer alternatives (Perrott, 2026);
- The ShareAction-facilitated Pesticides Working Group has engaged Corteva, FMC, UPL, Bayer and BASF since 2024 and reports that it has "yet to see sufficient evidence of concrete progress" (pers. comm.);
- FABRIC, launched by the Finance for Biodiversity Foundation in 2024, convenes 16 financial institutions to engage 16 apparel and luxury companies (Finance for Biodiversity, 2025).

## Financial institution roles and model cost lines

The modelling approach distinguishes between additional and redirected costs, capital expenditures, operational costs, research and development and other relevant cost lines. These distinctions matter because they determine what kind of finance instrument is needed and who ultimately bears the costs. For example:

- **Commercial banks and lenders:** equipment replacement premiums and SME processing upgrades, through use-of-proceeds and sustainability-linked lending;

[8] GBF Target 7 indicators include: Name, amount/volume/concentration of highly hazardous pesticides by type (per land/marine area); Pesticide use per area of cropland. In February 2025, COP16.2 adopted aggregated total applied toxicity (ATAT), which weights applied pesticide quantities by their toxicity, as an option for measuring the pesticide-risk element of Target 7 (Wolfram et al., 2026).

- **Development finance institutions and blended funds:** the yield-risk buffer, SME equipment and first-of-a-kind recycling, through guarantees and first-loss capital;
- **Investors:** the agrichemical and textile chemicals R&D gaps and recycling technology, through stewardship and venture capital;
- **Insurers:** crop-protection insurance during the IPM transition.

The practical implication is that redirected costs can seek to be mobilised through demand-side policy — procurement standards, import requirements, eco-modulation, retailer specifications — whereas differential costs typically require supply-side finance (public funds, blended finance, concessional lending, R&D grants) because no natural market mechanism generates the activity. It implies an important role for listed-equity investors through demand-side measures, through engagement with brands and retailers on RSLs, MRSLs and procurement, rather than just capital provision.

This allocation is a preliminary analytical proposal for review by the GFC Private Sector Financing and Investment Workstream, experts and other relevant stakeholders.

# Conclusions

The textile sector is associated with a broad swathe of environmental, social and governance issues and is under pressure from regulators and consumers alike to transition to a more sustainable, circular economy to minimise associated risks and impacts. Over 8,000 chemicals are used by the textile industry to produce different effects and finishes on apparel (Nimkar, 2018). On average, approximately 0.58Kg of chemicals are used to produce every 1Kg of textiles (Ellen MacArthur Foundation, 2017) but for cotton specifically, owing to the heavy application of chemical pesticides during the growth phase (fibre production), it is estimated that 0.35-1.5Kg of chemicals are required to make 1Kg of cotton textile (Sullivan & Cox, 2025; Ellen MacArthur Foundation, 2017).

Analysing the exact quantities and types of chemicals used to manufacture cotton garments is made challenging by a range of factors that include inconsistent definitions, a lack of systematic data collection and disclosure and differing regulatory priorities around the world. Data gaps severely hinder chemical traceability across the life cycle and there remains extremely limited data in the public domain regarding the presence, quantities, fate and impact of different chemicals in final products across all sectors. A review of existing Life Cycle Assessments (LCAs) for cotton, reveals that LCAs do not routinely consider chemical loads or impacts – likely as a result of limited access to data. The primary impacts included in the assessments are limited to greenhouse gas emissions, water footprints, land use and air pollution.

Phase 1 analysis for the present study identified the use of harmful and hazardous chemicals and chemical treatments at each of the four priority stages of the cotton value chain, including HHPs, dyes and process chemicals (e.g. for bleaching, texturizing, colour and performance) and chemical treatments (e.g. antibacterial/antimicrobial agents, waterproofing, stain-proofing,

flame-retardants). In addition to the widespread use of HHPs – a priority substance of concern for the GFC – the chemicals identified in cotton clothing value chains include substances of concern and substances of very high concern such as forever chemicals (e.g. PFASs), endocrine disrupters (EDCs, e.g. bisphenols), and carcinogenic, mutagenic and reprotoxic chemicals (CMRs, e.g. formaldehyde).

Exposure to chemicals across the cotton clothing value chain is associated with serious health impacts for farm and factory workers (direct exposure) and neighbouring communities (indirect exposure via contaminated agricultural land and freshwater sources). The costs of these socioenvironmental impacts are rarely accounted for and are largely treated as externalities by the companies involved.

The literature reveals emerging evidence of a transition to safer, greener chemistries and technologies around the world which is attributed to both emerging legislation in certain regions; reputational damage and consumer demand and adoption of circular economy principles. There is limited evidence to suggest that the transition is yet driven by the newly adopted GFC. Consequentially, an accurate assessment of the current financial flows and future financial needs across the value chains to support the implementation of the GFC is challenging and further hampered by lack of transparency, traceability and data disclosures on the use – and hazard profiles – of chemicals across the life cycle of cotton apparel. This challenge is unlikely to be limited to this value chain or sector – data gaps with respect to chemicals is widely cited in the literature.

Phase 2 analysed who holds the influence to change practice in the cotton clothing value chain and which actions they could prioritise. The preliminary financial needs modelling approach proposes a methodology intended as a framework for review and refinement, and possible replication for other value chains.

At a system level, analysing current financial flows and future financial needs, and defining the role of FIs is challenging. The reasons include data gaps (e.g. costs, flows, incentives, relationships), the fragmented nature of the system (e.g. high numbers of SMEs) and regional variations in regulatory frameworks. The outputs of this study together with the modelling approach described, could be used to inform the definition of parameters for national economic models, supplemented by country-level data. Such models could estimate the scale of finance required to align chemical-dependant value chains with the GFC targets; identify the costs that need to be covered and clarify who currently bears them – including smallholder farmers, who may face higher input costs despite having limited influence over the chemicals available to them. This could help governments and other stakeholders match priority actions with appropriate funding sources and financial instruments and determine what source and type of finance are needed.

## Recommended next steps

The modelling approach parameters need to be reviewed and refined with the GFC Textiles Industry Sector Programme, the GFC Private Sector Financing and Investment Workstream,

experts and other relevant stakeholders, starting with the IPM input cost delta, the transition-area share, existing capital stock estimates in processing, the chemicals-of-concern share and the priority actions for which the modelling approach put placeholders in view of the high level of uncertainty resulting from significant data gaps.

Other possible next steps to progress the assessment of financial flows and financial needs to achieve the GFC targets across value chains include the following:

- Develop regional parameter sets for the main producing systems (for example, India smallholder, Brazil large-scale and West Africa smallholder).
- Apply the modelling approach at national level with Member States and consult stakeholders on the financing needs of each value-chain segment.
- Assess current financial flows systematically, including public support to cotton farmers, DFI and bank portfolios, and EPR fee revenue.
- Allocate modelling approach costs to each priority stakeholder group.
- Develop indicative criteria to help investors determine whether an investment is GFC-compliant, as recommended in Phase 1 (Sullivan & Cox, 2025).
- Replicate in other priority value chains the modelling approach developed for the cotton clothing value chain.

# List of Appendices


Appendix 1: Phase 1 Report

Appendix 2: Cotton clothing value chain stakeholders

Appendix 3: Consolidated list of identified barriers and levers for change for specific stages of the cotton clothing value chain

Appendix 4: Identified opportunities (levers for change) for governments & policymakers and intergovernmental agencies to align the cotton clothing value chain with the GFC targets and objectives

## Appendix 1 – Phase 1 Report

The Phase 1 study was completed in March 2025 and submitted as an information document to the first meeting of the Open-Ended Working Group towards the implementation of the Global Framework on Chemicals which was held in Punta del Este, Uruguay in June 2025.

The information document can be accessed via the following link:
UNEP_GFC_OEWG.1_INF3_REV1_Financial_considerations.pdf

Recommended citation for the Phase 1 report:

Chemical use in textile value chains: Cotton clothing. Phase 1 of 2 towards ascertaining financial flows and financial needs in Chemicals Value Chains (A working paper). May 2025. Report prepared by Dr Rory Sullivan and Tanya Cox of Chronos Sustainability Ltd, for UNEP Finance Initiative (UNEP FI).

## Appendix 2 – Cotton clothing value chain stakeholders

The following table highlights the key stakeholders identified at each of the four highly chemical-dependent stages of the cotton clothing value chain.

| | |
|---|---|
| FIBRE PRODUCTION<br><br>• Pesticide & fertiliser manufacturers and suppliers (agrichemical companies)<br>• Standards/certification bodies (e.g. organic cotton)<br>• Agroecologists<br>• Non-Government Organisations (NGOs)<br>• Farmers; Farming cooperatives, associations and unions<br>• Government agencies (e.g. Ministry of Agriculture)<br>• National cotton board | TEXTILE PRODUCTION<br><br>• Garmenting factories (procurement)<br>• Standards/certification bodies<br>• NGOs<br>• Textile dye and treatment manufacturers and suppliers<br>• Labour unions<br>• Dye houses<br>• Weaving mills<br>• Spinning mills<br>• Cotton brokers |
| GARMENT MANUFACTURING<br><br>• Finance (Banks, Investors, Insurance Companies)<br>• Brands & retailers<br>• Garment manufacturing companies<br>• Manufacturers and suppliers of chemical treatments<br>• Dye houses<br>• Cotton brokers<br>• Textile producers<br>• Cotton traders | RECYCLING / END-OF-LIFE MANAGEMENT<br><br>• Brands & retailers<br>• Finance (Banks, Investors, Insurance Companies)<br>• Waste management operators<br>• Chemical recyclers<br>• Circular economy innovators<br>• Logistics companies<br>• Mechanical recyclers |

As part of the Phase 2 study, the influence that each of these stakeholder groups has in terms of helping drive the transition to a safer, more sustainable and GFC aligned cotton clothing value chain was analysed and priority stakeholder groups were identified, as further described in the section Points of Influence and priority actions. Financial institutions (Banks, Investors, Insurance Companies) were identified as an important point of indirect influence at all stages of the value chain. Their role in implementing the identified actions was considered separately.

| FIBRE PRODUCTION | TEXTILE PRODUCTION |
|---|---|
| Primary Stakeholders:<br><br>1. Agrichemical companies (Pesticide & fertiliser manufacturers and suppliers)<br><br>Secondary Stakeholders:<br><br>2. Standards/certification bodies<br>3. Agroecologists<br>4. Non-Government Organisations (NGOs);<br>5. Farmers; Farming associations and unions | Primary Stakeholders:<br><br>1. Garmenting factories (procurement)<br><br>Secondary Stakeholders:<br><br>2. Spinning mills<br>3. Standards/certification bodies<br>4. NGOs<br>5. Textile dye and chemical treatment manufacturers and suppliers |
| **GARMENT MANUFACTURING** | **RECYCLING** |
| Primary Stakeholders:<br><br>1. Brands & retailers<br><br>Secondary Stakeholders:<br><br>2. Standards/certification bodies<br>3. NGOs<br>4. Manufacturers and suppliers of chemical treatments | Primary Stakeholders:<br><br>1. Brands & retailers<br><br>Secondary Stakeholders:<br><br>2. Waste management operators<br>3. Chemical recyclers<br>4. Circular economy innovators<br>5. Logistics companies |

## Appendix 3: Consolidated list of identified barriers and levers for change for specific stages of the cotton clothing value chain

| Identified barriers | Identified Levers for change (Opportunities) | Value Chain stage: | | | |
|---|---|---|---|---|---|
| | | COTTON FARMING | TEXTILE PRODUCTION | GARMENT FINISHING | TEXTILE RECYCLING |
| Low transparency and traceability of chemical use across the value chain | • Adopting and enforcing mandatory transparency measures such as 'no data no market' and building standardised digital product passports for cotton textiles. | ✔ | ✔ | ✔ | ✔ |
| Limited awareness about the risks and impacts of exposure to chemicals | • Capacity building through on-site training and access to appropriate personal protective equipment. Market adjustments to incentivise use of safer chemical alternatives. | ✔ | ✔ | ✔ | ✔ |
| Lack of standardised assessment methodology and measure of impact for chemicals in use in cotton yarn/textile value chain | • Using the expert multistakeholder GFC Implementation Programme for textiles to develop a standardised assessment methodology and measure of (environmental and human health) impacts and facilitate value chain monitoring. | ✔ | ✔ | ✔ | ✔ |

| | | | | | |
|---|---|---|---|---|---|
| Prohibited use / risk of prohibited use of specific chemicals can lead to regrettable substitutions | • Stronger regulation taking a hazard-based approach, following the mitigation hierarchy, and eliminating groups of chemicals with similar properties as opposed to individual chemicals, based on a life cycle assessment can avoid the introduction of regrettable substitutions. | ✔ | ✔ | ✔ | ✔ |
| High numbers of small and medium sized stakeholders require mandatory change in practice to achieve consistency – voluntary efforts are unlikely to drive sector wide change | • Consistent regulations and government incentives or subsidies to enable a transition to low-chemical fibre, yarn and textile production. Prohibited use of the most harmful chemicals. | ✔ | ✔ | ✔ | ✔ |
| Concerns about interruption to livelihood during transition to organic/low pesticide farming - either as a result of increased labour costs, reduced yield or during organic certification process | • Provide support and livelihood protection through subsidies and incentives during the transition to low/no chemical farming.<br>• Subsidise cotton market to establish reliable market price for low-chemical cotton fibre.<br>• Improve access to crop protection insurance. | ✔ | | | |
| Low profit margins make ready availability of low-cost chemical treatments appealing | • Greener procurement and price adjustment to put premium on non-safe chemical use as opposed to a premium on greener production methods. | ✔ | ✔ | ✔ | |

| | | | | | |
|---|---|---|---|---|---|
| | • Market adjustments to factor in price of externalities associated with harmful chemical use.<br>• Introduce regulated licencing conditions and import restrictions for safe chemical use, supplemented with market interventions and finance mechanisms to scale safer production methods. | | | | |
| The absence of strong market signals/access to organic cotton markets | • Public and private incentives for brands and retailers to source organic cotton. | ✔ | ✔ | ✔ | |
| Inconsistencies between RSLs/MRSLs can undermine compliance/create gaps in the value chain where harmful chemicals are used | • Creating an international, GFC-aligned RSL/MRSL for cotton yarn and textile production within the GFC Textile Sector Implementation Programme.<br>• Establishing clear criteria for what constitutes GFC-aligned chemicals. | | ✔ | ✔ | |
| Limited design for circularity rendering garments 'unrecyclable' at end of life in a cost-effective way | • Incentivise circular, sustainable design techniques to increase quality and value of end-of-life materials<br>• Embed circular design principles, in line with waste hierarchy.<br>• Aligning emerging technology with aims and objectives of the GFC from the outset to limit use of harmful chemicals. | | ✔ | ✔ | ✔ |

| | | | | |
|---|---|---|---|---|
| | • Investment in- and demand for novel chemical treatments based on green and safe chemical design principles. | | | |
| Fragmented supply chains make it difficult to match suppliers of recycled content with requirements from garment manufacturers/brands | • Build and expand on existing coalitions of stakeholders to map and match specific supply and demand requirements across the whole value chain. | ✔ | ✔ | ✔ |
| Limited commercial-scale recycling of textiles due to limited infrastructure, poor design for end-of-life, technology limitations and wider environmental impacts (e.g. high energy inputs, water use, chemical use, harmful emissions) | • Up-scaling infrastructure for recapturing, sorting and recycling end-of-life textiles.<br>• Increase investment in R&D and innovation to reduce overall environmental footprint and improve efficiencies of recycling processes. | | | ✔ |
| Manual sorting high volumes of post-consumer textile waste is time-consuming and offers limited accuracy | • Investing in Near Infrared (NIR) sorting technology increases quality of raw material for recycling purposes, in turn increasing volume of secondary raw materials. | | | ✔ |
| Limited textile recycling capacity results in volumes of post-consumer waste outpacing processing capability | • Extended Producer Responsibility supporting reuse, repair and return of end-of-life garments.<br>• Technological improvements and investments to build recycling capacity, improving quality and availability of secondary materials. | | | ✔ |

## Appendix 4: Identified opportunities (levers for change) for governments & policymakers and intergovernmental agencies to align the cotton clothing value chain with the GFC targets and objectives

| | Identified lever for change: | Possible actions: |
|---|---|---|
| National Governments & Regional Policymakers | Introduce stricter chemicals legislation on production, trade and use, prioritising the most hazardous chemicals for elimination and phasing out substances of concern | • Prohibit use of HHPs and suspected HHPs in line with international policy frameworks (GFC Targets: A1, A4, A7)<br>• Obligate the sharing of data on the types/quantities/properties of all chemicals placed on domestic market for cotton growth/processing/finishing/recycling (GFC Targets: B1, B2, B3, B6, B7)<br>• Notify, regulate or prohibit the export of chemicals used in cotton value chains that have been prohibited nationally (GFC Targets: A5)<br>• Incentivise innovation in the development of safer, alternative chemicals for use at each stage of the value chain (GFC Target D4) |
| | Incentivise sustainable chemical management across the value chain | • Subsidise organic and regenerative farming practices (GFC Targets: D1, D2, D4, D5, E5)<br>• Support access to international cotton markets (GFC Target A1) |

| | | |
|---|---|---|
| Intergovernmental agencies | Build and implement awareness raising programmes in partnership with communities and civil society organisations | • Work with national and international stakeholders and academic institutions to develop national strategies and sectoral programmes of work that eliminate most harmful chemicals across the life cycle including implementation timelines (GFC Target: C1)<br>• Raise awareness and educate cotton value chain stakeholders on the hazards of use and exposure to harmful pesticides, chemicals and chemical treatments in terms of health risks (for workers directly and families indirectly), environmental degradation, commercial impact (e.g. water contamination, degrading soil quality reducing crop viability and long-term profit) (GFC Targets: B4, B5, E2, D7)<br>• Increased understanding on benefits of low/no pesticide farming including farmer training programmes based on agroecological farming practices and integrated pest management principles (GFC Targets: A3, B4, B5, D7)<br>• Training for healthcare workers to recognise and respond to pesticide poisoning including access to national poison centres (GFC Targets: A6, B5, B7, D7) |
| | Establish international metrics, indicators and targets for safer chemical use in cotton value chains | • Develop multistakeholder guidelines and internationally agreed minimum standards for the safe production, use and disposal of chemicals for each stage of the cotton value chain (GFC Target: A2) |
| | Establish integrated, sector-specific sustainable chemical and waste management strategies | • Foster knowledge exchange to develop regionally appropriate and sector-specific, sustainable chemical and waste management strategies across the cotton life-cycle, sharing best practices, technological developments and lessons learnt (GFC Target: D6, E1, E2, E4) |

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