A look into fibre sourcing

Overview of natural and synthetic fibres

Technical white paper

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Brussels, July 2023

Recommendations

- Embrace the concept of sufficiency. Reduce the amount of products put on the market - overproduction is real.
- If new fibres are needed, sustainable sourcing should be used.
- Integrate agroecology and organic farming into fibre sourcing. Tested definitions for agroecology and organic production are available and can guide sustainable sourcing practices.
- Do not create new buzzwords without common definitions – this will only delay the change needed to transform the textile industry.
- When it comes to sustainability claims: eliminate loose and stretchable definitions. Legislate explicitly on what market actors may or may not claim.
- Ensure that sustainable sourcing also addresses different stages of textile manufacturing, including the phases where huge amounts of chemicals, energy, and water are deployed, such as wetting, dyeing, and spinning. Implement regenerative systems as the starting point of business models that slow down the textile supply and value chain.
- Use fewer chemicals in textile production.

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Sustainable sourcing – starting with fibres

Sustainable sourcing is the integration of social, ethical, and environmental performance factors into the process of selecting suppliers[1]. It refers to the process of procuring cost-effective material that generates benefits and ideally minimises damage to the environment across the supply chain[2]. It also creates opportunities to reduce the environmental impact of production, ensuring mutually beneficial relationships with suppliers, leading them on a sustainability journey.

Incorporating sustainable sourcing practices into procurement and supply chain management processes can increase respect for social, ethical, and environmental values, minimising negative impacts. Within companies, the procurement function can enable supply chains, or be a barrier to them. When it comes to textiles, those choices are taken along the entire value chain with a process that involves sourcing, manufacturing, and consumption/utilisation of resources.

Sustainable sourcing includes sustainable techniques and practices implemented by an organisation when sourcing raw materials, products, and facilities from its suppliers. It also includes a focus on their social and environmental effects[3].

The textile industry is a vast and complex global network, encompassing the production of various types of fibres, fabrics, and garments. Traditionally, the industry has relied heavily on resource-intensive practices, including the cultivation of conventional cotton and the extraction of synthetic fibres from petrochemicals. These practices have had adverse effects on the environment, such as water pollution, soil degradation, and greenhouse gas emissions. Sustainable sourcing involves selecting and using raw materials in a manner that minimizes negative impacts on the environment and respects social and ethical considerations. This paper focuses on **the sourcing of fibres** and misleading claims. In subsequent papers, we will investigate the environmental footprint of manufacturing and production processes, fibre, which is where most of the environmental footprint of textile production lies.

When it comes to fibre characteristics, there are unsubstantiated and misleading claims over alleged "sustainable sourcing practices" that prove to be not so sustainable after all. This damages the image and impact of sourcing practices that are based on solid key requirements that respect people and the environment. This often occurs in the production phase with both natural and synthetic fibres, when confusion arises around the terms '**regenerated', 'regenerative', and 'recycled'**. This technical paper also aims to shed light on how these terms are improperly used, giving guidance on how they should be used instead to avoid greenwashing and ensure robustly sustainable sourcing practices.

Synthetic fibres: zooming in on polyester

Considering the definition provided above, can synthetic fibre ever be sustainably sourced? The short answer is not really. **Synthetic fibres** (also known as manufactured, man-made, or artificial) are made mainly from non-renewable coal and oil - resources that, when extracted, have massive impacts on the environment. Synthetic fibres raise significant concerns regarding their greenhouse gas (GHG) emission footprint and end-of-life. Oil is a complex compound that when processed and refined discharge many

[1] Sustainable Sourcing Definition | EcoVadis

[2] Lambrechts, W. (2020). Ethical and Sustainable Sourcing: Toward Strategic and Holistic Sustainable Supply Chain Management. In: Leal Filho, W., Azul, A.M., Brandli, L., Salvia, A.L., & Wall, T. (eds.), Decent Work and Economic Growth. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham, 402-414.

[3] https://link.springer.com/referenceworkentry/10.1007/978-3-319-71058-7_11-1

[3] Idem

toxic substances (e.g., BTEX compounds, particulate matter, nitrogen oxides, SO2, and CO). Oil and coal extractions are also linked to harmful spills into the environment, posing a serious threat to ecosystems.

The most common synthetic fibres include polyester, nylon, acrylic, and spandex[4]. The largest share is occupied by **polyethene terephthalate (PET)**, commonly known as **polyester,** accounting for around 60% of total fibres produced worldwide[15]. This is followed by polyamide (5% of fibres produced globally), with the remaining share consisting of polypropylene, polyamide, and acrylic. These fibres can be used for any purpose because they do not degrade easily and can be made into any length (continuous filament). Together, they make up between 64% and 72% of the market – see table below from TextileExchange. The use of synthetic fibres in textiles has more than doubled since 2000.

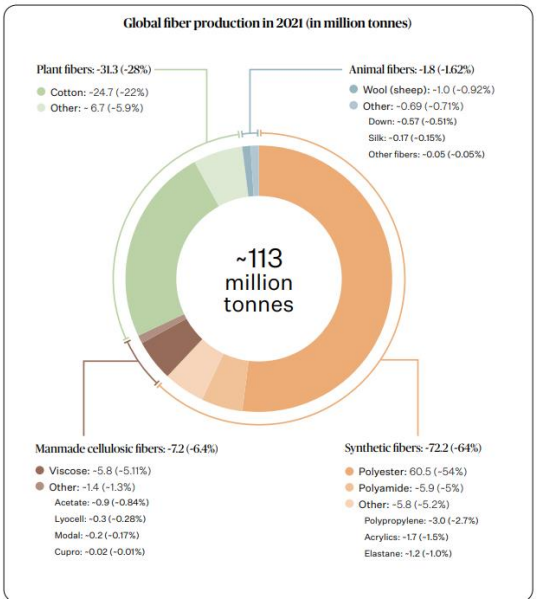

Figure 1: Global fiber production in 2021, Textile Exchange

Both synthetic and natural fibre garment production also have heavy impacts during ginning and spinning phases, with huge electricity consumption, and =large volumes of CO_2 emissions. The dying process also requires large amounts of resources, often discharging chemicals into the environment and producing large volumes of wastewater, which if untreated during the manufacturing process, can spill in the environment - and be toxic [5].

Importantly, polyester fibres are usually contaminated by antimony because of its use as a catalyst in the production of polyethylene terephthalate, and as a flame-retardant synergist in a variety of new and recycled polymers[6]. As a result, antimony is present in polyester textiles. In some countries, environmental authorities report about high content of antimony in wastewater that is discharge from polyester textile dyeing industries. It is known from available scientific publications that antimony and its compounds are harmful for both human and the environment. These processes can also discard cobalt, manganese salts, sodium bromide, and titanium dioxide. Making sure that products are toxic-free will be key within the forthcoming ecodesign discussions (Ecodesign for Sustainable Products Regulation – ESPR).

[4] Textiles - natural and synthetic fibres - Material categories and properties - Eduqas - GCSE Design and Technology Revision - Eduqas - BBC Bitesize

[5] Yuan, Z. W., Zhu, Y. N., Shi, J. K., Liu, X., & Huang, L. (2013). Life-cycle assessment of continuous pad-dyeing technology for cotton fabrics. International Journal of Life Cycle Assessment, 18(3), 659–672. https://doi.org/10.1007/s11367-012-0470-3

[6] https://www.sciencedirect.com/science/article/pii/S0273230020302506

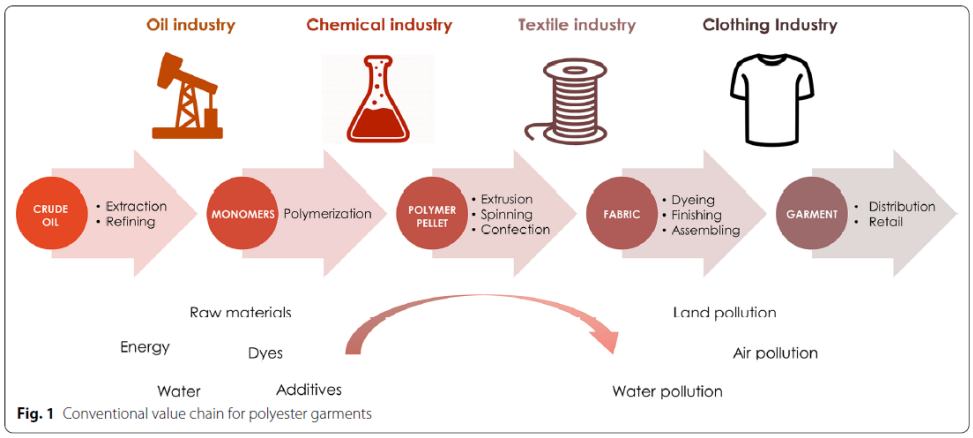

Figure 2: Polyester production process[22]

What the industry defines as "sustainable synthetic fibres" are mostly sourced either from recycled petrochemical feedstocks (such as plastics recycling – see below), or from a natural source such as fungi or sugar. For example, bio-PET and bio-based succinic acid is used in sportswear, automotive, agriculture, and textile applications[7]. All these come with issues, but we will only focus on the first in this paper.

Recycled, but not at all costs

Polyester is derived from virgin petrochemical raw materials. Only 14% comes from recycled material, mainly deriving from PET bottles – downcycling. Polyester-to-polyester recycling processes are still not at scale[15].

Turning plastic bottles into clothes removes them from circular recycling loops, in which they can be made into new bottles again. Basing sustainability strategies on the use of recycled PET is a false solution because it promotes the myth that we can continue to overconsume resources in the form of disposable plastic goods as they can be recycled into more products. rPET can only be downcycled and is mostly a one-way street to landfill or incineration[8].

In mechanical recycling, plastic is shredded into flakes, melted down, and pulled through spinnerets to make yarn. This is, however, a finite form of recycling because the quality of the product declines as fibres become shorter and weaker with every (re)cycle. Chemical recycling processes are not a better option, because they are significantly more energy-intensive than mechanical recycling and their yield is questionable[9]. Recycling polyester requires a massive amount of energy and chemicals for colour consistency. In terms of quality, recycled polyester garments share the same characteristics as virgin polyester ones[24], but still pose questions on its feasibility and overall sustainability. As recycled polyester comes from already existing plastics (mainly PET bottles), it is often subject to blends with virgin fibres or downcycling[20]. It also does not adequately address microplastics release. Both recycled and virgin polyester fabrics discharge microplastics, posing high threats to water ecosystems[10] and multiplying

[7] https://pubmed.ncbi.nlm.nih.gov/22188473/
[8] https://wardrobechange.eu/wp-content/uploads/2021/06/Environmental-CSOs-Recommendations-for-the-EU-Strategy-for-Sustainable-Textiles-June-2021.pdf
[9] CHEM Trust, Chemical Recycling: State of Play, study by Eunomia, 2020. https://chemtrust.org/wp-content/ uploads/Chemical-Recycling-Eunomia.pdf
[10] Özkan, İ., & Gündoğdu, S. (2021). Investigation on the microfiber release under controlled washings from the knitted fabrics produced by recycled and virgin polyester yarns. Journal of the Textile Institute, 112(2), 264–272. https://doi.org/10.1080/00405000.2020.1741760

plastic pollution. Microplastics do not biodegrade and thus accumulate in the environment. More and more literature is available on the risks of microplastics for the environment and for human health.

Synthetic fibres: the difference between regenerated and recycled is unclear

In the newly adopted standard ISO 5157 on Textiles — Environmental aspects — Vocabulary, the definition of regenerated fibres reads: "*fibres produced from naturally occurring polymers of cellulose or protein, where processing by dissolution is needed to convert them into fibre form*". In this case, it is therefore clear that the term "regenerated" does not apply to synthetic fibres.

Regenerated fibers, like Tencel (Lyocell) and Modal, are derived from sustainably sourced wood pulp, with ideally sustainable forestry practices encouraged to ensure the replenishment of the raw material. Interestingly, in the case of other synthetic fibres, "regenerated" does not have the same meaning as recycled fabric: some companies state that regenerated nylon is different from recycled fabrics because it maintains the same quality as the virgin material. It is claimed to be "identical'[11], which seems to refer to chemical recycling (depolymerisation, polymerisation and melt spinning resulting in a synthetic fibre as good as new). Contrary to cotton regeneration, explained further below, the recovery of by-products does not only come from internal fabric production process, but regenerated nylon comes from unused carpets or fishing nets. Manufacturing waste is only one part of the materials that will be "regenerated". In terms of processing, regenerated nylon follows a pathway comparable to recycled cotton and polyester, hence the distinction between "recycled" and "regenerated" being blurry.

Natural fibres: zooming in on cotton

Natural fibres consist of all fibres made with materials originating from natural resources). They can be primary (grown exclusively for fibre production) and secondary (where fibre is a by-product)[12]. They make up around 30% of the fibre market (see table above). Depending on the finishing and coating added to the production process, they can be renewable and biodegradable.

Cotton represents the majority of global fibre production (a bit less than 25% of the total), followed by jute, wool, hemp, and silk[13], which together account for around 7% of the fibre market. These fibres have all been under the spotlight for their environmental footprint. In the case of cotton:

- Its production involves huge amounts of water, which only partially comes from rainfall, deploying large volumes of artificial irrigation water[14]. Roughly 2,6% of water consumed worldwide is used for cotton production, contributing to water scarcity, droughts, and environmental harm[15].
- Cotton production requires heavy use of chemicals and land use[16], causing further environmental damage and resource depletion. A significant share of pesticides and insecticides consumption is

[11]Econyl© retrieved at: https://www.econyl.com/the-process/

[12] Sanjay, M. R., Siengchin, S., Parameswaranpillai, J., Jawaid, M., Pruncu, C. I., & Khan, A. (2019). A comprehensive review of techniques for natural fibers as reinforcement in composites: Preparation, processing and characterization. In Carbohydrate Polymers (Vol. 207, pp. 108–121). Elsevier Ltd. https://doi.org/10.1016/j.carbpol.2018.11.083

[13]FAO. (2021). Recent trends and prospects in the world cotton market and policy developments.

[14] Esteve-Turrillas, F. A., & de la Guardia, M. (2017). Environmental impact of Recover cotton in textile industry. Resources, Conservation and Recycling, 116, 107–115. https://doi.org/10.1016/j.resconrec.2016.09.034

[15] Chapagain, A. K., Hoekstra, A. Y., Savenije, H. H. G., & Gautam, R. (2006). The water footprint of cotton consumption: An assessment of the impact of worldwide consumption of cotton products on the water resources in the cotton producing countries. https://doi.org/10.1016/j.eco

[16]Baydar, G., Ciliz, N., & Mammadov, A. (2015). Life cycle assessment of cotton textile products in Turkey. Resources, Conservation and Recycling, 104, 213–223. https://doi.org/10.1016/j.resconrec.2015.08.007

used for cotton production, leading to issues with human health, biodiversity loss, water pollution, and soil health depletion[17].

In response to unsustainable practices, new means of production and initiatives have emerged. They aim to mitigate land-use impact, address the consumption of resources across the whole supply chain, and target the environmental footprint of manufacturing processes. However, paired with these new initiatives and production systems, sustainable textile production claims have become more frequent and mainstream – whether they are truly sustainable or not.

Regenerated, regenerative, or recycled?

The term 'regenerated fibre' is commonly used for the fibre group of man-made cellulosic/protein fibres, included in the draft ISO 5157 - *fibres produced from naturally occurring polymers of cellulose or protein, where processing by dissolution is needed to convert them into fibre form*.

Regenerated fibres are synthesised by the regeneration of natural polymeric materials, including wood pulp, cotton waste, and other plant-based materials. It follows a process called regeneration, in which the natural polymers are chemically treated to break it down into a liquid state before being passed through a spinneret to create continuous filaments. The most popular types of regenerated fibres include rayon, modal, and lyocell[18].

Regenerated cotton refers to the use of the leftover cotton yarns produced across the whole cotton supply chain. Without the 'regeneration' process, they would end up as waste, as they are a by-product that does not make it to the final stage of consumption. According to CottonWorks[19], **regenerated cotton is a synonym for recycled cotton**, which consists of pre-consumer waste scraps and post-consumer fabrics. The former consists of the volume of waste produced before the use and disposal phase, whereas the latter refers to all the cotton fabrics becoming waste after consumption.

Figure 2: Cotton recycling process[20]

The 'regeneration' process of-fibres takes the fabrics and mechanically transforms them into new fabric, by dissolving and spinning them into new yarn. The regenerated fibre with source material from pre- or post-consumer cotton is after the grinding process, getting dissolved and regenerated into a new fibre. Different from the manufacturing from raw virgin cotton, dying is not required, as the garments are already coloured. Consequently, highly polluting chemicals such as bleaching agents, softeners, dyes, wetting agents, and salts are avoided if fabrics are sorted properly. The yarns are afterwards knitted or woven with their end-use depending on the properties of the yarn. There is a need to mix yarns with virgin material because the strength is low when fabrics are ground. The trimming by-products can be then re-fibred in secondary products such as rolls.

[17]Grose, L. (2009). Sustainable cotton production. In Sustainable Textiles: Life Cycle and Environmental Impact (pp. 33–62). Elsevier Inc. https://doi.org/10.1533/9781845696948.1.33

[18] Textiles - natural and synthetic fibres - Material categories and properties - Eduqas - GCSE Design and Technology Revision - Eduqas - BBC Bitesize

[19]Cottonworks (retrieved https://www.cottonworks.com/en/topics/sustainability/cotton-sustainability/recycled-cotton/)

[20] TextiileAid (retrieved at: http://textileaid.blogspot.com/2019/03/recycled-cotton-benefits-and-challenges.html)

While it may be tempting to link the term **'regenerated'** with the agricultural phase of production, *regenerated cotton does not address the agricultural practice whatsoever*[21]. Resource saving claims refer to the post-harvesting production process (e.g., the dyeing phase) and do not involve any consumption cut during the pre-harvesting phase. Additionally, it does not address the environmental footprint of conventional cotton farming, which needs to radically change. On the other hand, **regenerative agricultural practices** refer to the regeneration of natural systems and do not consider recycling of production by-products or waste[22]. **This distinction establishes a clear difference with other means of sustainable cotton production, such as organic cotton, and could be confused with "regenerative" cotton in the first place.**

Regenerative cotton adopts regenerative agricultural practices to enhance soil health and crop rotation, improve water and land management, and reduce tillage[23]. However, it is a new approach, different from more established and tested farming systems (including organic and agroecology), and there are fewer methodologies that quantify their impact and benefits. Until recently, regenerative agriculture did not even have a certification. A pilot certification project called Regenerative Organic Certification™[24] was launched in 2019[15]. It uses as a baseline certification the USDA Organic certification (or any equivalent national organic certification scheme), meaning that farmers who apply for regenerative products are required to already have the organic certification. This just adds to the confusion.

While regenerated cotton claims to be a response to unsustainable, inefficient, and linear production-consumption patterns, there are still challenges and knowledge gaps. Moreover, it is not disclosed what the environmental savings of regenerated products are. While preventing production by-products from becoming waste is surely coherent with a circular system, it is still unclear what the climate and resource footprint of the regenerating process is. This question becomes even more crucial when big volumes of production are handled and processed. On top of that, 'recycled' and 'regenerated' are used as interchangeable terms, despite having two different meanings.

To understand more about the key principles of different agricultural production definitions:

Box 1 - Differences between means of agricultural production

	Definition	Source
Agroecology	"A holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems. It seeks to optimize the interactions between plants, animals, humans and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced. Agroecology is concurrently a science, a set of practices and a social movement and has evolved as a concept over recent decades to expand in scope from a focus on fields and farms to encompass the entirety of agriculture and food systems."	Overview | Agroecology Knowledge Hub | Food and Agriculture Organization of the United Nations (fao.org)
Organic agriculture	"A system that relies on ecosystem management rather than external agricultural inputs. It is a system that begins to consider potential environmental and social impacts by eliminating the use of synthetic inputs, such as synthetic fertilizers and pesticides, veterinary drugs, genetically modified seeds and breeds, preservatives, additives and	Organic Agriculture: What is organic agriculture? (fao.org)

[21] For example: https://barnhardtcotton.net/blog/know-your-fibers-regenerated-cotton/
[22] Ellen MacArthur Foundation. (2020). Vision of a circular economy for fashion.
[23] Fashion Industry Charter for Climate Action. (2021). Identifying Low Carbon Sources of Cotton and Polyester Fibres.
[24] Framework for Regenerative Organic Certified™ (2021)

	irradiation. These are replaced with site-specific management practices that maintain and increase long-term soil fertility and prevent pest and diseases".	
Sustainable agriculture	"To be sustainable, agriculture must meet the needs of present and future generations for its products and services, while ensuring profitability, environmental health and social and economic equity".	Sustainable agriculture | Sustainable Development Goals | Food and Agriculture Organization of the United Nations (fao.org)
Conservation agriculture	"A farming system that promotes minimum soil disturbance (i.e. no tillage), maintenance of a permanent soil cover, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production".	Conservation Agriculture | Food and Agriculture Organization of the United Nations (fao.org)
Regenerative agriculture	"Regenerative agriculture describes holistic farming systems that, among other benefits, improve water and air quality, enhance ecosystem biodiversity, produce nutrient-dense food, and store carbon to help mitigate the effects of climate change. These farm systems are designed to work in harmony with nature, while also maintaining and improving economic viability".	Regenerative Agriculture | FAO

What does this table tell us? That there are many proven and tested approaches when it comes to having a more sustainable approach to agriculture. These definitions have been around for a long time and must be supported with mandatory requirements enshrined into law.

One of the most widely recognized examples of sustainable fibre sourcing is organic cotton. Organic cotton is grown without the use of synthetic pesticides or genetically modified organisms (GMOs). It promotes soil health, reduces water consumption, and minimizes harmful chemicals' exposure to farmers and surrounding communities. Furthermore, organic cotton cultivation often employs more environmentally friendly practices, such as crop rotation and composting. **Organic cotton** aims to reduce the number of toxic chemicals released into the environment by avoiding the use of synthetic chemicals used in conventional agriculture. Organic claims consist of **mandatory law requirements** and have a specific certification and labelling scheme[13], contrary to regenerative agriculture. In the European Union, organic agriculture is regulated by the EU Regulation 2018/848[25], which outlines the rules for organic farming. This was published in June 2018 and entered into force 1st of January 2022.

Regenerative agriculture focuses on improving the health of soil that has been degraded by the use of heavy machinery, fertilisers and chemical pesticides in intensive farming[26]. It refers to a "system of farming principles and practices that increase biodiversity, enrich soils, improve watersheds, and enhance ecosystem services"[27]. It represents a significant response to conventional, intensive agriculture systems, and which involve a series of practices such as minimising the ploughing of land, avoiding tillage, rotating crops, and moving grazing animals to different pastures. All these parameters aim for a systemic shift, this concept is still fluid and, because it is not associated with any formal definition. To some extent agroecology or conservative agriculture could be confused with regenerative agriculture.
A transitioning from conventional, intensive practices to sustainable ones is needed. However, "regenerative agriculture" has started to be used by large agri-corporates, risking that it becomes a **greenwashing exercise** given the fluidity of the concept**.** Start implementing at scale techniques whose

[25]Regulation (EU) 2018/848 — rules on organic production and labelling of organic products
[26] Regenerative agriculture can help feed the world. What is it? | World Economic Forum (weforum.org)
[27] EIT Food (2020) (retrieved https://www.eitfood.eu/projects/the-regenerative-agriculture-revolution-2020)

environmental values have been proven, tested and certified should be prioritised. Adding new fluid definitions may slow down the changes that are sorely needed.

When it comes to sustainable sourcing, practices that enhance soil biology, minimise tillage, improve crop diversity, and increase water efficiency to reduce water consumption should be encouraged. The successful adoption of sustainable sourcing of fibre and sustainable agriculture practices relies on collaboration between various stakeholders, including governments, industries, farmers, NGOs, and consumers. Ultimately, farmers need to be supported in implementing sustainable farming practices, and at the same time workers' rights (such as guaranteeing a living wage and benefits, safe working conditions, decent working hours) need to be ensured to implement a truly sustainable system.

Conclusions

'Regenerated', 'regenerative', 'recycled' – charming buzzwords rather than concrete action?

In the development of a truly sustainable fibre sourcing process, confusion between different definitions represents a significant barrier. Particularly in the textile sector, different interpretations of the meaning of 'regenerative', 'regenerated' and 'recycled' textiles for both natural and synthetic fibres pose the risk of prioritising practices that do not have clear environmental gains.

Synthetic fibres – polyester

The term 'regenerated' in textiles is sometimes used to describe recycled textiles, with all the challenges and drawbacks that are embedded within textiles recycling. Recycling is part of implementing circularity, but it must be integrated in a holistic framework that prioritises the reduction of production. The incorrect practice of using regenerated fibre to describe synthetic fibres such as polyester or nylon poses a greenwashing risk.

Natural fibres – cotton

Regenerative cotton is different from regenerated cotton, as they follow two distinct supply chain pathways, address two different issues within the textile industry (farming footprint and management of industrial waste) and are not necessarily linked.

Sustainable sourcing of fibre and sustainable agriculture practices (starting with agroecology and organic) are integral to transforming the textile industry into a more environmentally and socially responsible sector. While reducing production volumes, by prioritising those practices and adopting sustainable fibres, the industry can reduce a part of its ecological footprint, mitigate climate change, and promote biodiversity restoration and conservation. The collective efforts of industry stakeholders, policymakers, NGOs and consumers are vital in driving this transformation and creating a more sustainable future for the textile sector.