ALTERNATIVE PLANT FIBRE LANDSCAPE ANALYSIS

BETWEEN TRADITION AND INNOVATION

FIBRAL
Global Plant Fibre Association

Foreword by UN Trade and Development & SouthSouthNorth

The world's material systems are at a crossroads. Plastic pollution, dependence on synthetic fibres, and climate-related disruptions to agriculture are converging pressures that demand not incremental adjustments but structural change. In response, the search for resilient, low-impact materials has moved from the margins to the centre of debates on industrial development, trade, climate action and rural prosperity. Alternative plant fibres, rooted in centuries of cultivation and ecological knowledge, offer a compelling part of this transition. Yet their potential has long remained fragmented, confined to smallholder farms, artisanal workshops, cottage industries and niche markets without the collective voice, market visibility or institutional support needed to compete at scale. Supporting these fibre value chains within a coherent circular bioeconomy is therefore essential, both to diversify future materials and to enable developing countries to participate more fully in emerging markets for sustainable materials.

This report by FIBRAL arrives at a decisive moment. Through the UK–UNCTAD Sustainable Manufacturing and Environmental Pollution (SMEP) Programme*, we have supported entrepreneurs in Uganda and Kenya who are demonstrating what is possible. Using agricultural waste from crops primarily cultivated for food, they are extracting spinnable fibres from banana pseudostems and transforming pineapple leaf residues into textile-grade materials. In regions where these crops are widely grown and large volumes of organic agricultural waste are generated, they are beginning to build supply chains that link rural producers to international markets. These initiatives signal a broader industrial transition that, with the right enabling environment, could contribute to more diversified and resilient trade in sustainable materials.

Plant fibres matter for three interconnected reasons. First, they offer renewable and biodegradable alternatives to high-impact materials such as polyester and conventional cotton, with its well-known environmental impacts, and in some applications can also substitute plastics. Within UNCTAD's framework, natural plant fibres are recognised as non-fossil materials capable of replacing plastics in certain functions without introducing new chemical hazards. Second, they create income and enterprise opportunities in rural areas by turning agricultural residues that would otherwise rot or be burned into valuable economic resources. Third, when cultivated regeneratively and processed responsibly, plant fibres can contribute to climate resilience, soil health and biodiversity, outcomes that many national circular economy, bioeconomy and climate strategies aim to achieve.

What FIBRAL is building, a pre-competitive platform where producers, processors, designers, buyers and researchers converge around shared data, best practices and advocacy, is precisely the type of sector infrastructure alternative fibres have long lacked. Markets do not shift on potential alone. Trade governance, investment flows and procurement decisions require credible evidence, transparency and a coordinated industry voice. By illuminating the landscape of plant fibre systems, this report helps provide that foundation. It lays the groundwork for stronger partnerships, more informed policy choices and more inclusive value chains capable of supporting the responsible growth of this emerging sector.
We commend FIBRAL's commitment to open knowledge and invite actors across the textile and fibre value chains to engage with its findings.

Henrique Pacini UN Trade and Development (UNCTAD) for the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme

Elzette Henshilwood SouthSouthNorth for the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme

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SMEP | Sustainable Manufacturing and Environmental Pollution Programme

UN trade & development | UK International Development — Partnership | Progress | Prosperity

Foreword by The Sustainable Angle | Future Fabrics Expo

We are witnessing a growing awareness build around our toxic dependency on synthetics, and the negative environmental impacts associated with these petrochemical-based materials. Regulatory measures on microplastic emissions and bans on single-use plastics around the world signal a shift in our material landscape. At the same time, increasing pressure on resource-intensive production systems—whether in conventionally farmed monoculture cotton, or the demands placed on forests for wood as a feedstock—has encouraged a broader conversation about diversification. In this context, there is a renewed interest in exploring how alternative plant fibres can complement existing natural materials, contributing to more regenerative and resilient fibre systems overall.

Recent years have seen an increasing recognition of plant fibres as positive, low-impact materials, with relevance across a variety of industries and multiple value chains. Alongside this awareness, we have seen a surge in research and start-ups in the material innovation space, intent on providing nature-positive, sustainable solutions and inspiring a growing interest amongst the industry professionals we work with.

The FIBRAL Alternative Plant Fibre Landscape Analysis is therefore very timely—it provides a detailed examination of this currently underexplored category of fibres, offering valuable insights into the globally diverse array of crops and produce in this space.

The Future Fabrics Expo welcomes the opportunity to platform and support the communication of this important report to the industry, which raises awareness of the current state of the plant fibre market, persuasively outlining benefits and future opportunities for the sector. The report consolidates foundational knowledge and data, bringing much needed clarity to misconceptions regarding the provenance, extraction methods and processing routes, and reveals the social and environmentally beneficial impacts of an extensive variety of plant fibres. The importance of this knowledge and disseminating education is critical in creating awareness and stimulating industry demand around these alternative plant fibres.

FIBRAL's mission, and the aims of the report align with that of our work at the Future Fabrics Expo—researching, educating and connecting the industry with sustainable material suppliers and innovators to action positive, sustainable change. The plant fibres examined here all play an important role in supporting biodiversity, mitigating climate change, and offer the potential to contribute to much needed diversification of the global fibre basket, while spreading supply chain risk.

The report provides key insights into how small-producers and industrial systems can work together; by 'joining dots' and aggregating suppliers, they can deliver scale and regenerative benefits together, realising the potential of plant fibres within the circular bioeconomy to strengthen rural livelihoods, and deliver measurable benefits for climate, human and planetary health.

Amanda Johnston Chief Design Officer, Future Fabrics Expo

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Lead researchers and authors

Sandra Bohne, Co-Founder and Director, FIBRAL and Consultant

Tilly Bintley-Bagot, Volunteer, FIBRAL

Ricardo Garay, Co-Founder, FIBRAL

Camila Charpentier Alfaro, Volunteer, FIBRAL

FIBRAL Team

Sandra Bohne, Co-Founder and Director, FIBRAL and Consultant

Ricardo Garay, Co-Founder, FIBRAL

Carmen Hijosa, Co-Founder, FIBRAL & Chief Creative and Innovation Officer, Ananas Anam

Hannes Schoenegger, Co-Founder, FIBRAL & Co-Founder and CEO, Bananatex

Johannes Fuerst, Co-Founder, FIBRAL & Founder, Montebelo

Achenyo Idachaba-Obaro, Founding Member, FIBRAL & Founder and CEO, Mitimeth

Mohamad Midani, Founding Member, FIBRAL & Adjunct Professor, NC State University

Riikka Juva, Former Co-Founder, FIBRAL & Head of Sales and Marketing, Fresh Del Monte

The authors and the FIBRAL team would like to thank everybody who has contributed valuable time to help with this publication. Our special thanks go to:

Contributing authors

Eduarda Bastian, Founder and Executive Director, Fibershed Brasil

Thomas Bressler, Managing Director, Wilhelm G. Clasen

Eva Engelen, Innovation Manager, Fashion for Good

Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery, Wageningen University Research

Justin Kühn, Head of Staple Fibre Technologies, Institut für Textiltechnik of RWTH Aachen University

Volker Mathes, Business Development, AVK - Federation of Reinforced Plastics

Lothar Müller, CEO, FibProMundo

Klaus Münzing, CEO, Fibre Innovation Centre Zerkall (FIZZ e.V.)

Dipanwita Ray, Innovation Associate (Footwear), Fashion for Good

Terry Townsend, Board Member, Discover Natural Fibres Initiative DNFI

Industry roundtable contributors

Among others:

Barbara Guettler, Manager Material Cycles, Leibniz Institut für Verbundwerkstoffe

Susan M., Head of Business Development Costa Rica, Eco:fibr

Volker Mathes, Business Development, AVK - Federation of Reinforced Plastics

Sadiah Steibli, CEO, Allianz Faserbasierte Werkstoffe afbw

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Executive summary

Executive summary

Across the globe, thousands of plant species can provide natural fibres, many used for millennia in textiles, tools, construction, and art—deeply embedded in cultural heritage and linked to sustainable livelihoods. While their ecological availability and functional diversity are high, commercial production remains largely concentrated in cotton and, to a lesser extent, jute, flax, and coconut fibres.

Yet, this landscape is beginning to shift. As governments and companies adopt bioeconomy strategies and ambitious sustainability targets, industries from textiles and construction to automotive and pulp & paper are seeking biobased, low-impact feedstock alternatives. This presents a significant opportunity for the plant fibre sector to scale, innovate, and advance sustainable industrial practices.

Plant fibres hold significant potential to contribute to climate resilience, circular material systems, and rural livelihoods. Recognised by the UN General Assembly in 2023 as drivers of sustainable development, they support land restoration, enhance ecosystem resilience, and create rural employment when integrated into regenerative agricultural systems. Strategic investment can therefore advance climate and development objectives while fostering long-term rural economic resilience.

To fully realise this potential, however, several interrelated structural, operational, and environmental challenges must be addressed. Decades of limited investment have left processing infrastructure underdeveloped, slowed innovation, and resulted in limited data and transparency. This has created a difficult starting point for emerging companies, which now face persistent challenges in reaching economies of scale. As a result, production costs remain high, demand is constrained, and the sector struggles to attract the level of investment needed for growth. At the same time, climate change is placing growing pressure on yields and fibre quality, underscoring the need for resilient production systems.

FIBRAL was created to help address these systemic challenges by strengthening pre-competitive collaboration across the plant fibre ecosystem. By convening stakeholders, supporting joint research, generating open-access data, and promoting best practices, we aim to reduce fragmentation, improve transparency, and build the evidence needed to unlock investment and sustainably scale the sector.

Key takeaways

- Global policies and climate goals demand a shift to renewable materials and circular approaches requiring large amounts of sustainable biomaterials. Responsibly produced plant fibres offer a scalable, nature-based solution that can strengthen rural livelihoods and climate resilience.
- To date the sector remains relatively small at 5.9 million MT and USD 3.8 billion (excluding cotton), but is expected to grow to 8 million MT by 2035. The strongest opportunities are in applications where plant fibres have clear technical advantages (e.g. filtration) and sectors with low entry barriers such as insulation, packaging, composites, and heavier textiles.
- Industry growth is less limited by the potential of alternative plant fibres, but by environmental challenges and structural barriers—such as outdated machinery, low market demand, and regulations built for conventional materials.
- Reimagining traditional plant fibres requires connecting Traditional Ecological Knowledge with modern innovation to unlock their full value as nature-based solutions and contributor to rural development. Small-producer and industrial systems have complementary strengths; when intentionally connected, they can deliver scale, quality, and regenerative outcomes together.
- What is needed is a collective voice across natural fibre systems, with alignment and collaboration among producers, innovators, and markets. Joint R&D, open technology transfer, shared best practices, and transparent data will be critical to enable sustainable scaling and long-term competitiveness.

About FIBRAL - Global Plant Fibre Association

Abacá fibre, source: Bananatex

About FIBRAL - Global Plant Fibre Association

FIBRAL was founded in 2022 under the name *Fibral Material Alliance*. The initiative began when Dr. Carmen Hijosa and Riikka Juva from Ananas Anam, Hannes Schoenegger and Stephanie Walter from Bananatex®, Ricardo Garay from Regenerate Fashion and Sandra Bohne joined forces with a shared vision: to create a collective voice for plant fibres in the rapidly emerging field of biomaterials.

What started as a small collaboration quickly evolved into a global voluntary network. Over the past years, FIBRAL has connected more than 150 organisations and individuals across 25 countries, creating space for exchange, collaboration and mutual support within the plant fibre community. Operating without a formal budget or institutional structure, the network has functioned primarily as an informal platform linking companies, researchers and practitioners who share an interest in advancing plant fibre materials.

As the sector has grown, it has become increasingly clear that the industry has reached a level of maturity where stronger coordination and representation are needed. To support the next stage of development, the network will now evolve into a formal global association.

Under our new name, **FIBRAL – Global Plant Fibre Association**, we will act as a facilitating platform bringing together producers, processors, manufacturers, buyers and academia on a pre-competitive basis. By strengthening coordination and partnerships, building the evidence base on plant fibre production and impacts, and increasing visibility for the sector, we aim to help de-risk public and private investment in the plant fibre ecosystem. In addition, FIBRAL intends to develop voluntary best-practice guidance on fibre quality and sustainable production, build capacity through technical workshops, and facilitate dialogue between producers and international markets to better align practices with market requirements.

Through this work, the association aims to empower producers to scale sustainable practices and positive impact, while enabling buyers to source with greater confidence—accelerating the adoption of plant fibres as nature-based materials within a circular bioeconomy.


Abaca fibre drying, Costa Rica, source: Wilhelm G. Clasen

Goal and scope of this report

Indigenous woman handling himalayan nettle, source: Himalayan Wild Fibres

Goal and scope of this report

Goal of the report

This report traces the current landscape of plant fibre systems, from their cultural and ecological foundations to their production pathways, market dynamics, and future potential. It examines how different fibre systems operate, where they are produced, and the social, environmental, and economic impacts associated with them. It is intended for producers; industry partners in the textile, automotive, construction, and pulp & paper sectors; as well as researchers, and investors. The report aims to improve transparency and support informed dialogue while providing clear insight into the opportunities, constraints, and pathways for responsible growth. It establishes a baseline for more detailed market analysis as the industry continues to evolve.

This report celebrates plant fibre's enduring legacy while establishing a new narrative that recognises their cutting-edge contributions to the biobased circular economy.

– Carmen Hijosa, Co-Founder, FIBRAL & Founder and Chief Creative and Innovation Officer at Ananas Anam

The report also aims to address gaps of information often seen in industry discussions:

- Fragmented information about plant fibres and confusion around definitions, extraction methods, and their distinctions from man-made cellulosics and biosynthetics.
- The need to bridge traditional and industrial approaches and demonstrate that heritage and progress are not only compatible—they can be mutually reinforcing.
- The need for greater insight into the range of plant species that can supply fibres and biomass for circular, resource-efficient systems.
- The lack of data on material availability, market potential, and the role of these resources in regeneration and carbon sequestration.

Scope

The scope of the report covers 36 plant fibres—excluding cotton—that are cultivated and harvested worldwide for industrial and artisanal use. We also list the largest producers of these fibres within and outside of our member network. This list is by no means exhaustive, and the report does not aim to rank fibre types, make value judgments, or recommend specific producers. The report also gives an overview of associated social and environmental impacts of fibres but does not attempt to provide comprehensive life cycle assessment; instead, it points to available knowledge and highlights key data gaps.

The analysis draws on public data, interviews, roundtables, and targeted data collection. The primary focus is on Tier 4 activities: cultivation, extraction, and processing of plant materials into raw fibres.[1] This stage is especially significant as it represents the greatest part of the natural fibres' heritage and traditions, as well as their labour intensity and environmental impacts. While the analysis does not cover downstream processing and product specifications in depth, it highlights key applications and industries where plant fibres are increasingly relevant, including textiles & fashion, automotive, construction, and pulp & paper.

Respect for Indigenous Peoples, Local Communities and their knowledge and traditions

In this report, we discuss traditional plant fibre practices and knowledge of Indigenous Peoples. It is important for us to acknowledge that this is a difficult topic due to the colonial history and that most of our authors and the founding team of FIBRAL come from the Global North. In presenting both ancient and modern fibre practices, this report seeks to explore synergies without claiming ownership or authority over traditions that are not ours. Indigenous knowledge belongs to the communities who hold and protect it, and is inseparable from its cultural, spiritual, and territorial contexts. References to traditional practices are made with respect and with the aim of honouring their contributions. This work does not seek to generalise, simplify, or instrumentalise such practices, nor to suggest they can be replicated without community consent and participation. We acknowledge the risks of reproducing colonial patterns and therefore approached these sections with awareness and sensitivity.

Introduction

Sisal plant, source: shutterstock

Definition and classification of plant fibres

Fibres of various forms can be found in all higher plants (especially vascular plants). They can be described as elongated fibre cells which form the structural elements that give strength and shape to the tissue of stems, branches and roots, but also to softer tissues such as leaves, flowers or fruits. They can also develop on the inside of fruits and seeds.[1] They can be short, such as kapok fibres with a length of 20 mm, or very long, such as hemp fibres, which can reach a length of up to 5 metres. It is not to be confused with dietary fibre found in plant foods.

Nature offers us countless plant species from which these fibres can be extracted effectively. To frame the magnitude; In America alone, it is estimated that there are over a thousand plant species that provide fibres, and over 800 are found in the Philippines.[2] It is therefore impossible to estimate the total amount of fibres available to the circular bioeconomy and that are yet to be discovered.

Plant fibres can be classified into the following categories: Bast fibres, leaf fibres, seed and fruit fibres, other straw and stem fibres, and cane, grass, and reed fibres.[3,4] Bast fibres are obtained from the phloem or bast surrounding the woody stems of plants such as jute, flax, hemp, and ramie. Leaf fibres are sourced from the leaves of plants such as pineapple or sisal. In some cases, they are extracted from the so called "Pseudo stems" of specific plants like abacá or banana. The pseudo stem that appears to be a true stem but is actually formed from tightly

Classification of plant fibres by the part of plant they are derived from

BAST FIBRES	LEAF FIBRES	SEED & FRUIT FIBRES	OTHER STRAW & STEM FIBRES	CANE, GRASS, REED
FLAX (Linen)	ABACA' (Manila hemp)	ANGICO POD	BARKCLOTH	COMMON REED
HEMP	AGUAJE	CATTAIL*	BOMBONAJE	MISCANTHUS
JUTE	BANANA & PLANTAIN	COCONUT FIBRE (Coir)	DATE PALM	SWITCHGRASS
KENAF	CHAMBIRA (Tucum)	GRAPE VINE FRUIT	OIL PALM*	
NETTLE	FIQUE (Cabuya)	KAPOK	SUNFLOWER STEM	
HIMALAYAN NETTLE	HENEQUEN	MILKWEED*	WATER HYACINTH	
RAMIE	PINEAPPLE (PALF)	PALMYRA PALM		
	RAFFIA			
	SANSEVIERIA			
	SISAL			

** For the sake of simplicity, cattails and milkweed are classified only as seed and fruit fibres. However, the stems of both plants can also be used to produce fibres. Oil palms are classified only as other straw and stem fibres, although the empty fruit bunches of the oil palm can also be used to make fibres.*

Classification of plant fibres by source of origin

- Fibre crops, e.g. abaca, jute, sisal
- Agricultural by-products, e.g. banana, pineapple, date or coconut palm
- Wild plants or invasive species, e.g. milkweed, water hyacinth, aguaje
- Biomass crops, e.g. miscanthus, switchgrass

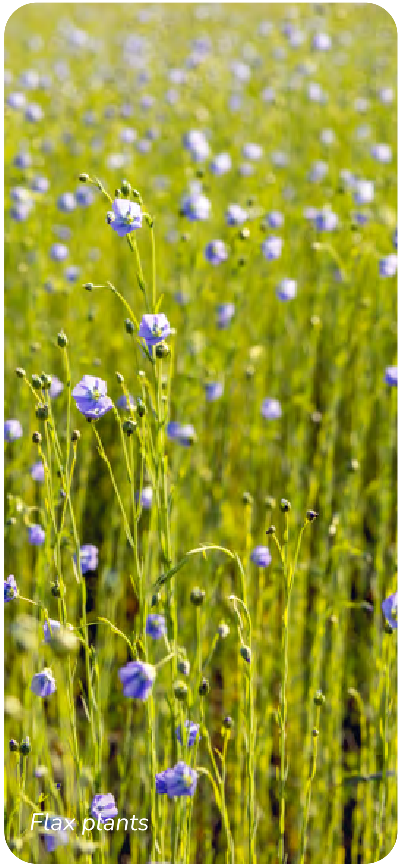
Categorisation of fibres is not always clear, as some fibres have multiple origins. For example, hemp can be grown as a fibre crop or collected as a by-product from CBD production, and plants like nettle or cattail may be harvested in the wild or be cultivated.

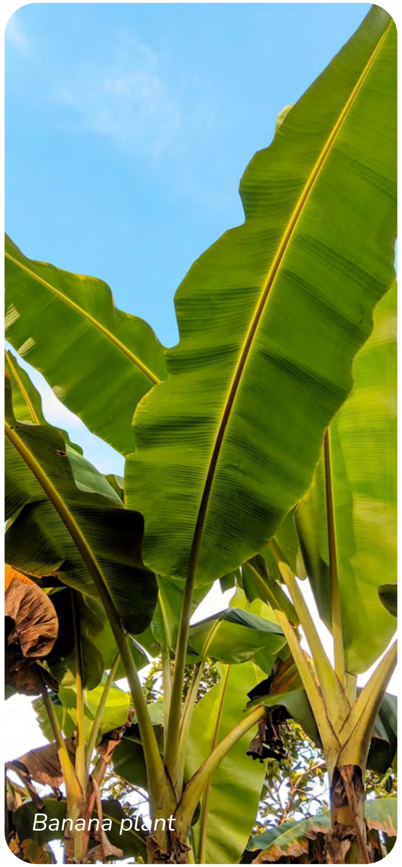
wrapped and overlapping leaf sheaths. Seed and fruit fibres are derived from seed pods or the empty fruits of plants. Examples include coir, extracted from the outer husk of coconuts, and kapok fibres, found in long seed pods of the kapok tree. The category other straw and stem fibres refers to all fibres derived from stalks and stems other than bast fibres, including materials like water hyacinth stems, an aquatic weed, or milkweed stems, a wild shrub. This category also includes barkcloth, a fibrous material obtained from tree bark, as well as residues from date palms, such as the fibrous mesh surrounding the tree or spadix stems holding the fruits. Lastly, cane, grass, and reed fibres are derived from the tall stems and stalks of plants, for example miscanthus and switchgrass.

The source of origin is another way to classify fibres, although not always as clearly defined. Plant fibres may be derived from fibre crops which are specifically cultivated for fibre production such as abacá, jute or sisal. They can also be harvested from wild plants or invasive species found in forests or marginal dry and wetlands, this could be for instance water hyacinth, milkweed or aguaje.

Another type of fibre comes from agricultural by-products which are organic wastes, including materials such as leaves, sheaths, pseudo stems, or empty fruit bunches, which are generated during the harvesting, collection, or processing of primary products like food, animal feed, or medicine. This could be pineapple leaves, banana pseudo stems or date palm leaves. Also, coir fibre is a residue of the coconut industry. The last category are biomass crops which are cultivated for the purposes of e.g. bioenergy, biochemistry and other biomaterials, including fibres. Examples include miscanthus or switchgrass.

Picture sources: Shutterstock





A brief history

Plant fibres have been central to human civilisation for millennia—used in clothing, ropes, furniture, and building materials. Archaeological evidence shows flax fibres were already used more than 34,000 years ago, making them the oldest known fibres used by humans.[5]

Indigenous Peoples and Local Communities across the globe have been relying on local plant fibres for everyday necessities and their unique methods of cultivation, harvesting, and weaving are deeply intertwined with their cultural practices. The expansion of fibre cultivation and its introduction to new regions and climates is closely tied to European colonialism. During this era, colonial powers advanced technology and infrastructure for plant cultivation and fibre production but also exploited Indigenous knowledge and labour, appropriating traditional fibre-related practices and converting them into large scale, export-driven industries.

For instance, Indigenous Peoples of the Philippines cultivated abacá already for centuries, before it became a major export commodity under Spanish colonisation. Later, during American control of the Philippines, abacá production was industrialised and further expanded at the expense of local autonomy.[6] Under British rule, jute cultivation and export expanded in India, and the industry saw advancements in technology and infrastructure, such as the establishment of jute mills and modern machinery. However, the British also exploited jute farmers and mill workers, who faced low wages and poor working conditions.[7]

Western Roman emperors also distributed plants to foreign countries to expand their production. For instance, sisal, originally native to Mexico, was introduced by a German botanist to what is now Tanzania in 1893, laying the groundwork for East Africa's sisal industry. By 1903, sisal cultivation had also begun in Kenya.[8] Originally from South America, the pineapple was introduced to the Philippines by the Spanish at the end of the 16th century. The natives, who were already skilled in weaving fabrics from various plants, saw the pineapple as another source of fibre, and it became an inherent part of their culture and tradition.[9]

During both World Wars, demand for plant fibres surged due to their durability and versatility in military products.[3] Jute was used for sandbags,[10] kapok for life vests,[11] and coir for military helmets.[12] Fibres such as hemp and sisal were vital for ropes, nets, and packaging materials essential to global trade.[3] In 1941 Ford designed a prototype vehicle that was made from hemp, wheat, spruce, corn, soybean, and flax pulp praised for its light weight and stability.[13] During these high times for plant fibres, expressions like "Jute – the golden fibre" and "Henequen – the green gold of Yucatan" were coined.

The rise of the plastics industry in the mid-20th century had a damaging effect and drastically reduced the use of plant fibres, triggering economic and social decline in many producing regions. Decades of underinvestment left the sector with outdated machinery, limited innovation and transparency—challenges that persist today.

Growing awareness of the environmental impacts of fossil-based inputs, glass fibres, and mineral wool—as well as increasing pressure on cotton and wood supply—combined with new policy and investment incentives for biobased materials, has renewed interest in alternative plant fibres. This renewed focus is reflected in the increase of research, patents, and start-ups exploring new fibre types, developing new extraction methods, and applications—modernising a centuries-old tradition for today's circular bioeconomy.

Sisal plantation in German East Africa, 1906, source: Wikiwand

Differentiation of processing approaches

Types of fibres generated from plants are frequently subject to confusion due to the range of processing methods that can be applied to the same raw material. Depending on how the fibre is treated, it can result in distinctly different categories of materials and thus differing properties—ranging from naturally extracted fibres to man-made cellulosic fibres and biosynthetics. The processing pathway chosen depends largely on the inherent properties of the fibre source and the desired performance characteristics of the final material.

This report and we as an association focus on fibres obtained through natural fibre extraction and recent technological innovations in this space. However, we are a supporter of the use of plant fibres in all forms and encourage to explore these options as well.

This section explains how different fibre production systems function and why they are distinct from one another.

Natural fibre extraction

Natural fibre extraction removes or dissolves non-fibrous components such as pectin, hemicellulose, lignin and waxes that hold the fibres together in the plant. The specific processes used vary depending on the source and type of fibre and can include mechanical, thermal, chemical and enzymatic techniques (See further details in chapter "*Production landscape*"). During natural fibre extraction, the plant's natural cellulose structure is maintained and not dissolved. Fine seed fibres such as kapok, as well as bast fibres like flax (linen) and hemp, are well-suited for apparel. In contrast, jute, sisal, and coir are naturally harder and coarse and traditionally used in applications requiring strength and durability like cordage or sacking. Another form of natural fibre processing is pulping, used for paper and packaging applications. In this process, lignin, hemicellulose, and other non-cellulosic components are removed to produce a fibrous pulp rich in cellulose. Pulping can be carried out through mechanical, chemical, or semi-chemical methods, commonly followed by washing, bleaching, refining, and sheet formation. Fibres such as abacá, jute, and hemp are particularly valued for specialty papers due to their long fibres, high tensile strength, and natural purity.

Comparison to man-made cellulosic fibres

Man-made cellulosic fibres (MMCFs) such as viscose, modal, and lyocell are produced by dissolving and regenerating cellulose, typically from wood pulp. The traditional processes use harmful chemicals like carbon disulphide, while newer methods such as lyocell recover solvents in a closed-loop system. These semi-synthetic fibres combine cellulose origins with the smooth, soft qualities of synthetics. The plant fibres discussed in this report can also serve as feedstock for MMCF production—and some already do, for instance hemp. Initiatives like the "NEXTGENNOW" project, spearheaded by Canopy, aim to produce 60 million MT of next-generation fibre alternatives within the coming ten years.[14]

Comparison to biosynthetic fibres

Biosynthetic fibres are produced by converting plant-based feedstocks—commonly corn, sugarcane, but also agricultural by-products—into polymers through fermentation or chemical synthesis. Unlike naturally extracted fibres, this process does not preserve the plant's fibrous structure; instead, it breaks biomass down into molecular building blocks, which are then reassembled into polymers like polylactic acid (PLA) or biobased polyester (bPET). Although less common, the plant fibres discussed in this report could also serve as potential feedstocks for such fibres.

The production of man-made cellulosic fibres and biosynthetic fibres enables standardised mass production through centralised industrial systems. Semi synthetic fibres are quite close in their performance to fossil-based fibres. Natural fibre extraction is mostly done by small farmers using simple artisanal or semi-mechanised techniques, but even if done on a larger scale for instance with hemp or flax, these processes lead to natural variations in quantity, quality, colour and consistency. Here product development to leverage their natural performance properties is essential.

Between Traditional Ecological Knowledge and innovation

Fibre plants hold a profound significance in the lives of Indigenous Peoples and Local Communities, representing not only practical materials for everyday use—like rope, basketry, food, textiles and medicine—but also sacred elements deeply intertwined with cultural and spiritual traditions. The selection of plants, harvest, and extraction of plant fibres are commonly accompanied by prayers, rituals, and ceremonies, reflecting a profound respect for nature's cycles and the ecosystem.[15]

This longstanding Traditional Ecological Knowledge (TEK) is passed down through generations and helps them avoid overharvesting of wild plant populations, restore degraded ecosystems, conserve water, and safeguard biodiversity. However, outcomes are context dependent, and such regenerative effects are not automatic; they rely on specific practices, community governance and local environmental conditions.

The extraction, spinning, and weaving of fibres often involve women's labour, linking plant-based production to both social identity and economic participation. Women's cooperatives not only preserve intangible heritage but also generate income for their families, bridging traditional artistry with modern livelihoods.[16]

Disruption through colonial and industrial processes

This intricate balance between human and ecological systems began to unravel with the rise of colonial extraction and industrialisation. Plant fibres that had once been managed communally and harvested with local ecological balance in mind were increasingly redirected toward empire-building and warfare, in some cases through expansion into large scale monocultures.[17] This legacy of industrial expansion makes clear that future growth must avoid repeating extractive patterns. Today, sustainably scaling plant fibre production requires a fundamentally different model—one grounded in equality and ecological stewardship. This principle is underpinned by the United Nations' 2023 resolution on natural plant fibres, which calls for the preservation and mutually agreed scaling of Indigenous technologies as a foundation for sustainable fibre futures.[19]

Bridging Traditional Ecological Knowledge and innovation

To sustainably increase global plant fibre production while supporting ecosystem health and rural development, it is essential to connect traditional ecological knowledge with modern innovation. This requires integrating small producers—including Indigenous Peoples and Local Communities, smallholders, women- and youth-led enterprises—into fibre value chains in ways that recognise and amplify their contributions.[19]

Collaboration with diverse partners in the private sector, government, NGOs, and public-private initiatives can unlock the finance, technology, and capacity building needed to support the scale of production. Especially innovators are playing an important role by working

Solar powered decortication, source: Ananas Anam

Innovation in plant fibres must begin with preservation. Scaling these materials must respect Traditional Ecological Knowledge, ecological limits, and the communities who have long cared for these resources.

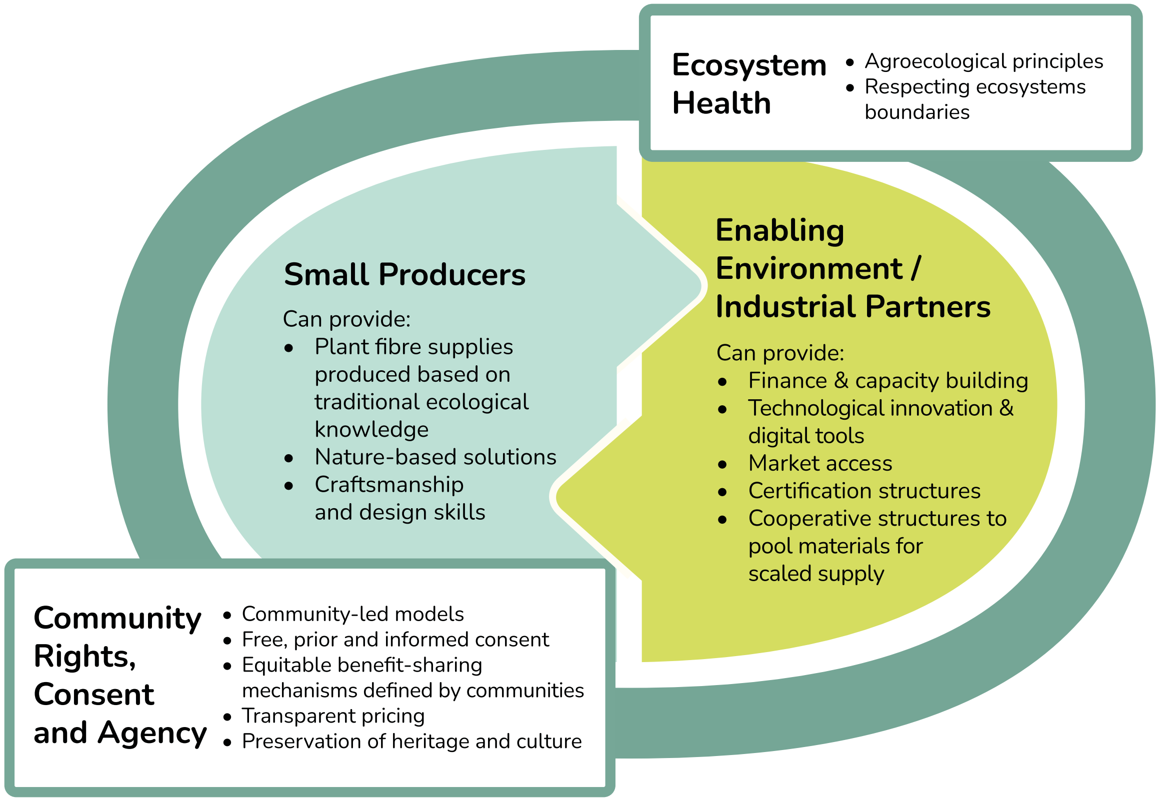
– Ricardo Garay, Co-Founder, FIBRAL

directly with artisanal and farming communities to revitalize traditional fibres. Practical examples include cooperative models built by governments or private-public partnerships that offer shared equipment—such as mechanised hand-fed decorticators or solar-powered drying racks—to boost efficiency without compromising ecological practices.[20] Other initiatives focus on women- and youth-led craft training,[21] or digital systems that help to connect farmers in remote areas, coordinate raw-material supply and streamline product logistics for global distribution.[22]

Critically, building equitable and sustainable fibre markets requires approaches that respect cultural heritage while ensuring fair economic opportunity. Partnerships that specify roles, responsibilities, and benefit sharing mechanisms can integrate TEK with contemporary production requirements, contributing to a more circular and adaptive bioeconomy. However, the creation of resilient markets for plant fibres must begin with the recognition that traditional knowledge and Indigenous practices are not only culturally and ecologically significant but also sacred and protected under national and international law—hence innovation can only follow preservation. Community leadership must be centred in all decision-making processes, ensuring that the rights, free, prior and informed consent, and agency of small producers are fully upheld and respected.

Scaling to mechanised or industrial processing, when guided by consent and ecological principles, can coexist with traditional practices and enhance efficiency without compromising cultural heritage or environmental stewardship. Community-led models and transparent pricing can help small producers and artisans maintain agency over production. Where communities identify opportunities for growth, access to buyers at different market levels, cooperative structures, and technological tools that support coordination and traceability may be valuable for business success. Certifications may also support market access when paired with targeted financial and capacity-building assistance for small producers. Balancing preservation and innovation therefore prioritises the protection of ecological functions, cultural assets, and resource stocks before introducing new technologies.

Bridging traditional ecological knowledge and innovation to sustainably increase fibre supply



LEGEND

Small producers: Indigenous Peoples and Local Communities, Smallholders, Women-and Youth-led Enterprises

Enabling Environment/Industrial partners: Innovators, Governmental Organisations, NGOs, Public-Private Partnerships

Market size and value

Pineapple leafs, source: shutterstock

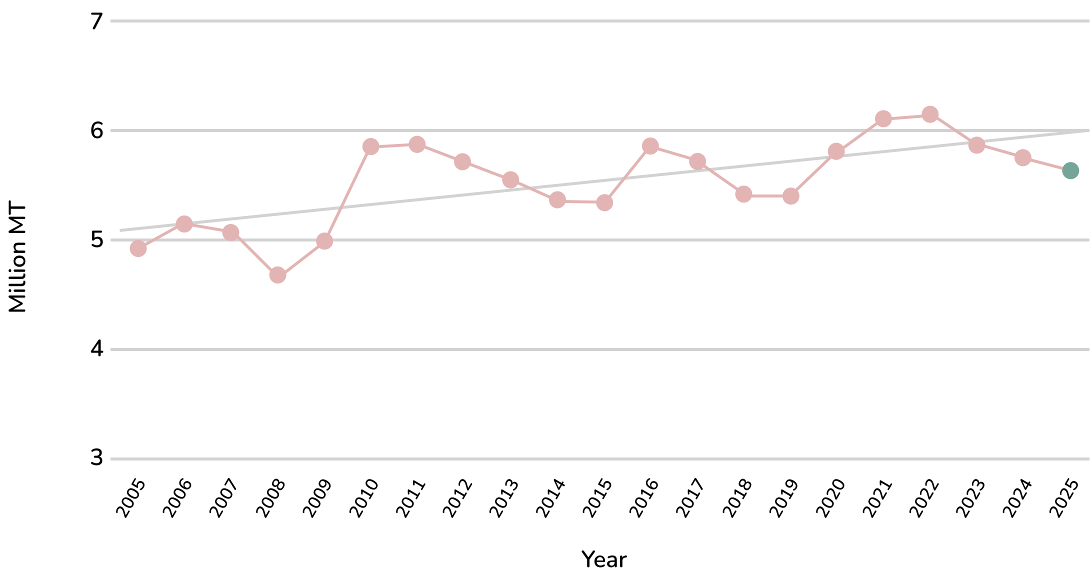
Market size

5.9 million MT of plant fibres (excluding cotton) were produced in 2023, up from 4.9 million MT in 2005.[1] For perspective, total global fibre production reached 124 million MT in 2023 dominated mainly by synthetic fibres with 67% and cotton with 19.9%.[2] These figures show that the plant fibre sector is still a comparatively small segment, shaped by current limitations in scalability, yet under the right supportive economic and regulatory conditions it has substantial growth potential.

The following statistics include data from industrially produced plant fibres (excluding cotton) as well as the emerging fibre types: pineapple leaf fibre and banana and plantain fibre (data collection started 2022). FIBRAL aims to collect and include more data on niche fibres in the coming years.

The graph illustrates the evolution of plant fibre production between 2005 and 2025 (forecast). Between 2005 and 2023, production rose steadily at an annual average rate of around 53,000 MT with year-to-year variation. In the recent past, from 2022, production started declining and is expected to be down by 8% to 5.6 million MT in 2025. This overall market decline reflects global uncertainty from inflation, geopolitical risks, increasing input costs, trade rules and supply chain disruptions, continuing to pose a challenge to trade flows and logistical

Alternative plant fibre production in million MT, 2005-2025 forecast. The figure for 2024 is preliminary, while the figure for 2025 is a forecast.



Source: Based on data from Townsend,T. (2025) and Fibral data

Industrial flax scutching, source: Alliance for European Flax-Linen & Hemp stability in the global economy at large.[1,3] In addition, climate change effects are increasingly impacting plant fibre supply due to unpredictable rain, droughts and extreme weather events like typhoons.

Global production figures conceal significant differences in trends for individual fibres. The bar chart displays the composition of the plant fibre market between 2012 and 2025. Jute, kenaf, and allied fibres consistently dominate, though their share declined from over 55% in 2012 to an estimated 49% in 2024, reflecting supply constraints and substitution effects. Coir maintains a stable share at ~20%, supported by steady demand from ropes, matting and geotextiles industries. The demand for coir pith—a by-product of the fibre production—is increasing which could drive production of coir fibre, in the future. Hemp shows robust growth, more than doubling in volume over the period, likely associated with rising demand for textile and biocomposite applications, while ramie collapses to negligible levels. Banana and plantain fibre and pineapple leaf fibre production show a steady increase from 2022, though they remain below 0.1% of the total market.

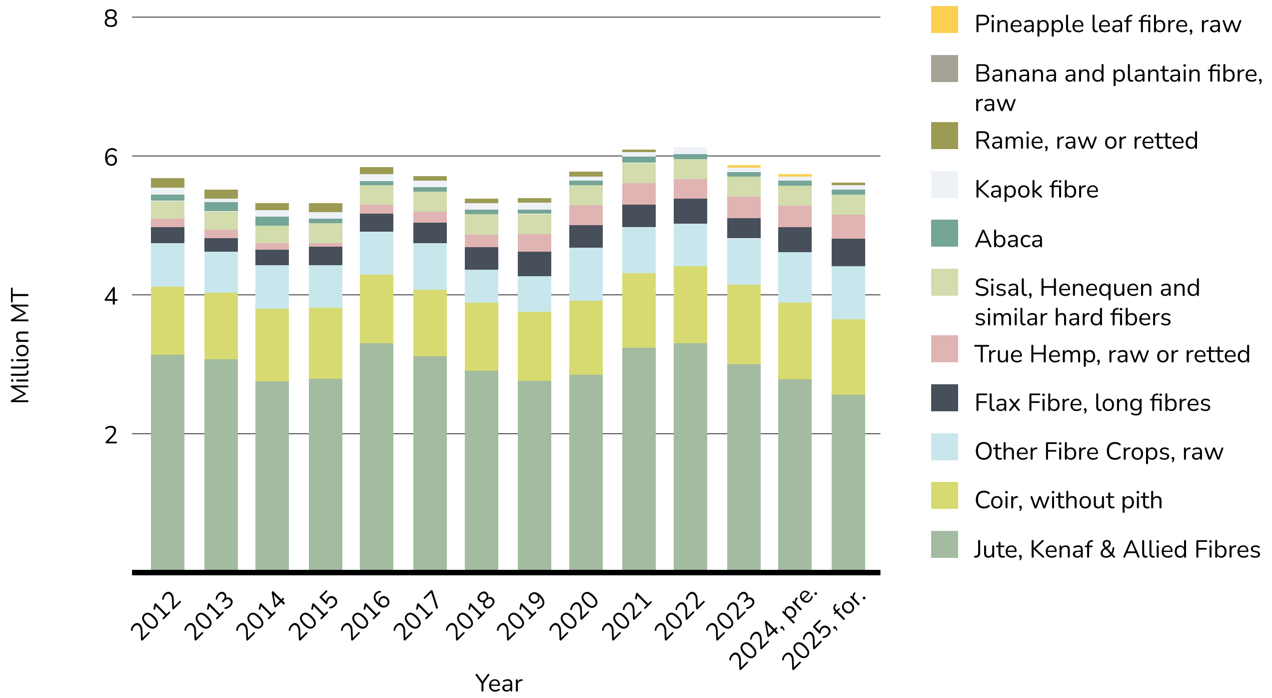
The table on the following page provides further detail on fibre production volumes since 2022. The data reveal contrasting trends: while hemp and flax (linen) show strong growth trajectories, up 22% and 8% from 2022 to 2025 respectively, traditional leaders such as jute and abacá contract sharply, falling by 22% and 26% respectively over the period. Emerging fibres, particularly banana and pineapple, expand rapidly from small bases, suggesting growing R&D efforts.

Future outlook and trends

Short-term fluctuations driven by macroeconomic conditions and environmental impacts do not necessarily reflect the long-term demand trajectory for plant fibres. If current declines are viewed as part of the normal variability observed over the past two decades, production could follow the historic trend line and reach approximately 6.6 million MT by 2035.[1] However, FIBRAL expects growth beyond business as usual.

If the industry successfully addresses today's operational and supply constraints over the next 1–5 years—and if regulatory frameworks, investment flows, and climate-resilient production systems continue to strengthen—plant fibre supply could exceed historical patterns and approach 8 million MT by 2035 – on par with man-made cellulosic fibre volumes.[1,2] These shifts would reflect not only greater production capacity, but also increasing recognition of plant fibres as strategic, low-impact materials across multiple value chains.

Distribution of alternative plant fibres in MT, 2012-2025. The figure for 2024 is preliminary, while the figure for 2025 is a forecast.



Source: Based on data from Townsend,T. (2025) and Fibral data

Industry dynamics already point in this direction. A rise in new start-ups, and expanding pre-competitive alliances is improving information sharing, cooperative R&D, market visibility, and access to investment. These developments are accelerating technological innovation and fostering greater coordination across the sector. At the fibre level, several notable trends are emerging: renewed interest in industrial hemp and flax, accompanied by new cultivation areas and large-scale processing facilities in the United States, North Korea, and parts of Europe, is reshaping production geography. At the same time, still-nascent but growing interest in fibres from pineapple leaves, banana pseudo stems, and kapok is helping diversify supply and reduce dependence on a small set of dominant crops.

Regulation will be a defining factor in the sector's long-term outlook. Stronger measures on microplastic emissions, restrictions on polyester and polypropylene in specific applications, and expanded bans on single-use plastics—particularly in the EU, Bangladesh, India, and OECD markets—could create significant new demand for plant-based alternatives. In parallel, the rising importance of corporate ESG strategies, sustainable material sourcing, and circularity commitments is likely to further influence market growth and favour renewable, lower-impact fibre options.

Production of alternative plant fibres in thousand MT, 2022-2025. The figure for 2024 is preliminary, while the figure for 2025 is a forecast.

	2022	2023	2024, pre.	2025, for.
Abaca	77	65	62	57
Coir, without pith	1,106	1,136	1,136	1,136
Other Fibre Crops, raw	607	651	690	720
Flax Fibre, long fibres	346	302	349	375
True Hemp, raw or retted	305	315	342	372
Jute, Kenaf & Allied Fibres	3,349	3,050	2,818	2,600
Kapok fibre	78	77	77	77
Ramie, raw or retted	9	9	9	9
Sisal, Henequen and similar hard fibres	276	278	270	290
Banana and plantain fibre, raw	1	2	3	4
Pineapple leaf fibre, raw	0.2	0.4	0.8	2
Total	6,154	5,885	5,757	5,642

Source: Based on data from Townsend,T. (2025) and Fibral data


Sisal harvest wagons, source: Wilhelm G. Clasen

Market value

As of 2023, the global market for plant fibres (excluding cotton) was valued at USD 3.8 billion.[1] In comparison, the overall textile fibres market (incl. natural, animal, mineral, manmade cellulosic and synthetic fibres) was valued at USD 43 billion in 2022.[4] An estimated 11.9 million households were involved in plant fibre production worldwide, the majority of them smallholder farmers in Global South countries.[1]

The table shows the global production value of plant fibres by fibre type including the number of producing households and average earnings per household per year. The data on household-level earnings reveal stark disparities across fibre types. For example, sisal-producing households earn on average USD 7,600 annually, while jute households earn less than USD 200. These differences are driven by variations in country living expenses, farm scale, productivity, and market structure.

Sisal cultivation e.g. in Africa is commercialised with higher yields per hectare and more concentrated land ownership, while jute is largely grown by millions of smallholders on fragmented plots, resulting in low per-household returns despite its large aggregate market size.

Coir is the lowest valued per kg fibre crop. As of 2024, farmers received USD 0.1 per kg. Prices paid to farmers for delivering husks to processors to produce coir is probably about one-fourth of the export price. That would mean that farmers receive the equivalent of just USD 0.05 per kg of fibre that is extracted from the coconut husks, which may explain why so few farmers are engaged in coconut husk trade.[1]

Flax producing households in Europe earn the most and producers of emerging fibres (banana & pineapple) have higher income as well, reflected by higher unit prices in the R&D phase. Such disparities highlight both the livelihood challenges in staple fibres like jute and the potential of higher-value crops to deliver more meaningful rural income streams if scalability barriers can be addressed.

Global production value by fibre type in USD, 2024. It is important to note that these figures do not reflect total annual household income. They only represent income from the production of the respective fibre, whereas households are likely to earn additional income from other fibre crops or other economic activities.

Source: Based on data from Townsend,T. (2025) and Fibral data

	2024	2024	2024	2024
	Average Price Received by Farmers	Value of Production	Producing Households	Average Earnings per Household
	USD/kg	USD Billion	Millions	USD Thousands
Abaca	1.2	0.1	0.1	0.5
Coir, without pith	0.1	0.1	0.6	0.1
Other Fibre Crops, raw	0.5	0.4	0.6	0.6
Flax Fibre, long fibres	1.5	0.5	0.01	51.8
True Hemp, raw or retted	0.4	0.1	0.2	0.8
Jute, Kenaf & Allied Fibres	0.7	2.0	10.0	0.2
Kapok fibre	2.9	0.2	0.2	1.0
Ramie, raw or retted	0.9	0.01	0.02	0.5
Sisal, Henequen and similar hard fibres	1.5	0.4	0.1	7.6
Banana and plantain fibre, raw	4.7	0.01	0.001	11.8
Pineapple leaf fibre, raw	8.9	0.01	0.0005	14.8
Total plant fibres		**3.8**	**11.8**	**8.2**

The following table summarizes indicative price ranges for all fibres. This data collection was based on a literature review and input from producers working with respective fibre types.

The data emphasize significant disparities: low-cost fibres such as kenaf (USD 0.3–0.5/kg) compete primarily on volume, while premium fibres like Himalayan nettle (USD 10–12/kg) and pineapple (USD 7–10/kg) currently are more in a niche luxury segment. Such variation underscores the fragmented nature of the plant fibre sector, where market potential depends not only on production scalability but also on consumer willingness to pay for sustainability or performance attributes. As a comparison in 2024, cotton had an average price of USD 1.5/kg, polyester USD 1-1.5/kg and glass fibre USD 3-4/kg.

Global price ranges of raw fibres in USD/kg as of 2025. The average prices refer to raw, unrefined fibres. To use materials for e.g. textile or composite applications further refining steps might be necessary adding to the price. These figures are rough estimates, as reliable data is scarce, and the small size of these markets leads to significant price fluctuations across seasons, regions, and producers.

Fibre name	Approximate producer price of raw fibre (USD/kg)	Fibre name	Approximate producer price of raw fibre (USD/kg)
Himalayan nettle	10 - 12	Sisal	1.5
Pineapple leaf fibre	7 - 10	Abaca	1.2
Palmyra palm	7.5 - 8	Ramie	0.9
Nettle	3 - 8	Jute	0.7
Banana and plantain	2.4 - 6.5	Fique	0.5
Chambira	4.5 - 5.6	Kenaf	0.3 - 0.5
Raffia	3.7 - 4.3	Oil palm	0.2 - 0.4
Common reed*	3.9 - 4.2	Coir	0.1
Cattail seed fibre	2 - 4	Cattail stem fibre	0.06
Flax (Linen)	1.5 - 3.5	Switchgrass	0.05
Kapok	2.9	Aguaje	NA
Water hyacinth	1.5 – 2	Angico	NA
Hemp	0.4 - 2	Barkcloth	NA
Henequen	1.3 - 1.9	Bombonaje	NA
Sansevieria	1.3 - 1.9	Grape vine	NA
Date palm	1.5	Milkweed	NA
Miscanthus	0.08 - 1.5	Sunflower	NA

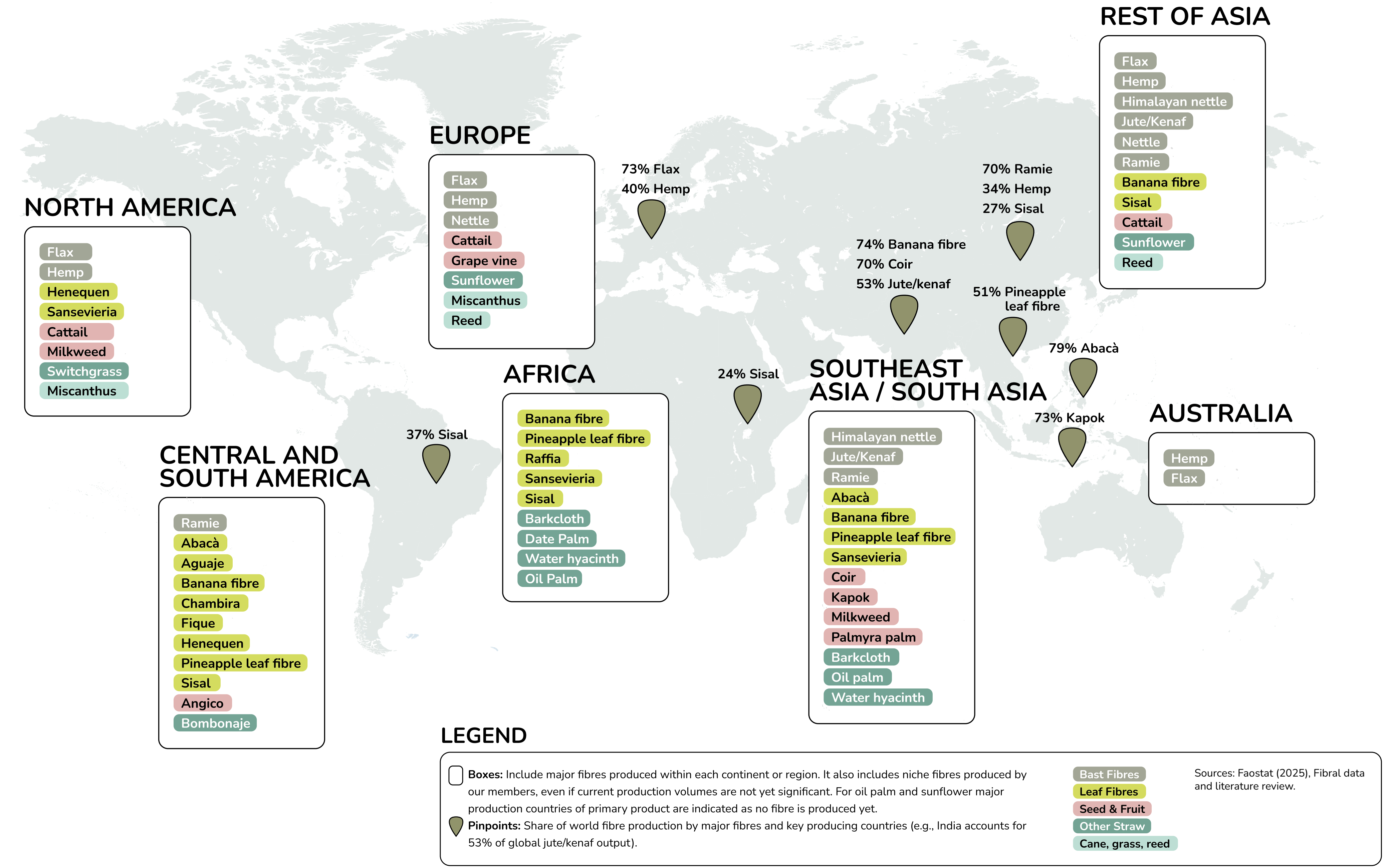
**Price per bundle, unknown how many kg per bundle*

Source: Townsend, T. (2025), Faostat (2025), Fibral data and literature review

Production landscape

Abacá decortication, Costa Rica, source: Wilhelm G. Clasen

Provenance of plant fibres



Natural fibre extraction

Plant fibres require varying levels of processing depending on their intended use and desired quality. Generally, achieving finer fibres requires more intensive refining steps. However, this does not necessarily mean that heavy machinery has to be used. High-quality fibres can also be obtained using traditional methods, whereby extraction is carried out by hand or with simple items like a broken plate.

Production systems range from small scale artisanal methods to fully mechanised facilities. Hybrid models often combine manual expertise with semi-industrial technology, preserving fibre quality while increasing throughput. While many fibres can be processed on generic machines, fibre-specific equipment often produces superior quality and a competitive advantage. Recent innovations in decortication have emerged in Spain, China, Taiwan, India, Bangladesh, and several African nations, though limited access to these technologies and IP ownership can slow wider adoption and knowledge sharing.

The box describes the common natural fibre extraction methods which will be mentioned throughout this chapter for individual fibre types.

Retting: A process that uses bacteria, moisture, or enzymes to break down cellular tissues and gums surrounding bast-fibre bundles, making it easier to separate fibres from the stem. Common methods include:

- Dew retting: stalks are spread on fields, where bacteria, sun, air, and dew ferment and degrade surrounding stem material.
- Water retting: stalks are submerged in rivers, ponds, or tanks, allowing moisture and bacteria to break down outer cells and pectin.
- Enzyme retting: modern, controlled method using pectinases and hemicellulases to dissolve binding substances faster than traditional methods.

Decortication or scutching: Mechanically strips the outer bark or non-fibrous material from plant stalks to isolate fibres. This step typically follows retting.

Cleaning: Mechanically separates raw seed fibres from seeds and other debris such as dust, leaves, and sticks.

Degumming: Removes gums and residual cellular tissues from bast or leaf fibres to soften and clean them, usually in heated water with chemicals or enzymes.

Hackling: Mechanical process for flax or hemp that separates long fibres from short and weak ones. This follows scutching.

Cottonisation: Mechanical process that shortens and combs fibres to resemble cotton, enabling them to be spun on standard cotton machinery.

Steam explosion: Exposes fibres to high-pressure, high-temperature steam followed by rapid depressurisation, breaking down fibre bundles, defibrillating them, and increasing structural porosity to make cellulose more accessible for further processing.

There is lacking standardisation for terminology in natural fibre extraction, which is why terms may be used differently by different manufacturers. Please also refer to the descriptions in the following subchapters.

This type of box will show artisanal fibre processing practices in the coming subchapters

Legend for production size indicated in this study

Lab scale: 0 - 1 MT p.a. Small scale: 1 - 10 MT p.a. Medium scale: 10 - 25 MT p.a. Industrial scale: > 25 MT p.a.

PRODUCTION LANDSCAPE

Bast fibres

Bast fibres

Bast fibres are woody-stemmed herbaceous plants, having the fibre located in the bast, between the epidermis and the woody core. Bast fibre bundles are several meters long and glued together with gums and residual cellular tissues which need to be removed to access the fibres. The fibres are strong with high tensile strength, low density, and good breathability and primarily used for ropes, twine, packaging, pulp and paper, geotextiles, composites, and increasingly for sustainable building materials. Their mechanical performance makes them also suitable for reinforcement in composites and textile applications.

The bast fibre yield per dry weight is averaging from 20-40%. That means when extracting fibres from the stalks ~ 20-40% of the weight remains as fibres. For some plants it can be lower, such as cultivated nettle (13-15%) or wild nettle (3-8%).[1]

Provenance

Bast fibres typically thrive in temperate to subtropical and tropical climates. For example, flax grows well in temperate regions like Northern Europe, while hemp is adaptable to both temperate and subtropical climates. Jute and kenaf prefer hot and humid climates such as those in South Asia, while nettle, especially the Himalayan variety, is found in cooler, high-altitude temperate zones.

Close up industrial hemp, source: Art_Pictures / Shutterstock

Jute, kenaf and allied fibres

Jute and kenaf (*Corchorus* spp., *Hibiscus cannabinus*) are long, shiny fibres mainly used to produce ropes and sacking for agricultural goods. In addition, carpets, handicrafts, composite materials, pulp & paper and construction materials are made from them.

Jute, kenaf and allied fibres grow in warm, humid climates and are predominantly produced in Bangladesh and India, where they play a vital socio-economic role. As of 2023-2024, India is the largest producer with ~ 53% and Bangladesh with 45% of world production. China, Nepal and Indonesia make up the remaining share.[2,3]

Countries with the largest production

Production process jute, kenaf and allied fibres

Jute or kenaf stems → Harvest (Hand cutting) → Water retting → Hand - stripping & washing → Drying → Raw Jute or kenaf fibre

Jute and kenaf fibre extraction relies heavily on manual labour. After hand cutting the stems, farmers immerse them in rivers or ponds for the water retting process. Followed by hand-stripping, washing and sun-drying. In India and Bangladesh this engages millions of workers.

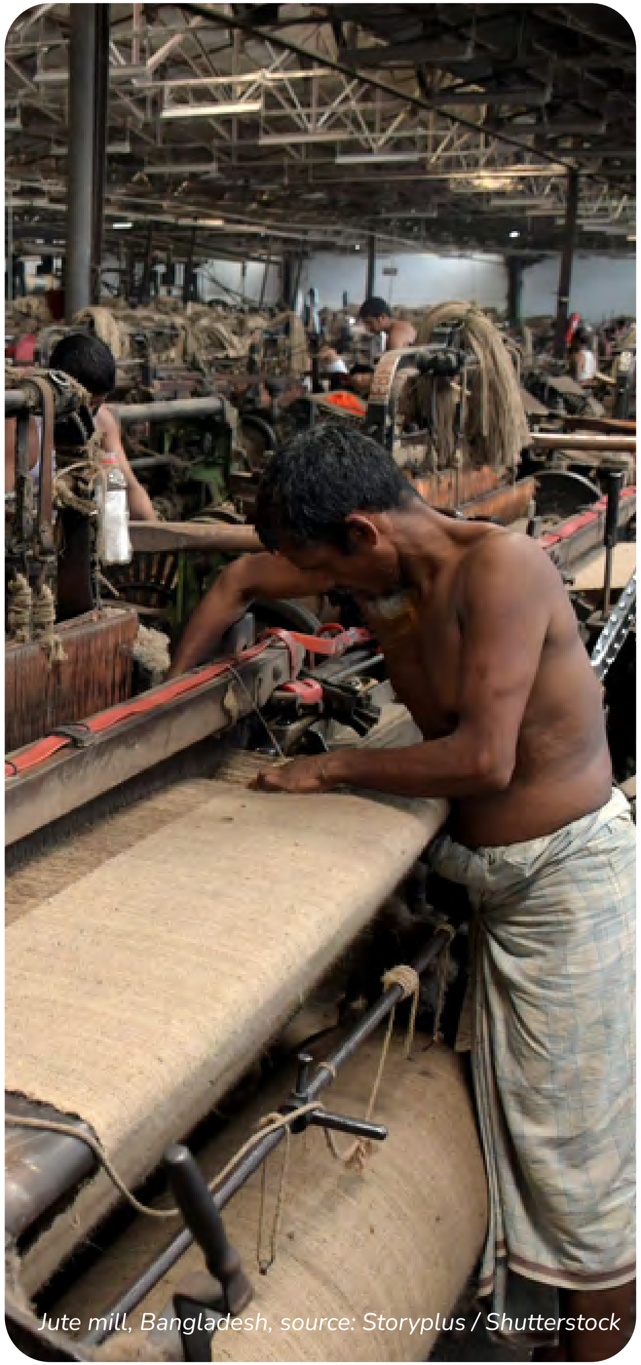
After manual extraction, jute is delivered to 38 major jute mills in India and 212 in Bangladesh.[4,5] Here fibres are processed into yarn, fabrics and other jute products through softening, carding, and spinning.[6,7] Despite its economic importance, India's jute industry remained largely stagnant over the past 100 years, still using colonial-era machinery and limited investment in modernisation.[8] By contrast, Bangladesh's privately owned mills are adopting new technologies. For example, the Akij Group began constructing the world's largest jute mill in Muksudpur, Gopalganj, in 2023. This facility, comprising six factories, is expected to process 600 MT of jute daily, or approximately 180,000 MT annually.[9]

Jute plants, source: Artyponds / Shutterstock

Key processors of jute, kenaf and allied fibres **Fibral member*

Company	Country of production
Akij Jute Mills	Bangladesh
Diamond Jute	Bangladesh
Wilhelm G. Clasen (GerBan Fibres)*	Bangladesh
Janata Jute mills ltd.	Bangladesh
Aarbur	India
Agro Native	India
Cheviot Company Limited	India
Ganges Jute Pvt.Ltd.	India
Gloster Limited	India
Kamarhatty Company Limited	India
Reliance Jute Mills	India
Sarda Group of Industries	India
Engage Resources	Thailand
Thai Kenaf Company	Thailand
Bast Fibers LLC	United States

Jute retting, source: tomaldas / Shutterstock



Jute mill, Bangladesh, source: Storyplus / Shutterstock

Flax (Linen)

Flax (*Linum usitatissimum*) is a soft, flexible, and lustrous fibre which is called "Linen" when made into a fabric. It has good breathability, dries faster than cotton but tends to wrinkle. Blending it with other cellulose-based fibres such as viscose or cotton can make it feel softer and less prone to wrinkling. Flax is primarily used in fashion, home textiles and other industrial applications, for instance composites. It is produced in Western Europe, with France and Belgium as the largest producers accounting for 73% and 9% respectively. Further producers are Belarus, China, Russia and the UK.[2]

Countries with the largest production

Production process flax

Flax fibre production begins with machine harvesting flax plants by pulling them from the ground, commonly followed by dew retting. The dried stalks are then broken to remove woody parts, scutched to clean off impurities, and hackled to produce smooth, fine fibres ready for spinning into flax yarn.[10] The results are primarily long flax fibres, which are spun using a wet spinning process, and short fibres, known as tow fibres, which are spun on ring or open-end spinning systems. Tow fibres can also be cottonised.

For scutching, 72 facilities in flax-producing countries process both long-fibre hemp and flax. European facilities are very modern with highly advanced machinery ensuring high fibre quality and consistency, with scutching lines typically processing 1,500–2,000 MT of fibre annually.[11,12]

Additional facilities in Europe specialise in long-fibre hackling and cottonising, making them versatile for both hemp and flax processing.[13]

Key processors of flax **Fibral member*

Company	Country of production
Albert Brille	Belgium, France
China Linen Textile Industry	China
Sematex	Egypt
COMLIN Cooperatives	France
Le groupe Depestele	France
SAFILIN	France
The Flax Company	France
Van de Bilt	Netherlands

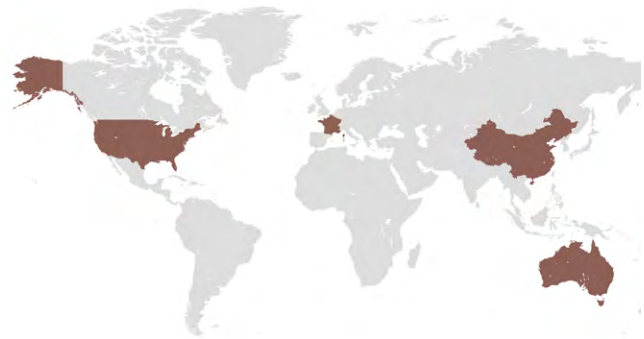
Flax field retting, source: Alliance for European Flax-Linen & Hemp

Hemp

Hemp (*Cannabis sativa*) is a versatile crop that thrives in a wide range of climates and soils, producing a diverse array of materials—including strong bast fibres, woody hurds, nutrient-rich seeds and oils, and flowers. Hemp fibre (from industrial hemp) and marijuana are produced from the same species of Cannabis sativa but from different strains. In the EU and US, the threshold for THC content is 0.3% Δ^9-THC.[14] Hemp breeds especially for high CBD content or oilseed are also increasingly used as an agricultural residue for various fibre applications. Hemp fibres are coarser than flax, making them less suitable for apparel unless they are blended with e.g. cotton. Common applications include composites, paper, insulation or denim and household textiles.

France is the world's biggest producer of hemp with ~ 40%. Followed by China with 34% and the US, North Korea, the Netherlands and Australia with ~ 4% each.[2]

Countries with the largest production



Production process hemp

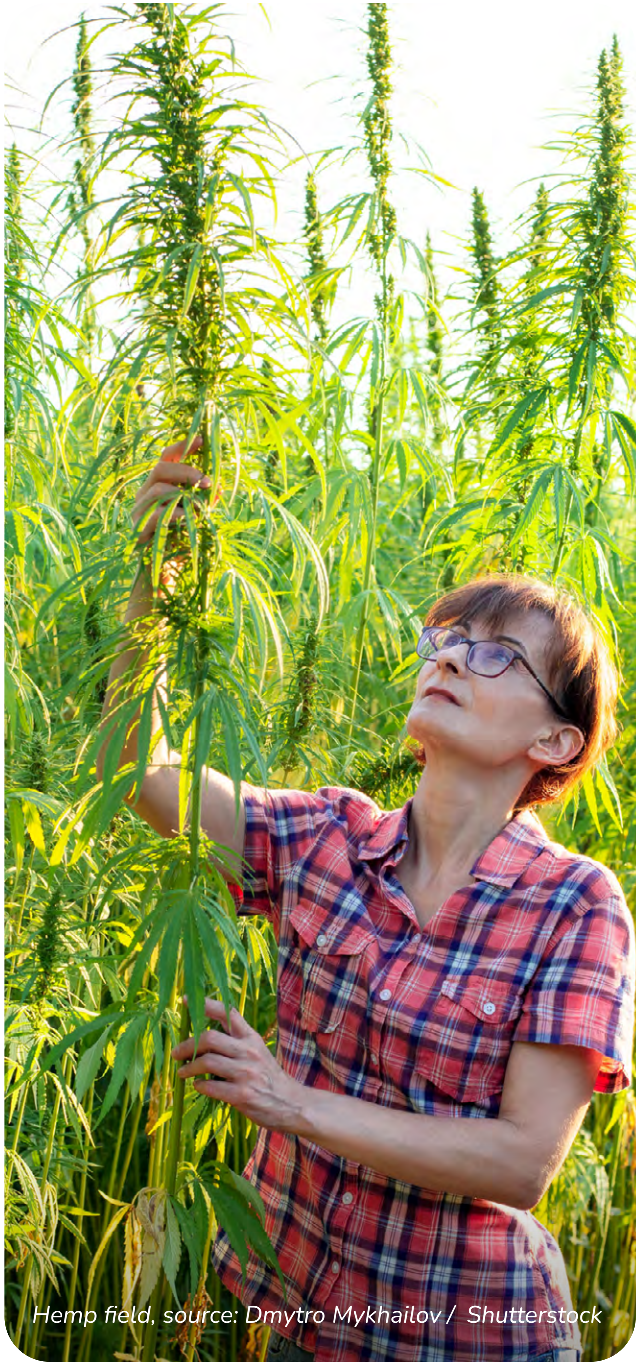
The production of hemp fibre begins with cutting the stems in the field, followed by retting— using water, dew, or enzyme methods. The next steps vary depending on the required fibre quality, length, and end use. A typical sequence for short fibres involves decortication, degumming and cottonisation resulting in short staple lengths for ring- or open-end spinning systems. Next to textiles, these fibres are ideal for construction or paper. Long hemp fibres can be obtained through common flax processing (scutching and hackling) and then be spun on wet spinning systems. As the hemp industry is growing, many refining methods are being re-developed, e.g. steam explosion.

With its long plant fibre history, France houses six of the 12 European decortication facilities dedicated to processing short-fibre hemp. There are two more in Germany and the Netherlands respectively, and one each in Romania and Lithuania. For scutching, 72 facilities in flax-producing countries process both long-fibre hemp and flax. Additional facilities in Europe specialise in long-fibre hackling and cottonising, making them versatile for both hemp and flax processing.[13]

Although hemp was widely used in China as early as 5000-6000 BC, the modern industry was only revitalized in 2010, making China one of the largest producers in the world today with the largest (and oldest) network of processing plants. The main production takes place in Heilongjiang and Yunnan provinces, but exact data is still difficult to collect. The Chinese central government is including the hemp industry in its long-term plans for major investment, indicating a likely modernisation and further expansion of the industry in the coming years.[15,16] In addition to the fibre processing capacities, 85% of the linen from Europe is spun in China.[17]

The 2018 U.S. Farm Bill marked a turning point for hemp

Hemp processing line, source: Cretes


Hemp field, source: Dmytro Mykhailov / Shutterstock

cultivation in the United States. By 2023, approximately 20 decorticators were thought to be operational, with six capable of processing three MT per hour or more. Others focus on hurd production or remain in research and development. Between 2024 and 2029, an additional eight to ten decorticators are expected to be installed, with four to six highly likely to successfully enter the market.[13] Notably, Panda Biotech, LLC launched a large scale facility in 2024 with the capacity to process 10 MT of industrial hemp per hour into textile-grade fibre, hurd, and micronised hurd.[18] This new era of hemp production in the U.S. is bringing high-tech machinery and innovation to the industry.

Key processors of hemp **Fibral member*

Company	Country of production
Circular Systems*	Belgium
Wuhai Fibers	China
La Chanvrière	France
Marmara Hemp	France
SAFILIN	France
Altmat	India
Canvaloop*	India
Natural Fiber	Lithuania
Dun Agro BV	Netherlands
HempFlax Group	Netherlands
Kombinat Konopny	Poland
Delta Agriculture	USA
Panda Biotech	USA

Artisanal practice of hemp fibre processing

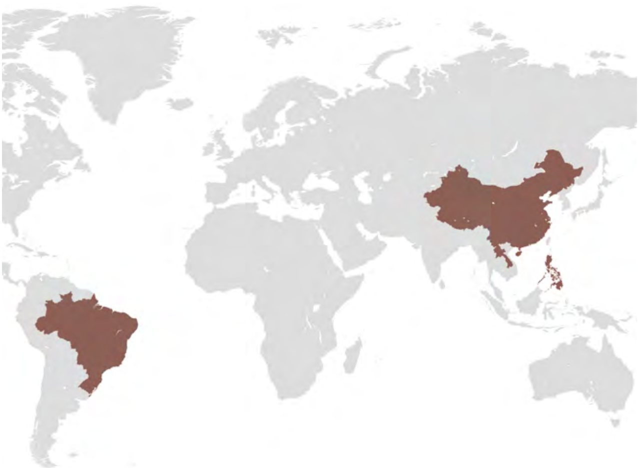
Romania, where hemp is also called “Cânepă”, has an ancestral tradition of growing and processing the plant with traditional methods. It starts with the harvest followed by water retting and breaking with simple manual tools called “Melițǎ”, the brake. For the subsequent carding process, three cards called “Piepteni” made out of wood with iron teeth are used. The fibres are then spun and the yarn bleached and softened before weaving. In the past, all textiles of daily life in Romania were made by hemp, like clothes, towels, bedding and rugs and it was regarded as a sacred plant integrated into Romanian culture and traditions. Between 1973 and 1990 Romania started to grow hemp in an industrial system and they became the fourth largest producer worldwide. Today they produce 1% of the global supply with modern machines.[19]

Ramie

Ramie (*Boehmeria* spp.) is a very strong bast fibre with low elasticity, making it rather stiff and brittle. Because spinning of the fibres is difficult, they have had limited adoption as a textile fibre. Common applications include industrial sewing thread, packing materials, fishing nets and filter cloth. Although, it is also used for home and interior textiles and furnishings.

Ramie is grown for fibre mainly in China with 70% market share. Other countries include Brazil, Laos and the Philippines.[2] The stalks are not retted in the same way as are other stem fibres such as jute, hemp, flax (linen), etc., because the pectinous substances in ramie are far more difficult to remove or break down. After harvest, the fresh, green stem's outer bark and inner core is removed during a decortication process, which is administered by hand or with a decorticating machine. In principle, any machine which is used for sisal or kenaf can be adjusted for ramie.

Countries with the largest production



Production process ramie

Ramie stems → Harvest (Hand or machine cutting) → Green decortication → Double degumming → Washing & drying → Raw ramie fibre

Decorticators developed for ramie include small mobile types suitable for use in the field and larger machines designed for central operation.[20] The ribbons, already partially separated, then undergo two degumming processes using chemicals or enzymes to remove the pectinous gums and expose the fibres. After washing and drying a cottonisation step may follow to further refine the fibres.

The high potential of ramie is not exploited in countries other than China due to technological and economic difficulties hindering efficient scaling—starting with the lacking availability and unaffordability of efficient decorticating machines for farmers. Although machines for similar fibres can be adjusted, ramie is best decorticated on machinery built for this purpose. Another hurdle is the essential degumming processes, which are perfected by the bigger mills and are treated as a trade secret. These barriers discourage farmers to invest and learn about ramie production which hampers supply of qualitative raw material.[20]

A recent milestone agreement between Ghana's Minerals Development Fund and China's Hunan Isunte Group aims to revitalise Ghana's mining regions through an USD 18 million investment in ramie cultivation and textile processing. The initiative is expected to generate 10,000 direct jobs across 15 mining districts.[21]

Ramie fibre, source: KPG_Payless / Shutterstock

Ramie processing, Japan, source: mm140 / Shutterstock

Key processors of ramie **Fibral member*

Company	Country of production
Akij Jute Mills	Bangladesh
Diamond Jute	Bangladesh
Wilhelm G. Clasen (GerBan Fibres)*	Bangladesh
Janata Jute mills ltd.	Bangladesh

Artisanal practice of ramie fibre processing

In the Hansan region in Korea, the weaving of "Mosi" (fine ramie) is registered as intangible cultural heritage under UNESCO. Weaving ramie cloth involves a number of very labour-intensive manual processes, including harvesting, boiling and bleaching ramie plants, spinning yarn out of ramie fibre, and weaving it on a traditional loom. At present, ~ 500 people are engaged in this practice. The techniques of making ramie fabric in the Uonuma region in Japan are called "Ojiya-chijimi" and Echigo-jofu and are registered as intangible cultural heritage under UNESCO as well. The labour-intensive manual process includes splitting ramie fibres from the plant with a fingernail and twisting into threads by hand. The finished fabric is bleached by the sun in the snow. Practiced today mainly by older craftspeople, the art remains a point of cultural pride and an important tool for reinforcing a sense of identity for the community.[22]

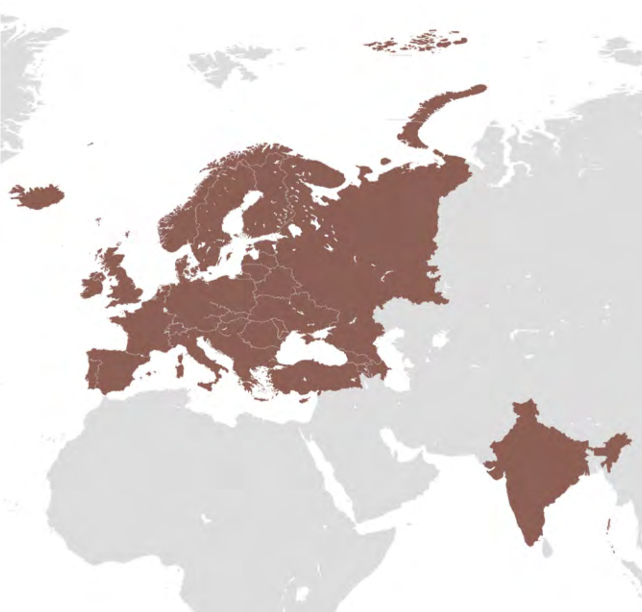
Weaving of mosi, Korea, source: Yeongsik Im / Shutterstock

Nettle and himalayan nettle

Nettle and himalayan nettle (*Urtica dioica*, *Girardinia diversifolia*) are harvested in the wild or cultivated on small scale. The fibres can be used similarly to flax and hemp but there is only some niche commercial production for textiles. Production data is non-existent.

While common nettle or also called "stinging nettle" grows across Europe and temperate Asia, Himalayan nettle is native to the Himalayan foothills of Nepal and India, typically found at elevations between 1,200–3,000 metres. These plants thrive in cool, moist climates with well-drained soils and partial shade, for instance on forest edges or terraced slopes.

Countries with the largest production



The extraction methods used for nettle are similar to those for hemp and flax (linen). As a result, the existing infrastructure for bast fibre processing in many European countries—particularly Germany—could be adapted for nettle.

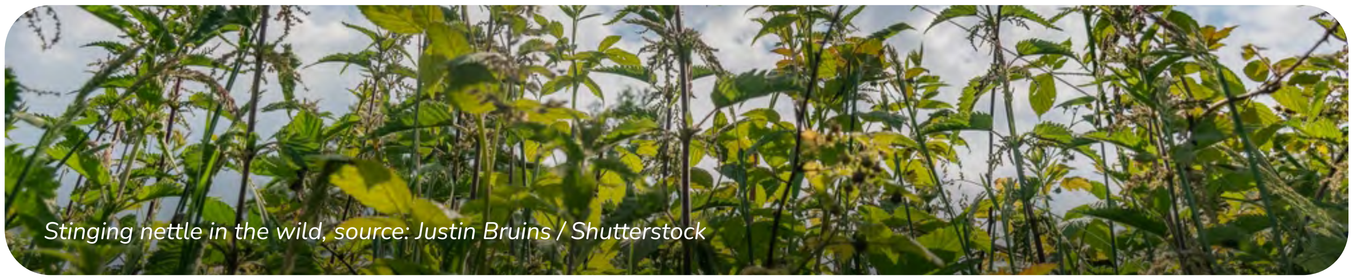
Himalayan Wild Fibers is a pioneering start up working with himalayan nettle from Nepal. Wild-harvested from mountain forests, the plant is managed through community-based forest groups that safeguard both ecological and economic interests. Harvesters cut mature stalks above ground, leaving the rhizome untouched. This approach not only sustains the plant's ability to regenerate but also strengthens root systems, improves soil stability, and supports richer forest growth. With this business the company provides access to global markets, income and support for women and marginalised groups.[23]

Key processors of jute, kenaf and allied fibres **Fibral member*

Company	Country of production
Felde Fibres	Germany
Canvaloop*	India
Gencrest*	India
Himalayan Wild Fibers*	Nepal

Artisanal practice of nettle fibre processing

Himalayan giant nettle, locally known as "Allo", grows in the Eastern to Far-Western regions of Nepal. Its range also extends to China, India, Bhutan and East Africa including Madagascar. Allo has cultural, economic and medicinal values for many communities like the Rais, Gurungs, Tamangs and Sherpas, etc. Indigenous Peoples and Local Communities utilize the fibre of this plant to make different articles for daily use such as medicine, ropes, fishing nets, coats, pants, bags, shawls, purses and many more items to sustain their livelihoods. The traditional process involves cooking the fibres to soften them, beating with a wooden hammer (mungro), washing and drying. Today, Allo products gained in economic importance which has led to higher demand and the residents of Darchula and Sankhuwasabha districts have started to harvest it more extensively.[24]



Stinging nettle in the wild, source: Justin Bruins / Shutterstock

PRODUCTION LANDSCAPE

Leaf fibres

Leaf fibres

Leaf fibres, also called “hard fibres”, are obtained from the leaves of monocotyledonous plants. They are mainly obtained from sword-shaped leaves that are thick, fleshy, and mostly hard-surfaced. The leaves are strengthened and supported by fibre bundles, often several feet long. Leaves of abacá and banana plants, where the pseudo stem is used, are an exception.[25] They tend to be coarser, stiffer, and more resilient than bast fibres, with high tensile strength, saltwater resistance, and good durability. Which makes them good for applications like cordage, ropes, carpets, floor coverings, specialty papers.

The fibres have a cellulose content ranging between 55% and 80%. However, the fleshy leaves and pseudo stems, from which the fibres are obtained, contain ~ 80-90% water which is why the fibre yield is quite low, averaging from 2% to 10%. For some extraction methods, such as hand-cleaned abacá fibres, the yield can be even lower with 1 to 1.5%. This makes high volume production of leaf fibres especially challenging.

Provenance

Leaf fibres thrive in the Global South in various climates. For instance, pineapple plants, banana and abacá are best suited to tropical and subtropical regions with high humidity and rainfall, whereas sisal and fique grow well in dry regions with hot climates.

Pineapple leafs and fibre, source: lisyl / Shutterstock

Abacá (Manila hemp)

Abacá (*Musa textilis*) is native to the Philippines. Abacá fibres are mainly used for cordage, specialty paper, e.g. tea bags, coffee filters, cigarette filters or banknotes, industrial textiles or fibre crafts and furniture. New developments include composite materials, apparel and nanomaterials.

The Philippines supply ~ 79% of the world's abacá fibre followed by the second largest producer Ecuador with 17%. The remaining volume comes from Costa Rica and Indonesia.[2,3]

Countries with the largest production

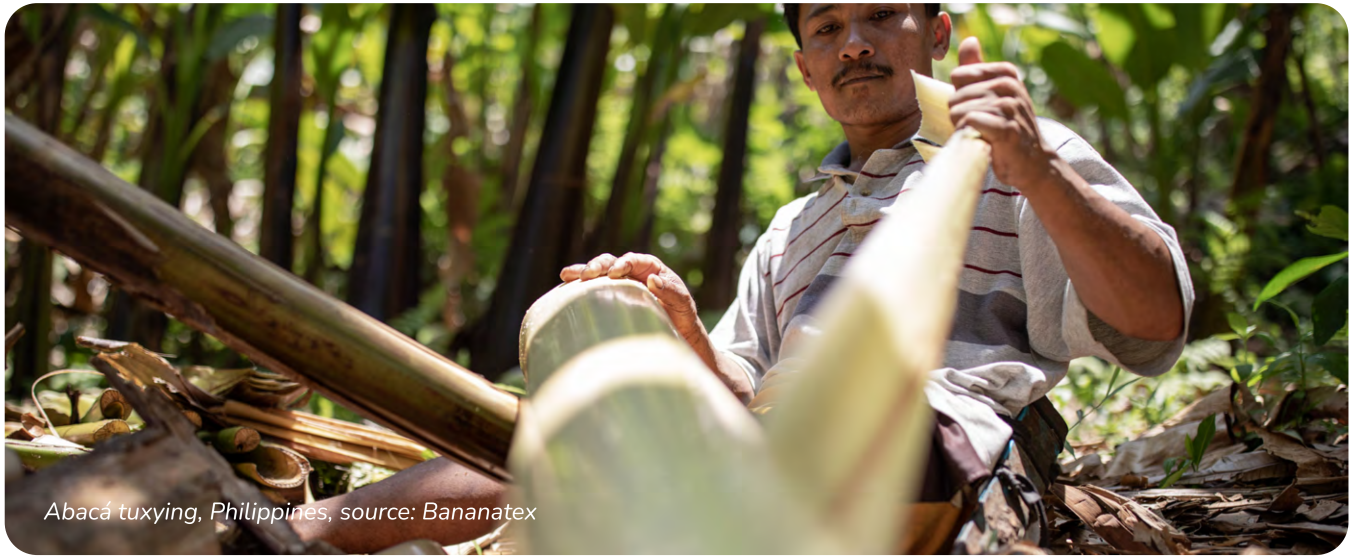
Production process abacá

Abacá pseudo stem → Harvest (Hand cutting) → Tuxying → Stripping (Manual or machine) → Washing & drying → Combing → Raw abacá fibre

The extraction process begins with manually cutting the mature plants and gathering the pseudo stems. In the following step, skilled labourers use a tuxying knife to separate the outer layer of the leafsheath called "Tuxy" from the inner layer. In the next step, the leafsheath are scraped either by a simple manual tool or semi-mechanised machines such as a decorticating machine or a spindle stripping machine. These fibres are then washed, dried in the sun, and sometimes combed to improve uniformity.

Abacá farming in the Philippines is typically done on small individual farms below 1 ha, with few cooperative-managed farms ranging from 10 to 100 ha. The farmers perform the primary extraction of fibres through either hand-cleaning with a stripping knife (92%), spindle-stripping (2%) or decortication (6%).[26] The hand stripping method yields an output of 15-25kg per day per operator, whereas a decorticating machine can produce up to 80kg per day and a spindle stripping machine 80 to 120 kg of abacá fibre per day.[27,28] Abacá fibre is being processed locally into pulp, cordage and various fibrecraft products. For instance, there are four industrial scale abacá pulp companies producing pulp for specialty papers.

In Ecuador production is mainly organised on relatively large farms, spanning around 50 ha. There is also a cooperative and otherwise small farmers. Abacá is cultivated as a principal monoculture crop.[29] Ecuador uses solely spindle-stripping machines; however, they are around 50 years old.[30] Ecuador offers highly favourable conditions for abacá production, thanks to its fertile soils and the absence of typhoons. Hence, the fibre quality, colour and consistency



Abacá tuxying, Philippines, source: Bananatex of Ecuadorian abacá are known to be higher than in the Philippines.[26]

Another producer is Costa Rica. Major pulp and paper manufacturers have repeatedly explored investment opportunities in the country, conducting trials and testing fibre samples; however, no regular large scale exports have materialised to date. Experts believe that this is due to quality differences which remain between abacá from Costa Rica and that from Ecuador and the Philippines. According to Costa Rica's Ministry of Agriculture and Livestock, the country's average yield of abacá is 1,284 kg/ha of dry fibre per year, with projections suggesting total annual production could reach 7,000 MT by 2025.[31]

Key processors of abacá **Fibral member*

Company	Country of production
Bioware Costa Rica*	Costa Rica
Angua S.A.*	Ecuador
Cooperativa abacá ecuador	Ecuador
G.m. abacá export	Ecuador
Fashion farmer*	Philippines
Specialty pulp manufacturing, Inc.	Philippines

Abacá tuxying, Ecuador, source: Wilhelm G. Clasen

Banana fibre

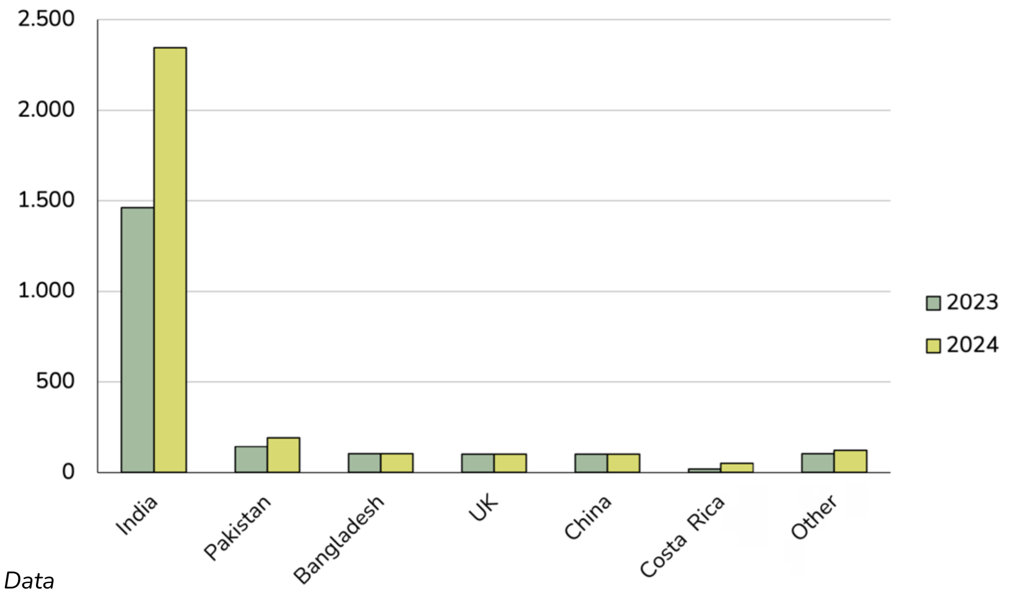
As a globally abundant agricultural crop, banana and plantain trees (*Musa sapientum*, *Musa paradisiaca*) are cut back after each harvest, leaving behind enormous amounts of organic waste that is usually left to rot or burned, producing harmful emissions. The extraction of banana fibres from these pseudo stems has only recently gained attention due to global interest in making greater use of agricultural waste. The extraction process is the same as for abacá, but the fibres are of lower quality. The fibres are used for clothing, accessories and footwear usually mixed with other cellulose fibres such as cotton or viscose (with a banana content of up to 60%).[32] They can also be used for alternative leather, hair extensions, period pads or other applications similar to abacá.

In 2023 and 2024 a total of 2,033 MT and 3,014 MT of banana and plantain fibre respectively were produced. In 2025, this is expected to increase to 4000 MT. FIBRAL identified 51 banana and plantain fibre producers.

India is the largest banana producer in the world although only a small fraction of their banana waste is currently utilised for fibre, with many initiatives struggling to scale up. In 2023 and 2024 India produced 1,500MT and 2,300MT of banana and plantain fibres respectively. Fibre cultivation and extraction is typically done by smallholders, making the supplier network difficult to map

Countries with the largest production

Global banana and plantain fibre production in MT, 2023-2024. The UK is indicated here because the reporting companies did not disclose the source of origin of raw fibres.



Source: Fibral Data

Banana fibre carpet making, source: Ziada Solutions

Banana fibre decortication, source: Ziada Solutions

or consolidate. A total of 21 banana fibre producers have been identified across small, medium, and industrial scales with likely many smaller ones being unidentified.

Farmers either manually strip stems or deliver them to local collection points with basic machinery. Experts estimate that these operations produce a maximum of 2–3 MT per month each. As demand rises, some larger producers have established machine parks with annual capacities ranging from 450 to 2,000 MT. However, the sector in India still faces significant challenges: limited investment, substandard equipment, and poor infrastructure constrain quality and scalability. With no domestic abacá industry, India lacks an established industrial base in pseudo stem fibre extraction and relies heavily on imported or newly developed machinery.[33] Despite strong production potential, these systemic weaknesses continue to limit India's competitiveness in global fibre markets.

Pakistan comes second with 143MT and 194MT banana fibre produced in 2023 and 2024. Pakistan is only a minor player in banana fruit production but has established itself as an innovative country for banana fibres. The National Textile University Faisalabad (NTU) has engaged in various projects with manufacturers to optimise the extraction of textile grade fibres from banana waste. For instance, together with Interloop, NTU developed a mechano-chemical process that refines decorticated banana fibres to the desired level of fineness and opens the fibre enough to produce a cotton hand feel.[34] Furthermore, NTU is working with Northumbria University and partners from the UK to create an innovative two-part system—the first part of which will use new technology to convert the banana waste into textile fibres, with the second part taking the waste generated from that process and using it to produce renewable energy.[35]

NTU is also involved in the Banatex EA project in Uganda, which upcycles agricultural waste from ~ 80 banana farms in the Wakiso and Mukono districts of Kampala. As part of the project, Texfad extracts raw fibres from banana

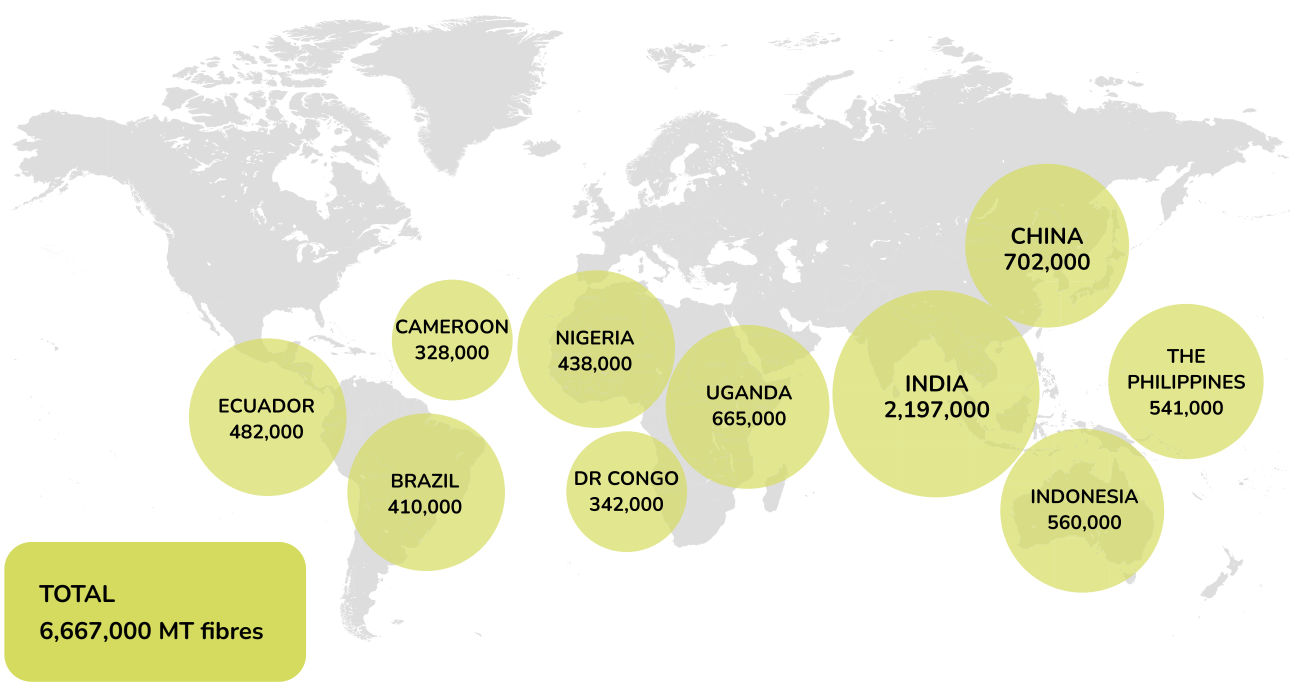
Banana fibre rope making, source: Jahangir Alam Onuchcha / Shutterstock trunks using a self-developed decortication technology and specialised fibre preparation equipment developed by NTU. The project is also exploring the possibility of providing farmers with mobile decortication units to extract the fibres themselves on their farms.[32]

Other countries such as Bangladesh, Costa Rica, Nigeria and Kenya engage in banana fibre research and production as well, but volumes remain on a smaller scale. Bangladesh produced 103MT and 104MT in 2023 and 2024. It is worth noting that Costa Rica has an estimated production capacity of ~ 300 MT per year, which it is currently not fully utilising.

Production potential

Together the top 10 banana-producing countries could produce 6.7 million MT of banana fibre per year estimated based on 2023 FAOSTAT data. This has been calculated based on 3 MT fresh stems per MT of banana fruits and 2% fibre yield.[36] India alone could make up 33% of that. The second and third largest banana fruit producers are China and Uganda. In China, we identified only two producers, which we assume operate at an industrial scale; however, no further details were available regarding the overall maturity of this industry in the country. In Uganda, the Banatex EA project was the only project identified so far. As the next largest producers Indonesia and the Philippines have not yet utilised the potential for banana fibre. Only one processor in Indonesia was identified operating on lab scale.

Production potential banana and plantain fibre in MT, 2023



Source: Food and Agriculture Organization (2025), Institute for Sustainable Communities et al. (2021)

Banana fibre, source: Ziada Solutions

Key processors of banana fibre **Fibral member*

Company	Country of production
Anis Enterprise	Bangladesh
Eco Fresh / Re-Root Tex Solution*	Bangladesh
Consulting Service International*	Bangladesh, Pakistan
Farfarm*	Brazil
Ecofitext*	Burundi
Shenyang Navigation Textile Chemical Fiber	China
Xinxiang Sunshining Ecotex Clothes	China
Bioware Costa Rica*	Costa Rica
St3ms*	Guatemala
Canvaloop Fibre*	France, Australia, India, Nepal/India
Ruratech Promotion*	Ghana
29acacia (Fiiba)*	India
Altmat	India
Anandi Enterprises	India
Champs Agro Unit	India
Dindayal Ropes India	India
Essence Fibers	India
Gagana Enterprises	India
Green Whisper*	India, France
Inlace Technical Textiles*	India
Kanha Banana	India
Mandakini Textile	India
Paco Bioteck	India
Planterra Banana Fiber*	India

Company	Country of production
Sengathali Biofiber*	India
Sp Grace Natural	India
Trunsara Business Associates	India
Velnatural fiber*	India
Gencrest*	India, France, Lithuania, Nepal/India
EW Beratung*	Indonesia/Asia
Ziada Solutions*	Kenya
Green Banana Paper	Micronesia
CraFibers	NA
Creatick Enterprises	NA
FloorTex Group	NA
Silfibres	NA
Mitimeth*	Nigeria
Alternative Fibre Solutions*	Pakistan
Interloop*	Pakistan
Natural Fiber Company*	Pakistan
Le Marche*	Pakistan, USA, Vietnam, China
Laminar Technologies*	Rwanda
Banatex EA	Uganda
Texfad*	Uganda
Abacá international	UK
Tropicanna Horticulture	UK
EcoPlanet Bamboo Group	USA

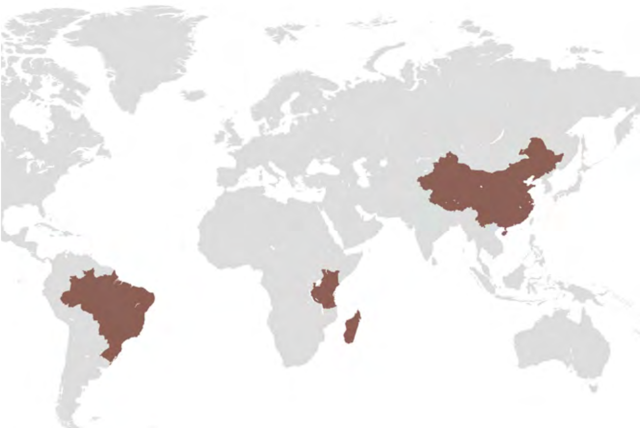
Sisal and henequen

Sisal (*Agave sisalana*) and henequen (*Agave fourcroydes*) are coarse and inflexible fibres. They can be used for paper, cordage, ropes and carpets. Sisal is the dominant fibre in the global market, while henequen is a weaker, niche fibre produced primarily in Mexico. Today, Brazil is the largest producer of sisal with 37%, followed by China with 27% and Tanzania with 24% of world production. The remaining amount is produced by Kenya and Madagascar.[2,3]

The common extraction process includes hand cutting the spiky leaves, followed by a semi-mechanised or fully automated decortication process, washing, drying and combing.

In Brazil about two-thirds of sisal farms have less than 10 ha, and only 4% cover more than 100 ha. Sisal fibre extraction is typically carried out using small, low-cost machines designed for family farms and smallholders.

Countries with the largest production



Production process sisal

Sisal leaves → Harvest (Hand cutting) → Decortication → Washing → Drying → Combing → Raw sisal fibre

These machines are portable and relatively simple, allowing farmers to process a quantity of about 15 to 20 kg/ha dry sisal fibre.[37] While this system provides an affordable and accessible option that supports rural livelihoods, fibre quality can be inconsistent, as results depend largely on operator skill and post-harvest handling.

In countries such as Tanzania and Kenya, the productive system is more advanced and characterised by large estates with a greater degree of mechanisation and more advanced agricultural techniques.[37] For instance, in Kenya 95% of sisal is grown by 10 sisal estates, and smallholder production only accounts for about 5%. Decortication is

Sisal harvest, Brazil, source: Wilhelm G. Clasen done in large continuous feed machines, called "Coronas", which need high amounts of water to wash the fibre and carry away the waste. The decorticators run most of the year to achieve an annual output of 1200-1500MT of fibre.

However, Africa has many smallholder farmers as well which use manual extraction techniques or small mobile decorticators, called "Raspador", which function similarly to the dry decorticating equipment in Brazil.[38]

Key processors of sisal **Fibral member*

Company	Country of production
Cotesi do Brasil	Brazil
East African Sisal Company	Kenya
Global Sisal Fiber	Kenya
REA Vipingo Group	Kenya
REAP Industries	Kenya
Katani Ltd.	Tanzania
SFI Tanzania	Tanzania

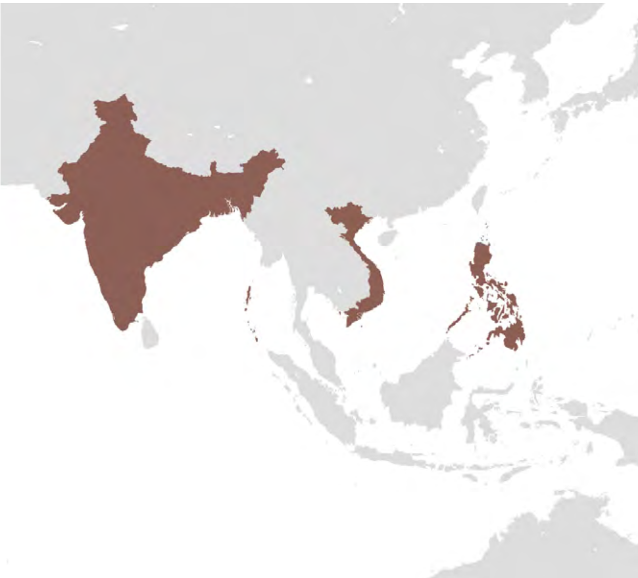
Sisal combing, Mozambique, source: Wilhelm G. Clasen

Henequen leaf harvest, Mexico, source: Leon Rafael / Shutterstock

Pineapple leaf fibre (PALF)

Around the world, pineapple leaves (*Ananas comosus*) are typically left to rot or burn after harvest, creating greenhouse gas emissions, air pollution and posing a threat to livestock grazing in the surrounding areas due to pineapple residue providing breeding ground for blood-sucking flies. Pineapple leaf fibres, also called “PALF” have gained recent attention and are used for heavier fabrics for clothing, accessories and footwear or as leather alternative. They are commonly blended with other cellulose fibres such as cotton or viscose (with a pineapple content of up to 20-30%). The art of making PALF has its origin in the Philippines, where its cultivation and production date back to the 16th century during Spanish colonisation.

Countries with the largest production



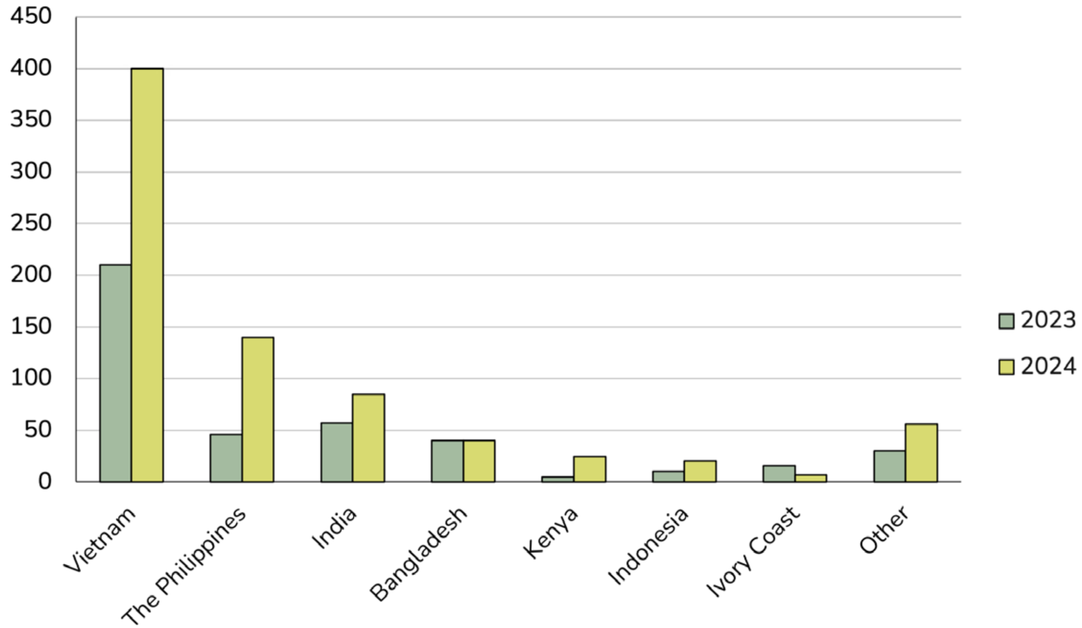
Production process pineapple leaf fibre

Worldwide production was 414 MT and 773 MT in 2023 and 2024 respectively. As global interest in the fibres grew, now Vietnam is the largest producer of pineapple leaf fibre, followed by the Philippines and India. Globally, 32 pineapple fibre producers were identified, with 22 of them being represented through FIBRAL.

Traditionally, PALF in the Philippines is obtained by stripping/scraping by hand, however today it is usually obtained using multi-fibre diesel-powered decorticating machines. After the subsequent washing and drying process, the fibre strands are broken down by a retting process or degumming. A subsequent cottonisation step further refines the fibres to make them applicable to cotton spinning equipment.

Although Vietnam itself has a relatively small pineapple fruit production volume, they now rank first as pineapple

Global pineapple leaf fibre production in MT, 2023-2024



Source: Fibral Data

leaf fibre producer worldwide, largely thanks to its strong end-to-end textile supply chain. They produced 210 MT and 400 MT in 2023 and 2024 respectively. In Vietnam commonly the same methods and machinery are used as in the Philippines. However, a few of the leading fibre producers have established industrial scale production with high-tech and more efficient machinery. In 2024, Singapore-based materials science startup, Nextevo, announced the launch of its inaugural production facility in Dong Nai province. This state-of-the-art facility transforms PALF into ready-to-spin fibre using their own efficient mechanical process for scalable production.[39] As of 2025, the company has a maximum capacity of 700 MT of fibre p.a. with one shift.[40]

In September 2024, another industrial scale producer, Ecofa, began collaborating with Bảo Lân Textile, a major yarn and fabric manufacturer. Together, they are increasing industrial scale PALF production, working closely with farmers and cooperatives across key pineapple-growing provinces in Vietnam such as Điện Biên, Ninh Bình, Thanh Hóa, Nghệ An, and Tiền Giang. Their approach uses automatic equipment lines and a closed-loop, zero-waste process.[41]

The raw leaves processed in Vietnam are sourced from all over South-East Asia, which makes it difficult to track production volumes by country. For instance, Nextevo's sourcing network spans 10 locations in Indonesia, one location in the Philippines and three locations in Thailand.[42]

While the Philippine's domestic textile infrastructure is less developed compared to Vietnam's, the Philippines compensate with strong agricultural expertise and raw material supply. They produced 46 MT in 2023 and 140 MT

Industrial facility for pineapple leaf fibre, Vietnam, source: Nextevo

in 2024. As a country with a rich plant fibre history, many local processors have gained extensive experience working with pineapple leaf waste, using both traditional hand-extraction and spinning techniques as well as mechanised extraction machinery. The Philippine Fiber Industry Development Authority (PhilFIDA), under the Department of Agriculture, plays a key role in supporting infrastructure, improving quality, and promoting standardisation in the sector.[28,43] The UK-based company Ananas Anam operates the only known large scale industrial production of PALF in the country. While no other major industrial producers have been identified, as noted, many fibre processors from other Asian countries source pineapple fibres directly from the many smallholders in the Philippines.

As of 2024, India is the sixth largest producer of pineapple fruit worldwide. The data on pineapple leaf fibre production is scarce, and not much is known about the extraction infrastructure and maturity of the market. It is assumed that they are relying on similar decorticating machinery as other Asian countries or new inventions. Seven major companies producing PALF were identified which are estimated to have a cumulative production capacity of 85 MT per year.

Another industrial scale project is set up in Kenya together with Del Monte Kenya Ltd., one of the largest pineapple producers in the country, and Mananasi Fibre Ltd. The project introduces a novel decortication technology that transforms pineapple biomass into valuable textile-grade fibres and nutrient-rich compost. By intercepting about 10% of Del Monte's pineapple waste, the project aims to produce 400kg of textile-grade fibre daily. So far, over 1,500 MT of pineapple waste have been diverted from Del Monte's fields, yielding 22 MT of textile-grade fibre and 158 MT of compost. The project has also generated employment for 85 individuals.[32]

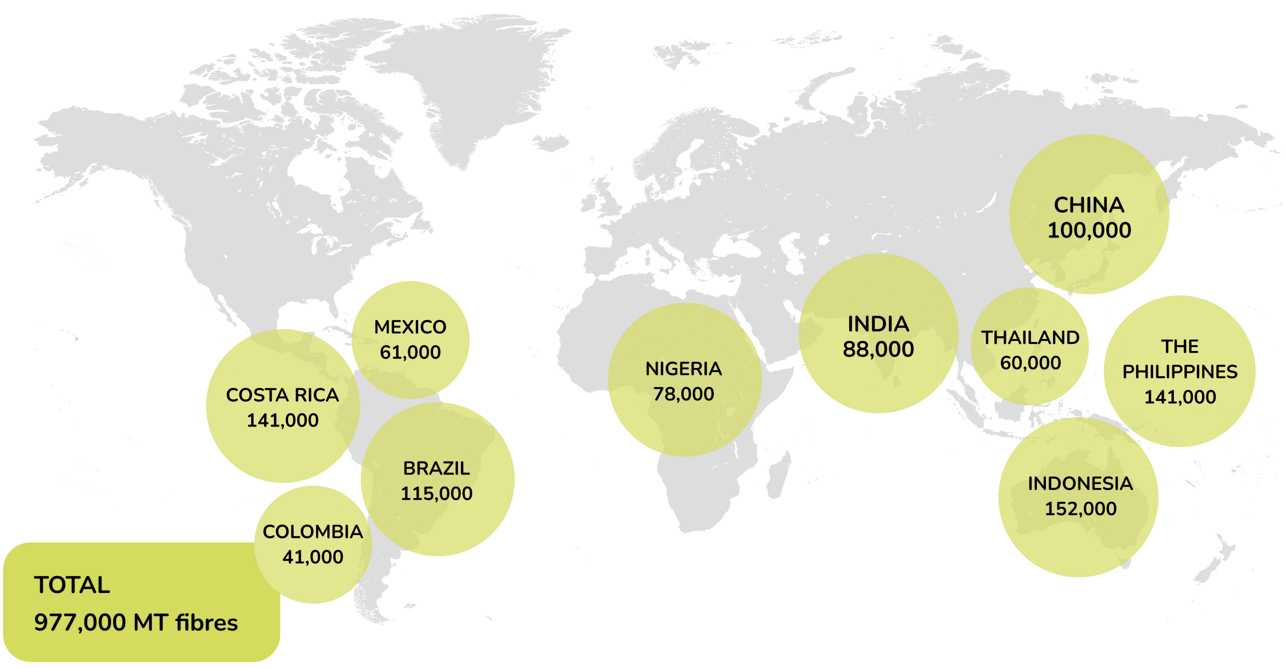
Other countries such as Bangladesh, Indonesia and Uganda engage in PALF research and production, but production volumes remain on a smaller scale.

Production potential

Collectively the top 10 pineapple-producing countries could produce nearly one million MT of PALF per year based on 2023 FAOSTAT data. This has been calculated based on 1.6 MT fresh leaves per MT of pineapples and 3% fibre yield.[36]

Indonesia is the world's largest producer of pineapples. Only two medium scale and lab scale producers that manufacture pineapple fibres were identified. Little is known about the maturity of the market, but it can be

Production potential pineapple leaf fibre in MT, 2023



Source: Food and Agriculture Organization (2025), Institute for Sustainable Communities et al. (2021)

Pineapple leaf fibre decorticator, Kenya, source: Mananasi

*Pineapple leaf fibres,
source: Jahangir Alam Onuchcha / Shutterstock*

assumed that, similar to the Philippines, many small farmers supply extracted fibres to large producers in various countries, e.g. Nextevo and Ecofa, which bring their expertise and infrastructure to the farms.

Next to the Philippines, Costa Rica is another big producer of pineapples despite the small size of the country. Four small scale producers of fibres were identified catering to textile, packaging and paper industries. In addition, several universities are conducting extensive research on the utilisation of pineapple leaf fibres for various industrial applications also with potential business partners mainly in Europe. The country has not yet succeeded to scale to commercial production mainly due to high wages, lack of investments into machinery for efficient harvesting of leaves (the pineapple plants are planted very dense which makes the harvest difficult).[44] In addition, Costa Rica's main pineapple variety (MD-2) is different from the well-researched varieties in the Philippines (Queen/Formosa, Red Spanish, Hawaiian) which gives them a drawback when it comes to research on extraction and processing techniques and product development. Lastly, Costa Rica does not have infrastructure for e.g. fabric making, which makes them dependent on neighbouring countries, mostly in South America.

Artisanal practice of pineapple fibre processing
Pineapple leaf fibres, called "Piña" in the Philippines, are traditionally used for the "Barong Tagalog", a men's shirt for festive occasions, or for wedding dresses and other traditional Philippine formal clothing. The art of piña handloom weaving in Aklan region is registered as intangible cultural heritage under UNESCO. The process starts by hand scraping the pineapple leaves with tools made from coconut shells, coconut husks or pottery shards. This is followed by knotting the piña fibres one by one to form a continuous filament. These fibres are then spun into soft, shimmering fabrics by hand. The craft continues to be practiced by skilled weavers committed to preserving this cultural heritage.[45]

Formal shirt "Barong Tagalog" made from pineapple leaf fibre, Philippines, source: Kim David / Shutterstock

Key processors of pineapple leaf fibre **Fibral member*

Company	Country of production
Eco Fresh / Re-Root Tex Solution*	Bangladesh
Consulting Service International*	Bangladesh, Pakistan
Circular Systems SPC*	Belgium
Ecofitext*	Burundi
eco:fibr*	Costa Rica
Ecosweet*	Costa Rica
Nicoverde	Costa Rica
Tropical Matter*	Costa Rica
Restalk*	France
Canvaloop Fibre*	France, Australia, India, Nepal/India
Ruratech Promotion*	Ghana
Altmat	India
Arn Enterprises	India
Chandra Prakash & Co.	India
Fiber Region	India
Gagana Enterprises	India
Vruksha Composites	India
PT. Berhasil Solidifikasi Pilar*	Indonesia
EW Beratung*	Indonesia/Asia
Econasi	Kenya
Mananasi Fibre*	Kenya
Rethread Africa*	Kenya
Pangaia*	NA
Food Reborn Co.	Okinawa, Taiwan, Indonesia
Le Marche*	Pakistan, USA, Vietnam, Philippines, China
Ananas Anam*	Philippines, Bangladesh, Ivory Coast
Natstruct*	Spain
Ukl Enterprise Co.	Taiwan
Nextevo*	Thailand, The Philippines, Indonesia
Texfad*	Uganda
Ecofa trading & production joint stock	Vietnam
Ecosoi	Vietnam
Fashion Link Joint Stock Company	Vietnam
Bnop Agriculture*	Zambia

Pineapple leaf harvest, Vietnam, source: Faslink

Fique (Cabuya)

Originally, the Indigenous Peoples of the Americas extracted and used the fique fibres (*Furcraea* spp.) to make garments, ropes, and hammocks for several centuries before the arrival of the Spanish conquerors. Large scale production of fique reached its peak in the 1950-70's with great demand for coffee bags made out of the material. Today, Colombia remains the largest fique grower in the world, with an annual production of ~ 17.400 MT of fibre, as of 2024.[46] Other large scale producers are Venezuela, Ecuador and Costa Rica. Fique is officially the national fibre of Colombia, and by law all Colombian coffee must be packaged in fique sacks.

Countries with the largest production

Production process fique

The fique plant is cultivated in 10 of Colombia's 32 departments and represents the main economic activity of around 70,000 families in the peasant economy.[47] Fique fibres are harvested by farmers on site using mobile decorticating machines with a capacity of 250-500 kg of fibres per day. Afterwards the fibres are commonly retted and cleaned to remove the remaining plant tissue and expose the fibres.[48] Farmers supply their produce to cooperatives with industrial scale machinery to perform the spinning and weaving or rope making. At an industrial level, approximately 70% of fique is used in packaging manufacturing, 15% in geotextile production, 10% in cords and ropes, and 5% in mattress manufacturing.

Countries such as Venezuela, Brazil, Ecuador and Costa Rica also traditionally produce fique fibres on a smaller scale, but data on production volumes and methods are lacking. It is assumed that they use the same manual or mechanical decorticating methods.

Key processors of fique **Fibral member*

Company	Country of production
Compañia de Empaques	Colombia
Ecofibras Curiti	Colombia
Fiquetex*	Colombia

Fique cultivation, source: Hector Ruiz/ Shutterstock

Raffia

The raffia palm (*Raphia* spp.) is native to tropical regions of Africa, especially Madagascar, but also Cameroon, Nigeria and Congo. It also occurs in Central and South America as well as the Philippines. The material is commonly used for handicrafts such as bags, hats, other fashion items, interior and furnishing.

The common production process is entirely manual. Only the leaves of the raffia palm are collected, leaving the palms intact. The harvested leaves are sun-dried before being stripped into fibres. These fibres are then bundled and woven into various forms, depending on their intended use. The process is labour-intensive, requiring skilled artisans. In some areas, the introduction of modern machinery and technology has enhanced production processes, enabling larger scale manufacturing and commercialisation of raffia products.

Countries with the largest production

Production process raffia

Raffia leaf → Harvest (Hand Pruning) → Drying → Manual stripping → Raw raffia fibre

Artisanal practice of raffia processing

Raffia has a rich history deeply rooted in the cultural heritage of many Indigenous Peoples, two of which are the Ibibio and Annang ethnic groups in the Akwa Ibom State in Nigeria. Its utilisation in this area dates back centuries, playing a significant role in the socio-economic fabric of the community. The growth and development of the raffia industry in Akwa Ibom State have been influenced by both traditional practices and modern advancements. Over time, artisans and craftsmen have honed their skills, passing down techniques for generations.[49]

Key processors of raffia **Fibral member*

Company	Country of production
IBELIV	Madagascar
Tropical Island Products Ltd.	Madagascar

Raffia palm leaves, source: Ella Doroshchenko / Shutterstock

Other leaf fibres

Henequen (*Agave fourcroydes*) belongs to the agave family but is only native to the state of Yucatán in Mexico. Its production reached its peak in the 20th century when it played a vital role in the international textile industry with 160,000 MT produced in 1960. At that time, it was called the "Green Gold" of Yucatan. The leading producer, Cordemex company, operated a huge processing plant equipped with cutting-edge automated technology for its time. The plant was closed 1990 due to deteriorating demand with the invention of synthetic fibres. Today it is estimated that less than 5,000 MT per year are produced.[50,51] The fibre is also produced in other Central American countries such as Guatemala, with similar methods to sisal.

Chambira fibre (Tucum) (*Astrocaryum chambira*) comes from the chambira palm, which is integral to the economy of the Bora, Indigenous Peoples living in the Peruvian, Colombian, and Brazilian Amazon. For centuries, the Bora and other Indigenous Peoples in the region have been extracting the fibres and twisting them into strings to produce woven hammocks, bags, and nets. The chambira fibre is an essential component of Indigenous identity and, more recently, of economic prosperity. The Bora people started to expand production to sell handicrafts to tourists. Recently, the fibre also gained international interest through the company Neofibers, a Peruvian start up combining the traditional extraction of fibres with innovative refining processes to obtain fine textile grade fibres for the fashion industry.[52,53] The exact production process is unknown.

Aguaje fibre (*Mauritia flexuosa*) stems from the aguaje palm. Its fruit is a staple food for local communities in the Amazon. In Peru, the residual fibres which can be obtained from the outer skin of the young leaves have not been used traditionally but were thrown away. Recently started initiatives by, for instance, Petroperu Selva Refinery and Neofibers, are teaching fibre extraction techniques to local communities of the Amazon River to produce handicrafts which can enrich their local economy. Here as well, the production process is unknown.

Sansevieria fibre (*Sansevieria* spp.) is extracted from the sansevieria plant which is native to Sri Lanka but occurs throughout the tropics and subtropics across the world. It is a well-known ornamental species as a house plant. In the Yucatan Peninsula in Mexico, especially in the community of Euan, Mayan people have been making hammocks from this fibre for almost 35 years.[54] The production process is unknown but likely similar to sisal.

Countries with the largest production

Key processors of other leaf fibres **Fibral member*

Fibre Type	Company	Country of production
Sansevieria	Angela Damman	Mexico
Henequen	Manufacturas de Henequén de Yucatán	Mexico
Aguaje / Chambira (Tucum)	Neofiber*	Peru

Chambira palm leaves, source: Dr Morley Read / Shutterstock

PRODUCTION LANDSCAPE

Seed & fruit fibres

Seed & fruit fibres

Seed and fruit fibres are derived from the outer coverings or seed hairs of certain plants, primarily dicotyledons. Seed fibres are soft, fluffy and lightweight and serve as dispersal structures whereas fruit fibres are commonly hard fibres and serve a protective function.

With their lightweight, water-repellent and naturally antimicrobial properties, seed fibres are mainly used in textiles, stuffing materials (pillows, cushions), insulation, padding, and certain nonwovens. Fruit fibres on the other hand are strong, coarse, highly abrasion-resistant fibres which are used for ropes, mats, brushes and mattresses.

Coconut husk, source: Seraj Mahmoud / Shutterstock

Cellulose content and fibre yield differ between fibre types; for example, kapok fibres contain approximately 35–64% cellulose, depending on species and growing conditions. In contrast, fruit fibres such as coir tend to have a lower cellulose content, typically around 36–43%,[1] due to their higher lignin and hemicellulose content, which contributes to their coarser texture and rigidity. In terms of extraction yield, coconut husks typically yield about 56–65% long fibres (bristle fibres) and 5–8% short fibres (mattress fibres).[55] When cleaning kapok fibres, only 1-6% of residues are disposed of, which leaves a fibre yield of 94-99%.[56]

Provenance

Seed and fruit fibres are predominantly produced in the Global South, where tropical climate conditions support their parent plants. On the other hand, cattail, also a seed fibre, thrives in the Global North in temperate terrain. Depending on the species, the seed fibre milkweed, can be adapted to temperate climates in Canada and the US, or to hot, dry conditions in India.

Coconut fibre (Coir)

Coir fibres (*Cocos nucifera*) originate from the husk of the coconut. The fibres are residue streams from the food industry that produces coconut milk, butter and oils. In addition, during fibre extraction a by-product called “Coir pith” or “Coco peat” is produced which is marketed as a peat substitute for horticulture as a growing medium. Coir counts towards the hard fibres and is mainly used for mats, ropes, carpets or home textiles.

While coconut palms are widespread across tropical regions globally, India dominates the commercial production of coir with 70% market share. Other countries include Sri Lanka, Vietnam and Thailand.[3] Despite coconuts being primarily cultivated for their food value, according to the Coir Board of India, only 4% of the farmers producing coconuts are engaged in coconut husk trade and coir production.[57]

Countries with the largest production

Production process coir (coconut fibre)

The common production process starts with hand picking coconuts either from the ground or from palms directly. The coconut is then impaled on a steel-tipped spike to split the husk. A skilled husker can manually split and peel about 500 coconuts per day.[58] Modern husking machines can process 2,000 coconuts per hour. The pulp layer is easily peeled off. Subsequently the husks are retted. Freshwater retting is used for fully ripe coconut husks, and saltwater retting for green husks. Fully ripe husks give brown coir fibre and green husks white fibres, which are softer. Both retting processes can take between 6-10 months, however, quicker methods including enzymes or extra mechanical methods have been developed to shorten the time. Traditionally, workers beat the retted pulp with wooden mallets to separate the fibres from the pith and the outer skin. In recent years, motorised defibring machines (hammermills) have been developed. White fibres are easier to separate than brown fibres.

Coconut cultivation in India has a long history and is predominantly practiced in states like Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, and Maharashtra. The production systems are largely traditional and smallholder-based, with farmers relying on age-old

Coir drying, source: xuanhuongho / Shutterstock

Coir production, source: Elen Marlen / Shutterstock

agronomic practices passed down through generations.

Mechanisation in Indian coconut farming and coir production remains limited compared to other agricultural sectors. Most processes, including harvesting, husking, and fibre extraction, are manually intensive. While some mechanised tools such as husking machines and fibre decorticators have been introduced, their adoption is restricted by high costs and fragmented landholdings. Efforts to improve mechanisation aim at increasing efficiency and reducing labour dependence, especially in coconut husk processing for coir fibre production. However, full mechanisation is still in progress, with ongoing research and development to tailor machines suitable for small scale farmers.[57]

Key processors of coir **Fibral member*

Company	Country of production
Coconut Products Impex	India
Geewin Exim	India
Kumaran Fibres	India
SR Coir	India
Fortuna Cools*	Philippines
Ceylon Coir Fibre Industries (Pvt) Ltd	Sri Lanka
Ceylon Coir Product	Sri Lanka
Hayleys Fiber	Sri Lanka
Tropicoco Vietnam	Vietnam

Coir matt making, source: Tuleyhcm / Shutterstock

Kapok

Kapok (*Ceiba pentandra*) is a smooth, twist-less and hollow fibre and its surface is covered with a layer of wax, which makes it hydrophobic. It has excellent thermal and acoustic insulating properties and is used for stuffing or non-woven products but can also be spun into yarn.

The kapok tree mostly grows wild and is native to tropical America, tropical Africa, and the East Indies. Kapok fibre production is currently dominated by Indonesia with 73% and Thailand with 27%.[2] There is also production in India.

Countries with the largest production

Production process kapok

Kapok seed pods → Harvest (Hand picking) → Open pods → Cleaning → Drying → Raw kapok fibre

The pods from the kapok tree are firstly hand-picked and the ripe pods are sun-dried for 2–3 days to loosen. Commonly, the pods are cracked, and the fibres are extracted through a manual process. Fibres are then separated from the seeds using baskets or sieve-like drums, where stirring causes seeds and debris to settle, leaving the clean fibres. Fibres are sun-dried for 3–5 hours to remove residual moisture, preventing mold and ensuring quality.[59]

Over the past decade, the company Flocus has made the greatest strides in the kapok industry. They operate a fully automated kapok processing facility with patented technology in Indonesia and plan to expand to India in the coming years. Flocus have built a vertically integrated and industrialised supply chain for kapok fibre providing certified fibres, yarns, fabrics, and nonwovens used in fashion, home and technical applications.[60]

In conjunction with that, they founded the Kapok Regenerative Agriculture Forestry (KRAF), a non-profit foundation that operates nurseries across Indonesia where kapok seedlings are cultivated and then gifted to local communities and farmers.[61] Flocus, in collaboration with KRAF, has pioneered the first safe harvesting technique in the kapok industry. Through dedicated training and the use of specialised gear, they have established a standardised, secure, and ethical method for collecting kapok — a practice that had never existed before.[62]

Kapok seed pod, source: Subroto Indonesia / Shutterstock

Key processors of kapok **Fibral member*

Company	Country of production
Agro Native	India
Agro Raya	Indonesia
Albioest Intiberkah Madani	Indonesia
Candra Kapok Factory	Indonesia
PT Randu World Hub by Flocus	Indonesia
PT Kapok Fiber Indonesia	Indonesia
Randu Indo Prima	Indonesia
Thaipure Kapok	Thailand

Industrial kapok production facility, source: PT Randu World Hub by Flocus

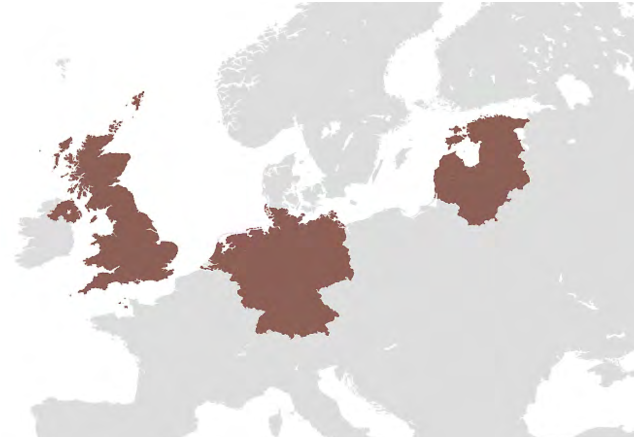

Save kapok harvesting method, source: PT Randu World Hub by Flocus

Cattail fibre

Cattail (*Thypha* spp.) gives fluffy and light weight seed fibres from the brown tube-shaped seed head. In addition, technical fibres can be obtained from the stem.* Comparable to kapok, cattail fibres have hydrophobic characteristics (they do not absorb water) and excellent thermal insulation properties. They are currently used for stuffing in apparel and home textiles.[63]

Cattail is a wetland species which thrives in temperate and boreal climates with shallow, slow-moving or standing freshwater. They are spread all over the Northern hemisphere. Though traditionally harvested in the wild, they are now being explored by universities and innovators for cultivated use in rewetting projects, where they contribute to land restoration, water retention, and carbon emission reduction while yielding fibres.

Countries with the largest production



**Due to the limited production and information about cattail stem fibres, they are not separately listed in the chapter "Other straw & stem fibres".*

Production process cattail

Cattail seed heads → Harvest (Hand or machine picking) → Open seed heads → Cleaning → Drying → Raw cattail fibre

The production process of cattail includes manual or mechanised harvest of the seed heads. This is followed by opening the heads, extracting the fibres and cleaning them. Lastly, they are dried.[64]

For the European Union, it is estimated that around 240 MT are grown on 20 ha. Mostly still on a research stage, these areas can be found in the UK, Germany, the Netherlands and the Baltic states.[65,66] Events such as the International Conference on the Utilisation of Wetland Plants shows the increasing interest in this material.

A pioneer in cattail fibre production is the company Ponda from the UK. They currently produce 2-5 MT/year. On a commercial scale they offer cattail fibres as stuffing for winter jackets and home textiles. Beyond that, they are exploring the use of the cattail stem fibres for pulp and composites etc.[64]

Key processors of cattail **Fibral member*

Company	Country of production
Greifswald Mire Centre	Germany
Ponda*	UK

Cattail plants, source: Bahammou1 / Shutterstock

Milkweed fibre

Milkweed fibre is extracted from the small seed pods of a wild shrub. They are lightweight, hollow, and water-repellent natural fibres with characteristics similar to kapok. In addition, technical fibres can be obtained from the stem.* Depending on the species, it commonly grows wild in temperate climates of North America (*Asclepias* spp.) or dry, arid regions of India (*Calotropis* spp.), thriving on marginal or degraded land with minimal inputs.

There is no information available about the production process, but it is assumed that this is similar to kapok fibre extraction. It is also unknown how much volume is produced.

A pioneer in milkweed fibre production is the company Faborg from India. They are using the Asian milkweed variety and are utilising both the seed fibres and stem fibres for their textile products. Their fibres are blended with organic cotton and spun into yarn for wovens and knits.[67]

Countries with the largest production

Key processors of milkweed **Fibral member*

Company	Country of production
Vegeto	Canada
Faborg*	India

Milkweed plants, source: wirestock on Freepik

**Due to the limited production and information about cattail stem fibres, they are not separately listed in the chapter "Other straw & stem fibres".*

Other seed & fruit fibres

Angico fibre* (*Anadenanthera colubrina*) stems from the angico tree–a species used in reforestation projects of riparian forests and found in different Brazilian biomes. The material derived from the tree is not a plant fibre in the general sense. The fruit pods are ground into a powder and utilised to create a biopolymer which is paired with additional natural polymers to form a vegan leather material. We decided to include this material within our scope as an exception.

Grape vine* (*Vitis vinifera*) is another example of a non-generic plant fibre within the scope of FIBRAL. The by-products from the wine industry in France (i.e. seeds, skins and the stalks) for instance from varieties like Grenache, Syrah, Cabernet Sauvignon and Cinsault, are used to create a vegan leather material. The residues are ground into a powder and transformed through a biopolymer process.

Palmyra palm fibre (*Borassus flabellifer*) is a coarse, durable natural fibre extracted mainly from the leaf stalks and fruit husks of the palm tree. Commonly found in South and Southeast Asia, especially India, Sri Lanka, Thailand and Bangladesh, the palmyra palm thrives in dry, arid climates and is valued for its resilience and low maintenance needs. The fibres are traditionally used in brooms, brushes, ropes, mats, and handicrafts, with growing interest in textile and other industrial applications.

**Angico and grapevine fibres sit at the edge of Fibral's defined scope, as their production processes involve biosynthetic steps rather than natural fibre extraction. However, the raw materials used closely align with Fibral's principles of renewable inputs, low-impact processing, and support for diversified bio-based materials. We therefore chose to include them, reflecting Fibral's openness to encompassing a broader range of processing methods that contribute to a sustainable and regenerative plant-based materials ecosystem.*

Countries with the largest production

Key processors of other seed & fruit fibres **Fibral member*

Fibre Type	Company	Country of production
Angico	Mabe bio*	Brazil
Grape vine	Planet of the Grapes*	France
Palmyra Palm EFB	Enn Panai*	India
Oil Palm EFB	Nextgreen global berhad	Malaysia

Palmyra palm fibre drying, source: Enn Panai

PRODUCTION LANDSCAPE

Other straw & stem fibres and cane, grass, reed

Other straw & stem fibres and cane, grass, reed

This section cumulates all other plant fibres derived from other types of stems and straw as well as cane, grass and reed. These fibres cannot directly be classified as a bast or fruit fibre but originate from stems, stalks and other agricultural residues.

Like bast and fruit fibres, the obtained fibres are strong, coarse and durable and applied for e.g. furniture, home textiles, wall coverings, construction and durable textile applications.

Provenance

This section shows a mix of fibres thriving in tropical regions such as barkcloth, bombonaje and water hyacinth and temperate climates for e.g. reed, miscanthus and sunflower.

Water hyacinth harvest, source: Fajar Kurniawan / Shutterstock

Water hyacinth fibre

Water hyacinth (*Pontederia crassipes*) is a fast-growing aquatic plant native to the Amazon Basin but now widespread in tropical and subtropical regions, thriving in warm, nutrient-rich freshwater environments such as lakes, rivers, and ponds. It is considered invasive because it spreads rapidly, forming dense mats that block waterways, disrupt transport and livelihoods, degrade water quality, foster disease-carrying pests, and outcompete native aquatic life. An option to overcome the pollution, water hyacinth can be harvested and used as fibres for interior, furnishings and home textiles. The main countries this is done are Nigeria, India, Thailand and Vietnam.

Countries with the largest production

Production process water hyacinth

Water hyacinth stems → Harvest (Cutting) → Drying → Cleaning from termites → Decortication → Retting / Washing & drying → Raw water hyacinth fibre

Depending on the end use there are different ways to process water hyacinth fibres. Typically, water hyacinth stems are cut close to the root, the leaves are removed and then dried in the sun. After the dried water hyacinth fibres are treated for termites, they are ready for basket weaving.[68] If they are aimed for textile applications, the plant's petioles are decorticated by manual or mechanical means, sometimes following a retting process, then cleaned and dried for use.

Although water hyacinth is already a million-dollar business for interiors and furnishings,[68] there is very little information and data available on its production volume and use for higher value applications such as textiles.

Mitimeth is a pioneering Nigerian company in this field transforming an environmental challenge into opportunity. By developing innovative applications for water hyacinth, the company partners with artisans in the Sabo and Ojurin, Bodija communities of Ibadan—many of whom are women and youth. Together, they craft unique home textiles, interior décor, and furnishing products while also advancing research into extraction technologies that enable the production of finer textiles. Mitimeth's work not only promotes sustainable design but empowers local communities, especially women, through skills development and income generation.[69]

Farmer harvesting water hyacinth, Indonesia, source: Verena Butet Hanis / Shutterstock

Key processors of water hyacinth fibres **Fibral member*

Company	Country of production
In-Between International	Netherlands
MitiMeth*	Nigeria
AtlGlobal	Vietnam
Phu Hao International	Vietnam
Viet Delta Co	Vietnam

Water hyacinth storage, source: Mitimeth


Water hyacinth handicraft, source: Mitimeth

Date palm residue fibre

Date palm (*Phoenix spp.*) pruning generates residues such as leaflets, spadix stems, leaf sheaths and midribs. These materials occur in significant volumes during seasonal maintenance and are often underutilised, with portions burned or landfilled in some regions. Improved collection and processing practices can help reduce air pollution and waste accumulation while supporting local industries, creating rural employment opportunities, and encouraging circular use of agricultural by-products. Several studies have highlighted the potential of these lignocellulosic residues as feedstock for natural fibres suitable for applications such as insulation materials, composites and certain textile uses.

Countries with the largest production

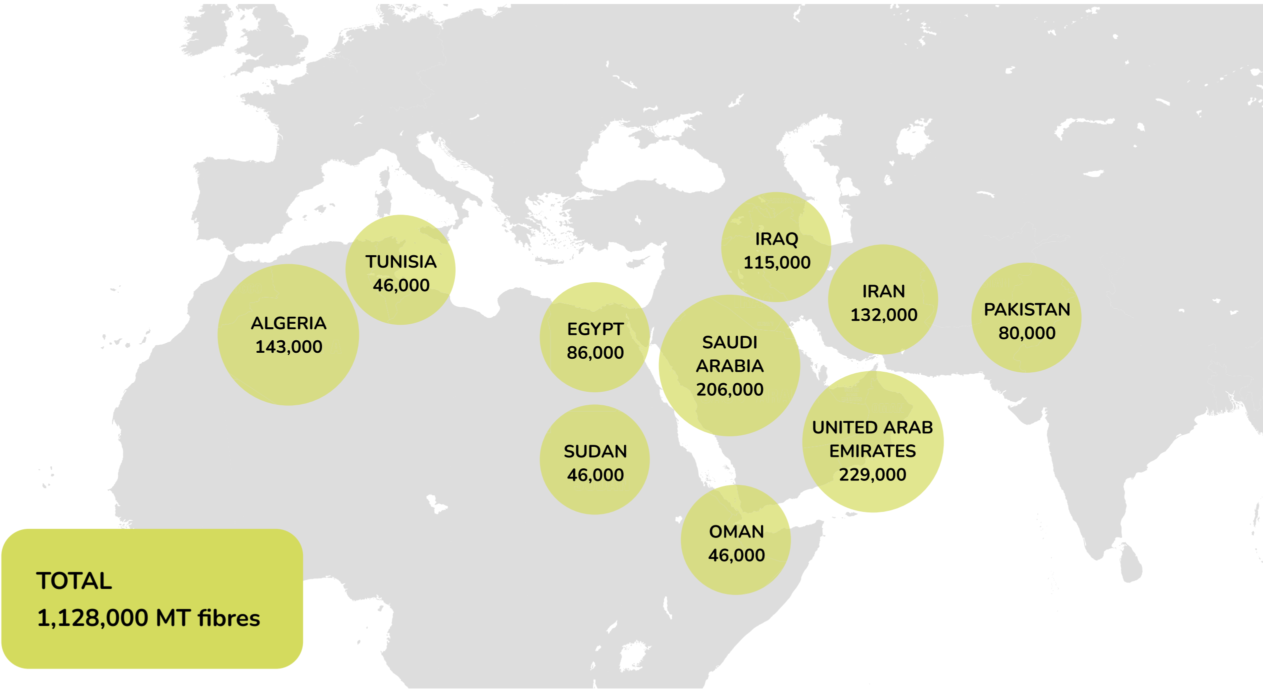
Processing pathways for date palm residues are still evolving and are generally assumed to draw on methods used for other leaf-based fibres, including mechanical decortication and fibre separation techniques. Despite growing research interest, date palm fibre remains an emerging material with limited industrial adoption, and most initiatives are currently at experimental or pilot stages. Ongoing academic and industry research continues to explore viable processing approaches and end-use applications across different sectors.

As shown on the next page, collectively the top ten date-producing countries could theoretically generate 1.1 million MT of date palm fibres per year based on 2023 FAO data and indicative residue estimates. Although countries such as the United Arab Emirates and Saudi Arabia lead in date palm cultivation, publicly documented research and pilot initiatives related to fibre extraction appear more dispersed, with activity emerging in several producing regions.

Date palm residues and fibres. Photo adapted from Midani et al. (2021).

Date palms, source: Androlia / Shutterstock

Production potential date palm fibre in MT, 2023



Source: Abdelouahhab, Piesik (2024), El-Mously et al. (2023).

Key processors of date palm residue fibres

Company	Country of production
Valorizen (PalmFil)	Egypt

Barkcloth

Barkcloth is a natural material crafted by hand from the inner bark of the mutuba fig trees (*Broussonetia papyrifera*) —predominantly sourced from Uganda—but also produced in Uganda, Indonesia and DR Congo.

After carefully stripping the bark, the rough outer layer is removed, leaving the soft inner bark. This is soaked in water to make it pliable, then repeatedly beaten with wooden mallets to spread and soften the fibres into a thin, flexible sheet. The sheets may be layered, felted together, or decorated with natural dyes, resulting in a textile-like material used for clothing, rituals, and household purposes.[72]

The company Bark Cloth from Germany is a pioneer for this material producing in Uganda with local communities. They give the barkcloth greater functionality through state-of-the-art production processes for textiles, wood alternatives, leather, and paper technology that are adapted to the socio-cultural context and infrastructure in order to meet global demand for renewable and ethically sourced materials.[73]

Countries with the largest production

Production process barkcloth

Artisanal practice of barkcloth processing

Barkcloth making is an ancient craft of the Baganda people and acknowledged as UNESCO Intangible Cultural Heritage. The Baganda live in the Buganda kingdom in southern Uganda. Traditionally, craftsmen of the Ngonge clan, headed by a Kaboggoza, the hereditary chief craftsman, have been manufacturing barkcloth for the Baganda royal family and the rest of the community. Its preparation involves one of humankind's oldest savoir-faire, a prehistoric technique that pre-dates the invention of weaving.[22] Barkcloth has a strong association with death and the afterlife, which explains why it's primarily worn day to day by Baganda witches and spiritual mediums.[74]

Key processors of bark cloth **Fibral member*

Company	Country of production
Bark Cloth*	Uganda

Barkcloth harvest, source: Barkcloth

Barkcloth beating, source: Barkcloth

Common reed

Common reed (*Arundo donax*) is a fast-growing, perennial grass commonly found in wetlands, riverbanks, and marshes in Northern Europe. Known for its tall, slender stalks and natural resilience, reed has been traditionally used in thatching, weaving, and ecological restoration. Its ability to filter water, stabilise soil, and support biodiversity makes it a valuable plant for both sustainable construction and other biomaterials as well as environmental conservation.

Reed is mainly harvested from natural stands in European peatlands. Data on overall EU production is not available. One of the most significant markets, northern Germany, is estimated to produce around 3 million bundles of reed annually through 141 companies. However, the total European demand is about 15 million bundles per year—far beyond what regional production can supply—indicating strong potential for expanding domestic reed harvesting. Other large producers are located in Southern and Eastern Europe, particularly Romania, Ukraine, Hungary, Poland, Austria, and Turkey. Since 2005, China has also become a major supplier, with most of its exports directed to the Netherlands.[75]

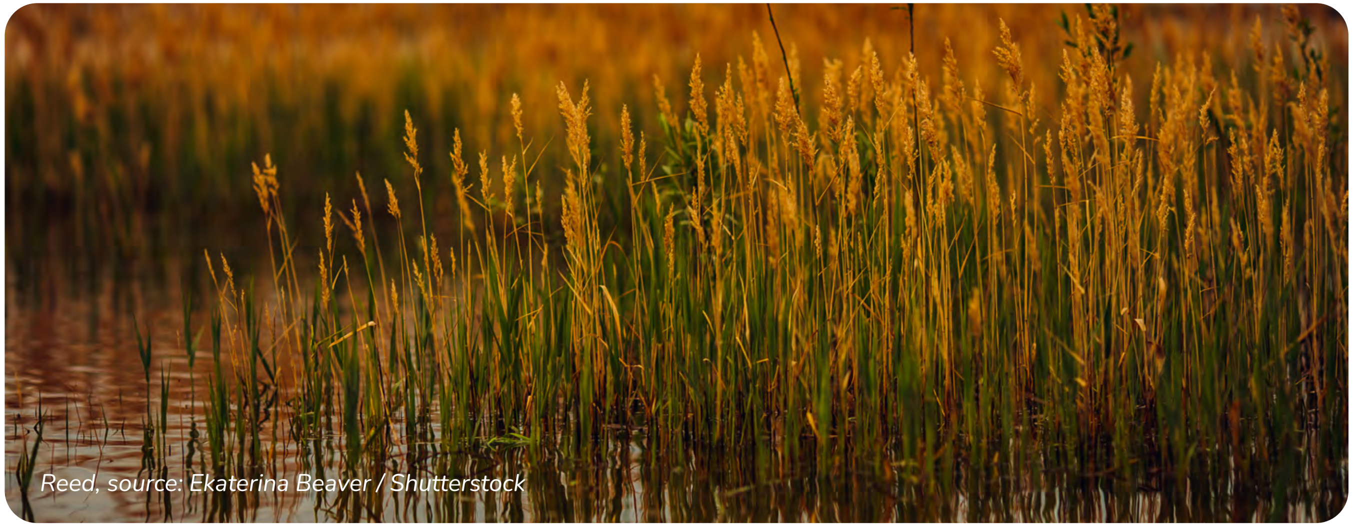
Countries with the largest production

Artisanal practice of reed thatching

The use of reed for roofing – "The Thatcher's Craft" is listed under UNESCO Intangible Cultural Heritage. This art can be found across Northern Europe. Roofing houses with reeds is one of the oldest building techniques. In fact, the first thatched roofs can be traced back as far as 4000 BC.[22]

Key processors of reed **Fibral member*

Company	Country of production
Reedest	Estonia
Hiss Reet	Germany



Reed, source: Ekaterina Beaver / Shutterstock

Other straw & stem fibres and cane, grass, reed

Bombonaje (*Carludovica palmata*), is native to the Amazon and gives a strong, flexible, and sustainably harvested natural fibre. Traditionally used in Peruvian crafts such as hats, baskets, and mats, it combines durability with lightness and cultural heritage. Grown and processed with minimal environmental impact, bombonaje supports biodiversity and empowers local artisan communities.[53] Bombonaje can also be found in Ecuador and Bolivia.

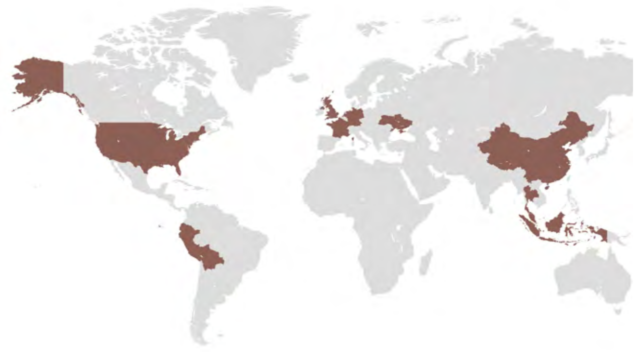
Oil palm fibre (*Elaeis* spp.) can be extracted from the processing residues of the oil palm industry. These residues include fronds (leaf stems), the leaves and the mesh surrounding the stem as well as the empty fruit bunch.* These fibres are typically coarse, lignin-rich, and are increasingly processed for various industrial purposes. Their production supports waste valorisation in the palm oil sector, though sustainability concerns remain due to deforestation and land-use practices tied to conventional oil palm cultivation. Major locations for oil palm plantations include Indonesia, Malaysia and Thailand. We were able to identify one company in Malaysia who is utilising this residue.

Sunflower fibre (*Helianthus annuus*) can be extracted from the sunflower stem as a residue from oil production. The fibres are similar to bast fibres from flax or hemp. The only production of sunflower stem fibre is currently on a lab scale in the UK by the company ClimaFibre. Other major producers of sunflowers and therewith a lot of potential for this fibre is in Ukraine and China.

Miscanthus (*Miscanthus* spp.) is native to Southeast Asia but adaptable to temperate climates as it is also grown in the UK, France, Germany, and the Netherlands. Micanthus is a biomass crop with potential for a variety of industrial biomaterials and biofuel. It is estimated that within the EU there is an annual production of 440,000 MT cultivated on 20,000 ha.[76,77]

Switchgrass (*Panicum virgatum*) is a warm-season perennial grass native to North America's tallgrass prairies. Selected by the U.S. Department of Energy as a model energy crop, it thrives on a wide range of soils—including marginal lands—and requires minimal water, nutrients, and herbicides. It can reach heights of 1–3 metre with an extensive fibrous root system. Its many uses span bioenergy, forage, habitat restoration, and soil health, making it a sustainable biomass crop for the circular bioeconomy.[78]

Countries with the largest production



**Although technically a fruit fibre, Oil palm empty fruit bunch fibres are not separately listed in the chapter "Seed & fruit fibres" as there is no significant production quantity.*

Miscanthus plants, source: RogerMechan / Shutterstock

Key processors of other straw & stem fibres and cane, grass, reed fibres **Fibral member*

Fibre Type	Company	Country of production
Miscanthus	Novabiom	Germany
Milkweed Stem	Faborg*	India
Oil Palm Residues	Nextgreen global berhad	Malaysia
Bombonaje	Neofiber*	Peru
Miscanthus	Terravesta Europe	UK
Sunflower	ClimaFibre*	UK
Cattail Stem	Ponda*	UK, Germany
Switchgrass	Prairie Lands Biomass, LLC	USA

Oil palm empty fruit bunch, source: salmonsembiring / Shutterstock

Bombonaje leaves, source: Carolina Jaramillo / Shutterstock

Market trends by key applications

Coir mattress filling, source: inna f. photography / Shutterstock

Market overview

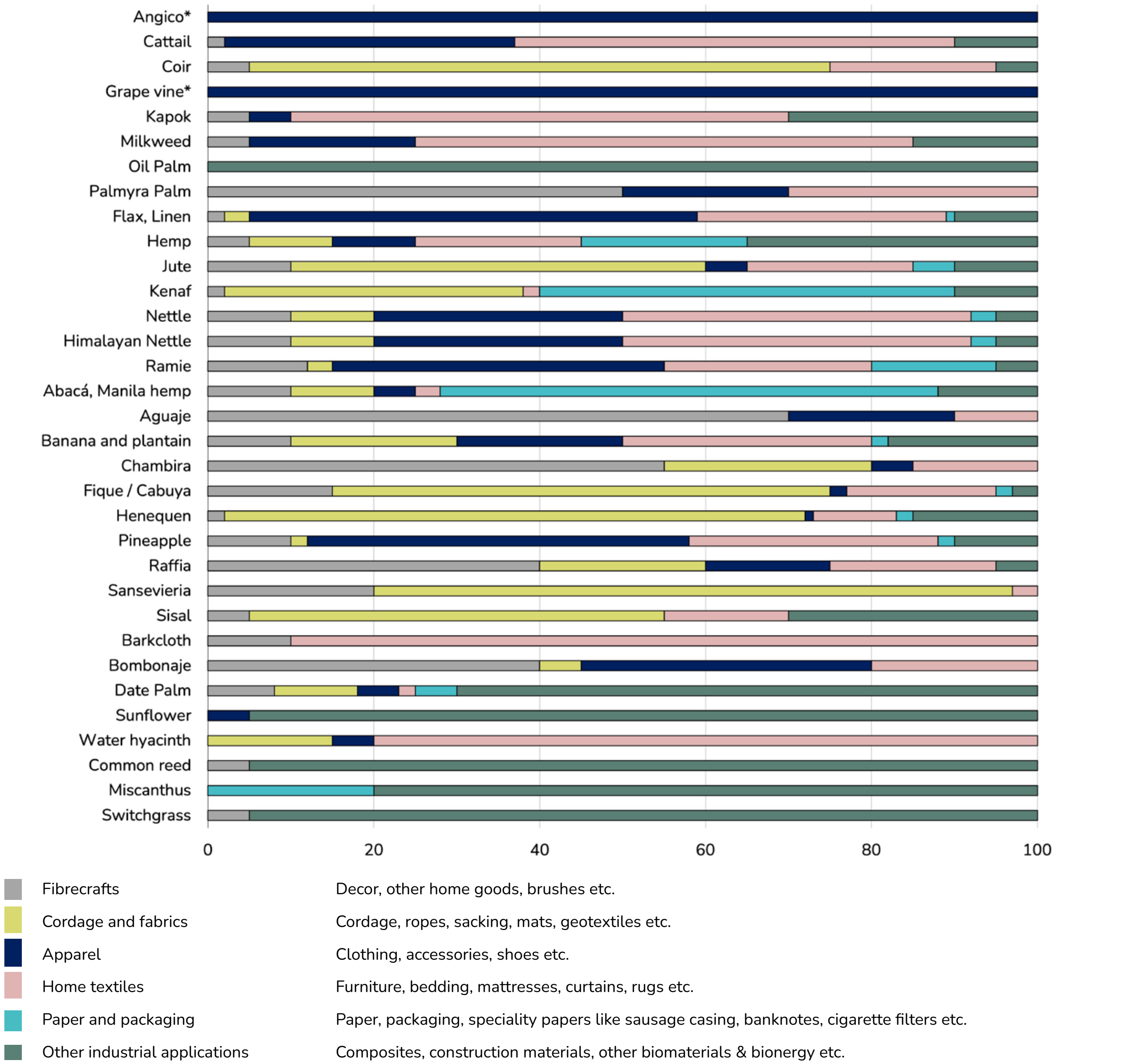
Plant fibres are used in a wide array of industries and applications—far too many to list them all. Major applications include sacking, carpets, cordage, textiles, fibre crafts and specialty papers such as tea bags, coffee filters, and sausage casings. Natural fibre composites are also well established in automotive applications. Owing to their inherent properties—low density and light weight, biodegradability, high specific strength and stiffness, insulation properties, and resistance to salt water—natural fibres continue to perform well across these sectors.

The bar diagram illustrates current plant fibre uses across industries, showing that fibres with similar properties often serve comparable purposes. This suggests opportunities to diversify fibre sources for greater supply reliability.

Seed fibres such as kapok, milkweed, and cattail are lightweight and short, mainly used for insulation and stuffing in bedding and mattresses. While innovations aim to adapt these fibres for higher-value apparel uses like woven and knitted textiles, such applications remain in early development. Bast fibres show broader versatility, influenced by their natural properties and the maturity of production systems and markets: linen dominates textiles, while kenaf and jute are strong in cordage and paper.

*Angico and grape vine are niche materials, currently used only by two of our association's members to produce bio-based leather, to clarify the 100% apparel use.

Uses of plant fibres for different sectors and applications by fibre type. This graphic is only a rough estimation based on limited publicly available data. The type of chart is adapted from Textile Exchange (2025).



Leaf fibres serve both artisanal and industrial applications—abacá is well established in specialty papers, while fique and henequen are key for cordage and sacking. Other fibres from straw, stems, cane, grass, and reed are mostly used industrially, particularly as biomass for biomaterials and bioenergy, with barkcloth and water hyacinth standing out in niche home textile and decorative markets.

Expanding the use of plant fibres to more commercial applications still present challenges. Matching the durability, strength, moisture resistance, and processability of conventional materials remains difficult. In recent years, momentum around plant fibre product innovation has been steadily growing. Driven by the circular bioeconomy, research activities have expanded and a wave of innovative small and medium-sized enterprises has emerged, developing new applications that take a 'fit-for-purpose' approach, exploiting their natural properties and finding easy-to-implement applications with lower performance requirements. For instance, single use paper containers where biodegradability is key and strength requirements are moderate.

"The future lies in intelligent material stewardship: leveraging plant fibres precisely where they perform best."

– Sandra Bohne, Co-Founder and Director, FIBRAL and Consultant

The graphic shows promising applications for plant fibres that were identified in an industry roundtable. These industries and applications are examined in more detail in the following chapters.

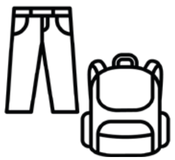
Emerging industries and applications for plant fibres with highest potential

Pulp and Paper
Applications: *Specialty paper, disposable containers, and tableware*
Plant fibres are well-established in specialty papers such as tea bags and coffee filters, with strong potential to replace even more plastic-based filters. As single-use plastic bans expand and concerns over deforestation grow, plant-fibre-based packaging, containers, and tableware show additional market growth potential.

Nonwovens
Applications: *Technical nonwoven fabrics*
With their relatively simple processing requirements ideal application for plant fibres with a wide range of uses from composites and alternative leathers to interiors, agriculture, sanitary and hygiene products and construction.

Construction and Insulation
Applications: *Bio-based insulation*
Green building regulations and industry advocacy are driving the adoption of plant fibres in sustainable construction. Already proven in applications such as blow-in/loose-fill and board insulation, they provide effective bio-based alternatives to conventional materials.

Automotive Composites
Applications: *Interior panels, trims, insulation*
Plant fibre reinforced composites support vehicle weight reduction and improved sustainability, with growing adoption driven by industry decarbonisation efforts. Already proven applications and use by various car manufacturers globally.



Textiles and Fashion
Applications: *Textiles, footwear, fashion accessories*
Potential for heavier-weight textile applications such as denim, backpacks, shoe uppers, or as backing materials for alternative leathers.

Natural fibre composites (Automotive)

Natural fibre composites (NFCs) are high-strength composite materials consisting of natural fibres embedded in a polymer matrix. In 2024, the global composite market reached a volume of around 14 million MT and is expected to grow to 16 million MT by 2029.* Natural fibres still play a minor role as reinforcement material for composites, dominated with >90% by glass fibre. In 2021, natural fibres were used at 1 million MT, making up only 7% of the total market size.[1]

In Europe, the majority of NFCs are used for automotives with around 90%.[2] It can be assumed that this is similar on a global scale, but no data was found. Primary fibres are cotton, flax (linen), kenaf and hemp, with other fibres under investigation.

The use of NFCs per car ranges between 2-20kg in components like floor and door panels, seat backs, luggage compartments, door and roof panels etc.[2] Exemplary car manufacturers and their applications are listed in the table. With global car manufacturing totalling at 75.5 million units in 2024, an average of 755,000 MT plant fibres could have been used.

*This refers to raw materials consumed to produce composite parts and not the weight of the composites.

Composites made from plant fibres are characterised by high rigidity and strength as well as low density, which gives them great potential for lightweight construction and makes them interesting for the development of modern, fuel-efficient cars and for electromobility.[3,4]

On the downside, characteristics such as high moisture absorption, limited thermal stability, and inconsistent fibre quality lead to reduced durability, dimensional instability, and difficulties in maintaining reliable mechanical properties. These natural variations make it still challenging to achieve the consistent performance required for the high safety requirements in automotive environments, especially for outside car parts.[3,5]

Furthermore, plant fibres offer biodegradability and potential for recyclable composite applications, making them an appealing alternative for automotive manufacturers. Yet, despite research confirming the recyclability of NFCs, widespread commercial use is still constrained by technical barriers, cost inefficiencies, and uncertainties surrounding safety standards.[6,7]

Application examples for NFCs in the automotive sector

Manufacturer	Model	Application	Plant fibre
Ford	Mondeo CD 162, Focus	Floor trays, door inserts, door panels, B-pillar, and boot-liner Door panels	Kenaf, wheat, beaver
Toyota	ES3	Floor mats, spare tire covers, door panels and seat backs, luggage compartments	Kenaf, sugarcane, bamboo, beaver
Daimler Chrysler	A, C, E, and S class, EvoBus (exterior)	Door panels, floor panels, trunk panels, dashboards, pillar cover panels, seat backrests, insulation	Flax, sisal, coir, wood, kenaf, banana, cotton
BMW	3, 5, and 7 series and other Pilot	Seat back, headliner panel, boot-lining, door panels, noise insulation panels, and molded foot well linings	Flax, sisal, cotton, wood, hemp, kenaf

Source: Elfaleh et al. (2023)

Natural fibre composites (Construction)

The global construction sector consumes over 60 billion MT of materials annually, with cement, concrete, aggregates, and steel being major components. Energy demand and greenhouse gas emissions associated with construction represent over a fifth of global emissions.[8] As a result, construction has become a key focus area for the circular bioeconomy, with growing efforts to replace conventional materials with more sustainable alternatives.

Especially in the Global South, plant fibres have always played an important role in construction. In countries across Asia many rural houses are still made using various plant fibres and agricultural wastes for roofing, insulation, fencing or brick reinforcement.[9] In Tanzania and Brazil, sisal fibre reinforced cement tiles are used.[10,11] Many other fibre crops and agricultural residues are being tested for these purposes such as abacá, banana and pineapple, date palm and jute, etc.[12]

Across Europe, reed is widely used as traditional material for roof thatching. In more modern structural and engineering applications, natural fibre composites are utilised to create load-bearing constructions such as beams, roofing, multipurpose panels, water tanks, and pedestrian bridges. Panels and particle boards can for instance be made from hemp and flax,[13] cattail stems,[14] reed[15] and miscanthus[16]. They can also be used in decking and siding, e.g. for terrasses.[17] In addition, lightweight concrete can be made from reed or miscanthus as well as hemp (called "Hempcrete").[18,19]

Plant fibres serve as renewable, biodegradable building materials that store carbon when incorporated into structures, while requiring less energy to produce than conventional building materials. They are lightweight and strong. However, their hydrophilic nature and low thermal stability pose barriers when combining them with hydrophobic thermoplastics for boards and beams or materials like concrete. These characteristics can lead to poor interfacial bonding and increase the fibres' susceptibility to moisture-related degradation, including dimensional changes, loss of strength, and biological decay.[3,5] This can be a hurdle to compliance with common building standards and certifications.

However, the worldwide drive for lower-impact building materials is spurring innovation, opening the door for plant fibre innovations.

Hempcrete, source: Isohemp

Natural fibre composites (Furniture and consumer goods)

Another growing NFC market is in the furniture and consumer goods sector, where plant fibres are used for chairs, tabletops, sporting goods like tennis rackets or bicycle frames, surfboards, instruments, luggage, cutlery and many other products as alternatives to synthetic composites.

This can be a hemp chair shell, luggage made from flax fibres and cutlery made from agave wastes, all typically bonded through bio resins.

Production potential is strong, as this sector requires lower fibre quality and consistency than automotive or construction markets. This allows for more flexibility in material use. The market environment is favourable, driven by consumer demand for sustainable products and regulatory support for bio-based materials. Thus, the outlook remains positive, with continued innovation expected to broaden applications and strengthen market share.

Insulation

Globally, main insulation products are based on mineral wool (glass and stone wool) and plastic foams (EPS, XPS, PUR). Mineral wool—as the main insulation material for buildings—was produced at 19 million MT in 2019.[20] The biobased insulation market—with under 10% market share—is currently dominated by wood-based insulation, including wood fibre boards and wood wool products. Cellulose insulation, primarily derived from recycled paper, represents the second largest category.[21]

Plant fibres provide insulation in forms such as loose-fill, non-wovens, or boards, alone or blended with conventional materials. Examples include blow-in insulation from cattail or hemp—commercially established in Germany, Austria, and the Netherlands[14]—as well as fibreboards from coconut[22] or kapok[23] and non-woven insulation from milkweed[24].

Plant fibres convince through good insulation performance, low weight, and natural moisture regulation. They also offer advantages in safety, avoiding harmful air emissions and being easier to handle during installation. However, as with natural fibre composites, widespread adoption is slowed by conservative building regulations, limited awareness among specifiers, and persistent technical concerns, particularly around moisture management and fire resistance.[25,26] Despite these challenges, the bio-based insulation market is expected to continue growing, driven by global efforts to decarbonise the construction sector.


Hemp insulation, source: Olga_Ionina / Shutterstock


Hemp composite chair, source: Vepa

Textiles

Alternative plant fibres offer breathable, absorbent, durable, and hypoallergenic properties and are applied across apparel, home textiles, interiors, furniture, and industrial uses. Flax (linen) and hemp are well established in fashion and home textiles, where they are appreciated for their natural handfeel and premium aesthetic. Water hyacinth and bark cloth, are used in furniture and decorative home textiles, while coir is primarily applied in agricultural geotextiles. Fine seed fibres such as cattail and milkweed, are used as filling materials for winter jackets and home textile products. Despite this diversity of applications, the textile market remains dominated by synthetic fibres and cotton, with alternative plant fibres accounting for only a small share.[27]

Wider adoption is limited by inherent fibre characteristics. Many alternative plant fibres have shorter staple lengths, reduced flexibility and elasticity, and a coarser structure, which complicates processing on textile machinery designed for cotton or wool. Achieving comparable processability and tactile quality typically requires specialised equipment or additional treatments. As a result, initial applications tend to focus on heavier textiles such as denim, backpacks, and shoe uppers.

To expand their suitability for finer clothing, innovation efforts have focused on "cottonising" plant fibres to enhance compatibility with conventional spinning machinery and approximate the performance of cotton. Blending plant fibres with other virgin or recycled fibres—typically at shares of up to 30%—is another widely used strategy to achieve the required texture, durability, and quality for specific end uses. In recent years, advanced processing techniques such as enzyme retting, degumming, multi-stage mechanical refinement, nano-pulsation, and steam explosion have further improved fibre fineness and spinning performance. Another example is the reinterpretation of the traditional Japanese "washi paper" technique. In this process, paper made from abacá using traditional methods is cut into narrow strips and spun into fine yarn, resulting in a lightweight and durable material that bridges craft and industrial innovation.[28]

Plant-based leather alternatives for bags, jackets, footwear, and automotive interiors have reached a relatively advanced stage of development. These materials typically consist of woven or non-woven plant fibres coated with partially or fully bio-based plastics, as seen in hemp leather used by Volkswagen[29] or pineapple leather applied by Forvia[30]. Pineapple leaf fibre demonstrates strength comparable to cow leather while offering strong resistance to colour fading.[31] Additional examples include grape marc and banana-based leathers, which are used primarily in fashion accessories such as shoes, belts, and bags.

Within the home textiles and furniture sector, plant fibres are experiencing renewed interest for use in carpets, baskets, chairs, curtains and placemats etc. This revival can be linked to growing consumer interest in supporting artisanal craftsmanship and a bohemian-look. Another reason could be to use less harmful materials in their homes.

Despite these opportunities, alternative plant fibres are widely perceived as higher-risk options within the textile industry. This perception is driven by uncertainties related to quality consistency, performance, cost competitiveness, machinery compatibility, and supply reliability. Consequently, only fibres that can consistently meet industrial standards are likely to be adopted at scale. Currently in fashion, plant fibres are primarily used in small-scale or experimental collections without formal offtake agreements. This limits investment security for small producers and continues to hinder commercial scaling.

Ensemble, 100% Abacá fibre, source: Bananatex

Pulp and paper

The pulp and paper industry remains one of the world's largest manufacturing sectors, which produced about 193 million MT of wood pulp and 401 million MT of paper and paperboard in 2023.[32] Production is still dominated by wood, although manufacturers are under increasing pressure to rethink their raw materials due to risks of deforestation and climate change. To diversify the raw materials base and regionalise resource use, non-wood fibres such as abacá, jute, hemp and flax (linen) can become an alternative. Although they continue to play a role, particularly in specialty papers,[33] pulp production from non-wood fibres remains marginal at 11.2 million MT, or 5.8% of global output in 2023.[34]

Abacá is the most important non-wood fibre for specialty and security papers, used in tea and coffee filters, banknotes, cigarette papers, and sausage casings, which together represent over 84% of global demand.[35] Its fibres provide strong and bright cellulose suitable for chlorine-free bleaching and applications that require high strength and neutral taste. Limited availability of high-quality fibre and rising costs, however, have constrained demand in recent years. Manufacturers are optimizing fibre use and investigating alternatives such as wood cellulose, alginate, and PLA, though none match abacá's performance entirely.[36] If supply and price pressures were reduced, abacá could see wider use, including as a substitute for other plastic-based specialty papers.

Abacá also remains relevant in banknote production. Japan continues to use notes with roughly 30% abacá, while the Philippines until recently used about 20%. Yet many countries are shifting to polymer notes due to their longer lifespan, improved durability, and enhanced security. Organisations such as the Philippines Fibre Industry Development Authority continue to promote abacá for currency paper nationally as well as internationally.[37]

A range of other plant fibres, including banana, coir, palm residues, and wheat and rice straw, are used in molded packaging, disposable containers, and tableware, segments that are expanding with plastic restrictions. While plant fibres could also be used more widely in standard paper and board, higher costs remain a barrier. Even so, interest is rising; for instance, the Confederation of European Paper Industries notes growing attention to non-wood pulp for hygiene papers and packaging. This renewed interest is driven by regional availability of agricultural residues, lower carbon footprints, rising wood prices, and opportunities for sustainability-based product differentiation. But challenges persist, non-wood fibres differ greatly from wood fibres as they have a higher silica content, shorter fibres and variable composition and therefore require specialised processing. Seasonal availability and investment costs for special equipment are compounding challenges.[38,39]

Technological innovations for non-wood pulp making combine resource efficiency, emission mitigation and digital process control. For instance, enzyme-assisted pulping, bio bleaching, hybrid-fibre blends and sensor systems reduce wastewater, improve mechanical properties and optimise yields and consistency.

Overall, the search for alternative fibres is expected to intensify, aided by global moves away from single-use plastics and increasing demand for biodegradable, fibre-based pulp and paper products. Non-wood fibres can serve as a strategic complementary raw material—particularly in agriculturally strong regions and for companies that prioritise ESG, carbon management, and resilient supply chains.

Coffee filter, source: Kristina Sorokina / Shutterstock

Market trends by region

Jute coffee bags, source: il21 / Shutterstock

Market trends by region

Global plant fibre markets continue to reflect a North–South dynamic, though this pattern is gradually evolving (Also refer to the map in the chapter "*Production landscape*"). Tropical regions in Latin America, Africa, and much of Asia remain the main suppliers of raw fibres, forming the backbone of global production with flax (linen) from Europe as an exception. In contrast, Europe and North America dominate in machinery manufacturing for advanced fibre pre-treatment and processing technologies. An exception is China also as a major developer of natural fibre machinery.

This divide makes value chains uneven. In many fibre-producing countries, e.g. Ecuador, Brazil or Kenya, the majority of raw fibres is exported with little domestic processing. This leaves significant untapped potential for local value addition and increased domestic consumption—opportunities that could boost revenues, reduce reliance on volatile global trade, and cut the environmental costs associated with long-distance transport.

Regulatory frameworks also strongly influence market dynamics. Governments around the world are adopting bioeconomy strategies and are drafting bans on single-use plastics.[1,2] On the other hand, current regulations are often fragmented and disadvantage plant fibres by overlooking their environmental and social performance potential compared to conventional materials and other biomaterials, thereby constraining their competitiveness in certain markets.

The following sections explore regional trends in the plant fibre market across Asia, Africa, Latin America, Europe and North America—highlighting their respective strengths, challenges, and future opportunities.

Asia

Asia is one of the world's most important producers of plant fibres, shaped by its wide range of climates, strong agricultural base, and millions of smallholder farmers who rely on fibre crops for income. Several countries have introduced policies to protect and grow these sectors. India and Bangladesh, for example, require jute packaging for key agricultural goods, ensuring a stable domestic market for jute growers.[12,13] The Philippines has taken a broader route with the Philippine Tropical Fabrics Law, which promotes government procurement of locally made textiles and fibres.[14]

The region is a global hub for fibre processing and manufacturing. Asia is home to approximately 93 pulping companies, accounting for 70% of the world's non-wood pulp production.[15] Leading countries are adopting innovative approaches: India leverages wheat straw and bagasse while transitioning to cleaner soda—anthraquinone pulping methods; China focuses on bamboo and reed, employing closed-loop chemical systems under its Green Manufacturing Strategy;[16] and Japan has a large specialty paper sector, using abacá in high-performance products such as tea bags, coffee filters, and banknotes.

Asia is also one of the largest and fastest-growing markets for natural fibre composites. As of 2023, the region is estimated to cover 48% of global natural fibre composite consumption.[17] Broader composites demand in Asia is expected to grow at 4 to 5% annually, creating strong opportunities for plant fibres in lightweight board and structural applications.[18] Construction growth further expands the market outlook. India, China, and Indonesia are expected to be among the fastest-growing insulation markets through 2026, especially in commercial and industrial buildings. Expanding local production capacities for NFCs and insulation materials could support cost-competitive adoption while reducing reliance on imported alternatives.[19]

Pile of jute fibres, Bangladesh, source: Wilhelm G. Clasen

Africa

Africa has a long-standing tradition of plant fibre production, with sisal remaining the region's most established export crop. Tanzania and Kenya are the largest producers, exporting roughly 70 and 90 % of their sisal output respectively.[26] Regional markets use sisal mainly for geotextiles, sacks, twine, baler twine, and ropes, but uptake in higher-value applications such as biocomposites, construction boards, and specialty papers remains limited due to constraints in processing technology, investment, and industrial processing.

Cotton continues to dominate the continent's textile fibre economy, yet most Sub-Saharan African countries export more than 90% of their cotton lint rather than processing it into yarn or fabric.[28] The African Continental Free Trade Area identifies textiles and apparel as a strategic value chain for regional industrialisation,[29] which could indirectly benefit other plant fibres through shared infrastructure, processing clusters, and harmonised standards.

In recent years, interest in alternative fibres has grown across research institutions, start-ups, and development programmes. Studies and pilot projects have explored fibres sourced from pineapple leaves, banana pseudo stems, date palms, coconut husks, and invasive water hyacinth. In East Africa the United Nations Trade and Development Agency together with Sustainable Manufacturing and Environmental Pollution Programme facilitated the formation of the East Africa Alternative Fibre Forum. It brings together key producers, buyers and enablers to explore the enabling environment, host producer-buyer-financier roundtables and facilitate dialogue for plant fibre industry acceleration.[30] A pioneer in East Africa is Del Monte Kenya which has started to produce pineapple leaf fibres from their 4,500ha of pineapple plantations—a huge opportunity for scaled supply.[31]

Beyond national and regional projects, continental frameworks are creating a more supportive environment. The African Union's Agenda 2063 and the related African Bioeconomy Strategies encourage diversification of biomass-based industries, improved natural-resource productivity, and the development of regional green manufacturing.[32]

Latin America

Latin America holds abundant plant fibre resources deeply connected to cultural heritage and Indigenous craftsmanship. Many communities continue to rely on locally sourced fibres for traditional weaving and knitting, shaping textiles, accessories, and household goods that carry long-standing regional identities.

At the industrial level, the region remains largely export oriented, with limited capacity for value-added processing. This gap signals significant room for downstream development. Brazil leads global sisal production with about 37% of the market, exporting most of its output.[26] Ecuador is a major producer of abacá, supplying raw fibre for specialty papers and ropes used mainly in Europe and Asia. Despite producing its own natural fibres, Ecuador still imports jute bags from India for agricultural use. Colombia dominates global fique production, and unlike its neighbours, consumes most of it domestically in products such as coffee and cocoa bags.[27]

Costa Rica has an active R&D landscape focused on pineapple leaf and banana fibre. Scaling production, however, remains limited by gaps in processing expertise for local varieties, the need for specialised machinery, high labour costs, and the absence of domestic infrastructure to convert fibres into textiles or pulp. Even so, a growing wave of small, innovation-driven companies is beginning to build new processing methods and early-stage industrial capacity for next-generation plant fibre materials.

Sisal transport, Mozambique, source: Wilhelm G. Clasen

Europe

Europe plays a pivotal role in the global plant fibre market. It supplies roughly 80% of the world's flax (linen) and remains the largest hemp-growing region, supported by strong engineering capabilities in fibre processing. European machinery makers for plant fibre extraction such as Andritz Laroche, Temafa, Trützschler, and Cretes shape global standards. The region also hosts influential trading houses, i.e. Wilhelm G. Clasen and Wigglesworth & Co. that anchor global fibre commerce.

In the non-wood pulp and paper sector, Europe plays a significant role with at least 33 companies already working with fibres such as abacá, flax, hemp, bagasse, miscanthus and other agricultural residues.[3] Amongst them are world-leading specialty paper producers such as Magnera and Ahlstrom-Munksjö which are at the forefront of developing plastic-free, fibre-based solutions including tea bags, coffee filters, and compostable sausage casings derived primarily from abacá fibres.[4]

Europe is also a leader in natural fibre composites. Car manufacturers such as BMW and Mercedes-Benz use plant fibres in lightweight interior components, encouraged by the EU End-of-Life Vehicles Directive and CO_2 emission standards. Yet slower electric car uptake, supply chain strains, and wider economic pressure are currently limiting new R&D for NFCs and bio-based leather alternatives.[5]

The building sector presents growing opportunities, driven by the EU Construction Products Regulation, the Ecodesign for Sustainable Products Regulation, and the Energy Performance of Buildings Directive. These policies encourage bio-based insulation and building materials, although strict performance requirements can slow the entry of new fibre-based products. Industry leaders such as Saint-Gobain are already developing solutions from wood cellulose, hemp, and cotton.[6]

Europe's regulatory landscape with regards to fashion and textiles is raising expectations around recyclability, traceability, and due diligence. The EU Strategy for Sustainable and Circular Textiles,[7] EU Deforestation-Free Products Regulation,[8] and the Corporate Sustainability Due Diligence Directive[9] all push for more transparent and responsible sourcing. At the same time, regulations like the Product Environmental Footprint (PEF) methodology inadvertently disadvantage natural fibres. The PEF currently omits key environmental indicators such as microplastic emissions, plastic waste generation, and material circularity. As a result, natural fibres are not competing with plastics on a level playing field.[10] In addition, the EU Textile Labelling Regulation requires disclosure of fibre composition but does not formally recognise newer plant fibres such as pineapple leaf, banana, or cattail fibres. This lack of formal recognition hinders market access.[11]

Bast fibre decortication unit, source: Andritz

North America

North America's plant fibre sector, mainly for hemp and flax (linen) is expanding due to supportive policies and growing number of fibre farmers and processors. In the U.S., the 2018 Farm Bill legalised industrial hemp, and the Sustainable Farms, Fibres, and Forests Act strengthens domestic fibre crop development, while the USDA BioPreferred Program creates early demand for fibre-based biobased products.[20–22] Canada's licensing framework under the Industrial Hemp Regulations supports production in key agricultural provinces.[23] Large producers like Panda Biotech, Ind Hemp, Bast Fibre Technologies etc. are fostering national product development from natural fibres. In flax, the North American Linen Association is gathering a growing number of farmers and producers together developing the national flax industry.[24]

A large end-use sector for plant fibres in North America is composite applications. In 2023, the region accounted for an estimated 34% of the global natural fibre composites market.[17] Hemp and flax (linen) are particularly well-suited for these applications due to their mechanical performance and compatibility with polymer systems. Regulatory changes such as the approval of hempcrete under the US Residential Building Code for non-structural wall infill systems poses market expansion potential.[25]

In the pulp and paper sector, leading specialty paper manufacturers such as Ahlstrom-Munksjö, Magnera, Delfort, Twin Rivers, Suominen, Mativ have facilities in North America using wood and natural fibres for filtration materials and other technical specialty papers.

Hemp harvesting, source: defotoberg / Shutterstock

Systemic constraints and barriers to scaling

Pineapple leaf and banana fibre extraction, source: Jahangir Alam Onuchcha / Shutterstock

Systemic constraints and barriers to scaling

Developing resilient markets for plant fibres requires addressing a set of interconnected systemic constraints: structural and policy barriers that influence investment conditions, standards, and market incentives; operational and supply chain challenges that affect quality, consistency, and coordination; and environmental and contextual pressures that limit resilience. These constraints shape how supply chains function, how markets develop, and how competitive plant fibres can become relative to conventional materials. Drawing on a survey conducted among FIBRAL's member community and insights from industry experts, this section outlines the main barriers that continue to limit the growth and integration of the plant fibre sector.

1. Structural and policy constraints

Lack of reliable offtake agreements
Securing reliable offtake agreements remains one of the most critical barriers to financial viability across the plant fibre supply chain. Because many plant fibre products are still emerging and lack economies of scale, they often remain more expensive than conventional alternatives. Where actual or perceived performance is lower, end users are reluctant to pay higher prices, limiting demand and slowing uptake. Weak demand, combined with fragmented supply chains—characterised by smallholder systems, cooperatives, traders, and exporters with limited bargaining power—creates price volatility and exposes farmers to market risks. These uncertain outlooks reduce incentives for farmers to invest in fibre cultivation.

Funding and investment limitations
Investors perceive the sector as higher risk due to uncertain production costs, variable yields, fragmented supply chains, and unstable market demand. As a result, access to grants, concessional loans, and venture capital remains limited compared with more established segments of the bioeconomy. This financing gap restricts the ability of producers and processors to invest in machinery, infrastructure, agronomic improvements, and scaled innovation. Payments for ecosystem services (PES) as innovative financing tool could become a promising mechanism for fibre cultivation systems, but are still at an early stage of development and not widely accessible.

Limited industrial integration
Existing industrial machinery, design software, recycling infrastructure, and end-of-life pathways are optimised for conventional materials such as cotton, viscose, and synthetic fibres. Substituting plant fibres requires costly adaptations across multiple stages of production, making companies cautious about rapid supply-chain transitions. This hesitancy is reinforced by limited awareness of plant fibre properties, inconsistent communication of benefits, and insufficient demonstration of performance across applications. As a result, plant fibres are not yet widely viewed as drop-in substitutes, slowing adoption and reducing market pull.

Regulatory and policy barriers
Plant fibres operate within fragmented and unfavourable regulatory environments. Despite their environmental and socioeconomic benefits, they are frequently overlooked in agricultural, biodiversity, food security, and bioeconomy policies. This limits access to incentives, funding programmes, and recognition under sustainability frameworks, including those related to carbon credits and ecosystem services. Trade is further constrained by incomplete classification under the Harmonized System (HS) Code: fibres such as banana, pineapple, or nettle lack a specific code reducing traceability and obscuring market data. In addition, technical standards—particularly in construction, composites, and mobility—are typically designed around conventional materials, creating compliance barriers for plant fibre products.

2. Operational and supply chain constraints

Unstable quantity and quality of supply
A stable supply of high-quality fibre is essential for commercialisation and long-term market development. Natural fibre crops face seasonal variability, pests, and increasing climate volatility. Moreover, alternative fibre extraction has low conversion rates—sometimes only 1–2% of total biomass—requiring large volumes of raw material to yield modest fibre output. Many farmers, particularly in the Global South or in emerging fibre sectors, rely on multiple income sources and cannot afford to invest in soil improvement, resilient agricultural practices, or machinery. Weak institutional support—such as limited training services, nurseries, and extension systems—further constrains productivity and quality.

Processing and technology gaps
Advancing processing technologies is key to improving efficiency, consistency, and scalability. Many producers rely on generic or outdated machinery that is unsuitable for specific fibre types or for meeting the standards required by sectors such as textiles, pulp and paper, or high-performance composites. Limited access to specialised

equipment reduces throughput and makes it difficult to meet quality specifications. A lack of pilot facilities and research centres restricts experimentation and slows the development of improved processing methods. Knowledge and IP sharing across producers remains limited, delaying the diffusion of best practices and technological innovation.

Missing standardisation

Unlike cotton, most alternative plant fibres lack comprehensive and widely adopted standardisation. While jute, sisal, flax, and hemp have established grading systems in certain producing countries, fibre quality often still depends on subjective assessment. Comprehensive standardisation—covering variety selection, cultivation practices, processing guidelines, and fibre classification—would improve consistency, reduce transaction costs, and support predictable pricing. Clear standards also strengthen buyer confidence, facilitate industrial integration, and enable certification schemes and investment decisions.

Traceability and data gaps

Traceability remains limited across plant fibre value chains. Small scale and community-based producers lack the financial or technical capacity to comply with emerging data and documentation requirements, and few standards currently address non-cotton plant fibres (also see chapter "*Certifications and traceability*"). Market data (volumes, prices, quality etc.) as well as data on environmental impacts and social and labour conditions remain sparse, making it difficult for buyers, investors, and policymakers to assess risk or plan for long-term supply.

3. Environmental and contextual constraints

Climate change and extreme weather events

Fibre cultivation and processing rely on stable climate conditions. Excessive rainfall, prolonged droughts, storms, and typhoons already affect yields and fibre quality, particularly in the Global South. As climate volatility increases, production risks and supply variability are likely to intensify, especially where producers have limited adaptive capacity.

Demographic change

Lastly, the ageing workforce poses significant risks to the continuity of plant fibre systems. Younger generations are increasingly reluctant to take up labour-intensive roles in cultivation and processing, threatening the transfer of traditional skills and knowledge. Without modernisation, improved working conditions, and gradual mechanisation, the sector risks losing essential expertise required to sustain and scale fibre production.

Coir ropes on a bicycle, Indonesia, source: Uud N. Hudana / Shutterstock

Environmental and social impacts

Destroyed abacá plants after typhoon in the Philippines, source: Care Philippines

Sustainability of plant fibre systems: Current evidence and data gaps

While many traditional and Indigenous plant fibre production systems are inherently regenerative and adapted to local ecosystems, scaling these systems does not automatically result in sustainable outcomes. As production intensifies, environmental impacts, land use, labour conditions, worker and community safety, and land and resource rights may be adversely affected.

These risks occur not only during cultivation and harvest but also during processing, particularly in industrial settings, where chemical inputs, energy and water use, and mechanisation can harm ecosystems and worker safety. This highlights the importance of designing fibre production systems that embed regenerative, circular, and safe working principles from the outset.

Life cycle assessments (LCAs) are valuable for identifying environmental impacts but have methodological limitations in capturing the full range of negative and positive effects. In particular, LCAs often overlook qualitative impacts on biodiversity and soil health, as well as social dimensions such as labour conditions, land and resource rights, and community well-being. The diversity of fibre crops and region-specific production and processing systems further complicate assessment and comparability.

Environmental impacts

Agricultural practices: growing conditions, inputs, and land use

Plant fibre crops vary widely in their climatic requirements, soil needs, and cultivation systems. Some fibres are grown in smallholder, low-input systems, while others are produced in large monoculture plantations that may depend on water, fertilisers, and pesticides. Access to modern farming technologies also influences both yields and ecological footprints.

Monocultural systems are common for many fibre crops, including coconut in India and Sri Lanka;[1] Hemp, flax, and miscanthus in Europe and North America;[2–4] sisal in Tanzania, Kenya, and China;[5] and pineapple and banana in tropical regions worldwide. Monocultures can make fibre supply more uniform and reduce labour costs, but they also carry environmental risks such as nutrient depletion, soil degradation, reduced biodiversity, and increased water demand.[6–8] These impacts are most pronounced in high-input plantation systems. Industrial pineapple and banana farms in Costa Rica, the Philippines, Ecuador and Brazil for example, rely heavily on fertilisers and pesticides, contributing to soil erosion, water contamination, and long-term soil exhaustion.[9–12] Similarly, coconut and oil palm monocultures in Southeast Asia and the Philippines pose challenges such as loss of soil fertility and deforestation, when land conversion for monoculture farming replaces biodiverse ecosystems resulting in soil salinization, reducing land productivity over time.[7,13]

However, many producers have adopted practices that reduce these risks. Hemp and flax (linen), while sometimes fertilised depending on soil conditions and yield targets,[6] are generally considered low-input crops: they suppress weeds through dense canopy cover, require few pesticides due to natural resilience, and improve soil structure with deep root systems. They are commonly grown in crop rotations which can enhance soil health.[14,15]

Sisal production in Brazil, jute in India and Bangladesh, and abacá in the Philippines are largely smallholder-based. Although smallholder systems can also be monocultures,

Coconut plantation, source: lzf / Shutterstock they commonly integrate fibre crops with other food crops, livestock, or trees to diversify income and reduce risks. Abacá, for example, is commonly grown alongside coconut or fruit trees in an agroforestry system helping maintain soil health. Only a fraction of farmers is using fertilisers, and these are mostly organic,[16] while jute rotations with rice, wheat, or lentils are widespread in South Asia[17]. In Brazil, sisal has long been grown without fertilisers or pesticides, and decortication residues are returned to fields as natural fertiliser.[5] Jute leaves are likewise used to enrich soils in India.

Deforestation is another risk associated with natural fibre production. Many coconut-growing areas were formerly forested, with coconut cultivation identified as a primary driver of deforestation in some regions, such as the Pacific Islands.[7] Similarly, abacá is frequently planted as secondary forest on land cleared of primary tropical forests through the "kaingin" slash-and-burn practice in the Philippines.[18]

Water use varies between plant types. Jute is mostly rainfed, requiring irrigation only in drought-prone areas.[19] Bananas demand frequent watering to maintain productivity.[20] In contrast, Western European flax requires almost no irrigation and contributes minimally to water-related environmental impacts.[15] Sisal is also a drought resistant plant which does not depend on irrigation.[5]

Fibre extraction and processing

Plant fibre extraction methods span from traditional manual techniques to advanced industrial systems, each with distinct environmental implications. In many smallholder or artisanal settings, hand-stripping fibres from stalks and drying them naturally minimised external energy and chemical use but is extremely labour-intensive and limits scalability for global supply chains. By contrast, mechanical processing uses simple or semi-automated machinery such as decorticators and scutching machines. While reducing manual labour and improving product uniformity, these methods depend on fossil fuel-powered equipment, slightly increasing energy consumption and greenhouse gas emissions. The waste and wastewater generated by traditional extraction methods can cause environmental problems and lead to CO2 and other greenhouse gas emissions when incinerated or landfilled.

Industrial fibre refinement techniques can involve chemical degumming or pulping, enzymatic treatments, and specialized mechanical extraction methods such as decortication or cottonisation which consume significant amounts of energy, water and chemicals and can also have adverse effects on the surrounding environment if solid wastes and wastewater are not treated appropriately.

Water retting is a widely used method for extracting bast fibres like jute, hemp, and ramie. Though effective, water retting requires large volumes of water and can increase eutrophication in aquatic ecosystems.[21,22] Field retting, common in Europe for flax (linen) and hemp, also has eutrophication effects but to a lesser extent.[23] Alternative methods, such as enzyme retting in controlled settings, aim to reduce water use and pollution but face limited adoption due to higher costs and technical barriers.

Abaca fibre extraction, source: HushKetchup / Shutterstock

Social and labour conditions

The cultivation and processing of plant fibres is to a large extent rooted in rural regions of low- and middle-income countries. The work in this sector can be physically demanding, poorly paid, and without strong social protections. Smallholder farmers and workers face several recurring risks: low and volatile income, lack of formal contracts, occupational health hazards, unequal access to rights and opportunities and child labour.[24–30] Gender disparities and migrant labour dependency are also recurring themes.[31]

A central challenge is limited transparency. Consistent, comparative information and monitoring systems on labour conditions across fibre types or producing regions are scarce. Much of the literature relies on case studies, high-profile investigations, or anecdotal reporting. While e.g. child and forced labour have been documented in several contexts,[32–35] for most fibres, evidence remains fragmented, leaving significant blind spots.

Occupational health and safety vary widely between manual and small scale, and industrial settings. Manual work in retting and drying exposes workers to waterborne contaminants, fibre dust, or repetitive strain, while industrial mills may present risks linked to machinery, long shifts, and inadequate protective equipment. The absence of robust enforcement mechanisms means workplace safety can remain fragile.

Livelihood security is another systemic concern. Fluctuating global market prices, competition with conventional materials, and weak bargaining power put farmers and fibre workers in a precarious position. Informal employment offers no social protection, health care, or retirement coverage, and under these conditions, fibre production may supplement but rarely guarantee sustainable household income.[26]

Indigenous Peoples across the globe have long cultivated and processed plant fibres, using Traditional Ecological Knowledge that sustains both livelihoods and cultural heritage. However, the broader plant-fibre sector often falls short of supporting these communities: insecure land tenure leaves ancestral territories vulnerable to external agribusiness and resource-extraction interests;[36] labour arrangements frequently involve low wages, informal or family-based work with limited social protections, and in some contexts even coercion or child labour;[37] and market structures tend to marginalise Indigenous producers, offering little control over pricing or value addition.
These cases underscore that while plant fibres can foster cultural resilience, income generation, and environmental stewardship, such benefits depend on securing land rights, fair labour conditions, and inclusive governance that centres Indigenous knowledge and agency.

Emerging best practices for sustainable plant fibre systems

As the plant fibre sector continues to evolve, especially start-ups and younger generations taking over established family businesses are positioning plant fibres within a modern bioeconomic framework defining new best practices. In doing so, they are placing greater emphasis on working with traditional knowledge and regenerative farming methods. Machinery, production processes and waste management are being redesigned according to the principles of the circular economy and biorefinery, while at the same time placing greater emphasis on occupational safety, formalised working agreements and transparent contracts. Also refer to chapters “*Between Traditional Ecological Knowledge and innovation*”, “*Production landscape*”, and the following chapter.

Jute retting, Bangladesh, source: Md. Ashaduzzaman Noor / Shutterstock

Plant fibres as a nature-based solution and contributor to rural development

2023 UN Resolution on natural plant fibres and sustainable development

In December 2023, the UN General Assembly introduced a dedicated agenda section for natural plant fibres for the first time, following the Resolution A/RES/78/169 "Agriculture development, food security and nutrition: natural plant fibres and sustainable development"—a milestone recognizing their vital role in rural development, the bioeconomy, and global sustainability.

As discussions focus on advancing sustainable production and innovation for these fibres, the resolution calls for greater international cooperation and investment to position plant fibres as key materials for meeting climate and development goals worldwide.[38]

When cultivated in line with environmental restoration goals, plant fibres offer strong potential as nature-based solutions and drivers of livelihood and economic development. Recognised by the UN Resolution on natural plant fibres, their low-impact, climate-resilient production can reduce environmental degradation and greenhouse gas emissions while supporting biodiversity. Integrated into regenerative agricultural systems, plant fibres can enhance land restoration and ecosystem resilience, while simultaneously creating employment—particularly for women and smallholder farmers—strengthening rural development and food security, and contributing to long-term economic resilience.[38]

The following sections describe the ecological and social value of plant fibre systems:

Enhancing biodiversity and soil health through regenerative agriculture

In many regions, plant fibres are grown within mixed farming systems that naturally support biodiversity. When fibre crops are integrated into regenerative or agroforestry models, they help rebuild soil health, create habitat diversity, increase resilience to climate extremes, and reduce pressure on forests. Multi-layered systems that combine fibre crops with trees or food plants enhance nutrient cycling, improve soil stability, and support pollinators and wildlife. Well-established examples include abacá intercropped with coconut or fruit trees in the Philippines,[16] kapok grown alongside other local crops in Indonesian agroforestry systems,[39] and sisal cultivated with other crops in Tanzania to improve soil fertility and farmer income.[40] Coconut agroforestry is also widespread across tropical regions, where palms are mixed with understory crops to maintain ecological balance while maximising land productivity.[7]

Replenishing marginal lands

A lot of plant fibre varieties are sturdy, low input crops which can thrive on marginal lands. For instance, biomass crops such as miscanthus and switchgrass—increasingly cultivated for renewable energy and biomaterials—can thrive on marginal lands incl. depleted soils, erosion-prone slopes, or heavy clay where they improve soil and water quality.[41,42] Milkweed is another drought-resistant crop ideal for restoring poor soils on marginal lands. It thrives without irrigation on dry, barren terrain where conventional crops fail, supporting biodiversity while revitalising land health.[43] In Brazil, sisal is grown on marginally productive lands in semiarid regions not suitable for other crops.[5,44]

Utilising agricultural waste to reduce harmful waste management practices

Plant fibres extracted from agricultural residues such as pineapple leaves, banana pseudo stems, grapevines, date palm fronds, and oil palm by-products make use of biomass that would otherwise be discarded. In many producing regions, these residues are burned, left to rot on the field, or dumped in unmanaged sites, practices that release CO_2, methane, nitrous oxide, and particulate pollution. Turning these wastes into fibres helps reduce these emissions while lowering the volume of organic material entering landfills or clogging waterways. This approach can also ease waste-handling burdens for farmers and agro-industries, while creating new income streams for farmers. At the same time, careful management is needed: some residues serve critical local roles such as animal feed, building material, mulching, or maintaining soil organic matter. Sustainable residue-based fibre systems therefore require context-specific planning to ensure that fibre extraction complements, rather than competes with, community needs and soil health.

Controlling infestations

Plant fibre extraction can also be a way of controlling and using invasive plants. For example, water hyacinth is an invasive aquatic plant, which clogs waterways and disrupts ecosystems. By harvesting it and converting its fibres into valuable products such as fibre crafts, furniture, construction materials, or compost, communities can reduce its spread and ecological damage. This approach supports reducing biomass in infested areas, turning an environmental nuisance into a valuable resource.[44]

Rewetting peatlands

Paludiculture provides a sustainable way to restore peatlands as critical ecosystems to carbon sequestration while maintaining productive land use. Maintaining high water tables prevents peat degradation and enhances carbon sequestration, as rewetted peatlands accumulate new peat and store significant amounts of carbon. Cultivating cattail and reed within them supports biodiversity by creating valuable habitats and improves water quality through nutrient retention. These wetland plants supply renewable raw materials for e.g. textiles and construction, offering economic opportunities to local communities and farmers. However, it is crucial to avoid excessive harvesting to prevent disruption of habitats vital for aquatic species.[45,46]

Renewable & biodegradable materials with multipurpose uses

Plant fibres are inherently biodegradable, which can support circular material flows and enable sustainable end-of-life options and mitigate fossil based microplastics. However, the biodegradability of final products depends on how fibres are combined with other materials, as well as on processing and finishing methods.

In addition, plants we source fibres from are very versatile often also giving food, feed, medicine, and building materials, enhancing overall resource efficiency. The wide range of applications for plant fibres further strengthens their potential environmental and social value across diverse sectors and value chains.

Repurposing extraction waste in a biorefinery approach

Processing plant fibres generates large volumes of solid and liquid by-products that can be transformed into value-added materials. Nutrient-rich wastewater can be treated and reused to produce organic fertilisers, support algae farming, or reduce the toxicity of textile effluents by fuelling microbial pollutant degradation.[47,48] Solid residues from fibres like sisal, pineapple, and banana can be converted into bioenergy, soil conditioners such as biochar, paper, or animal feed.[49,50] A biorefinery approach not only minimised pollution but also enhances the economic and environmental value of fibre production, with opportunities applicable across the full range of plant fibres discussed in this report.

Fostering rural development

Plant fibres can significantly advance rural development by diversifying income, creating local jobs, and supplying affordable materials for local use and export. Their cultivation and processing stimulate small enterprise

The value of plant fibres

Environmental & Climate Resilience

- Enhancing biodiversity and soil health through regenerative agriculture
- Replenishing marginal lands
- Utilizing agricultural waste to reduce harmful waste management practices
- Controlling infestations
- Rewetting peatlands

Renewable & Circular Material Systems

- Renewable raw materials
- Biodegradable
- Multipurpose use of all parts of the plant
- Extraction waste can be repurposed in biorefinery approach

Social Impact & Rural Livelihoods

- Fostering rural development
- Preserving culture and heritage
- Creating livelihoods for small producers

growth and foster innovation in farming and manufacturing. With favourable climates, rich biodiversity, and strong traditional knowledge, especially the Global South is well positioned for competitive fibre production. Strengthening value-added processing and market access can further boost economic resilience and inclusive rural growth.

Preserving culture and heritage

Plant fibres carry deep social and cultural significance. In rural areas and for many Indigenous Peoples, fibres remain essential to household economies, traditional crafts, and cultural identity. Activities such as weaving, basketry, and ropemaking not only provide livelihoods but also preserve ancestral knowledge. In many regions of the Global South, plant fibres continue to support domestic resilience, offering affordable, accessible materials for daily use and export. At the same time, fibres represent material culture and heritage, increasingly recognised as assets for sustainable, locally grounded development.

Creating livelihoods for small producers

Small producers—Indigenous Peoples and Local Communities, smallholders and women-, and youth-led enterprises—often serve as key innovators and leaders within fibre-producing regions. Their participation in cultivation and processing enables them to build sustainable livelihoods, develop entrepreneurial skills, and access higher income.[38] Targeted support and investments in these producers not only enhance rural development and community resilience but also help modernize the industry and integrate diverse actors into global value chains, ensuring more inclusive and equitable growth across the plant fibre sector.

Sisal, banana smallholding, source: Signature Message / Shutterstock

Certifications and traceability

Supply chain transparency is increasingly important due to evolving regulations and growing corporate accountability for Environmental, Social, and Governance (ESG) performance. Certifications and traceability systems can enhance credibility and access to global markets, yet adoption remains limited in the alternative plant fibre industry.

One key challenge is the scarcity of fibre-specific standards compared with cotton. The technical diversity of natural fibre sources—including cultivated fibre crops, wild plants, agricultural residues, and biomass crops—combined with varied production systems, makes standards difficult to design and enforce across regions. In addition, there is confusion within the industry. Farmers do not know which certificates they should acquire to generate the right market interest, and brands do not know which certificates are available.

A few fibre-specific schemes exist, such as the Responsible Hemp Standard, European Flax Certification, and the Abaca Code of Good Agricultural Practices. Plant fibres can also be certified under adjacent frameworks, including general textile standards, biobased content standards, social and facility standards, and environmental and safety management systems. A good example of an effort to adapt an existing mainstream standard to plant fibres was the 2017 Abaca Sustainability Initiative which aligned abacá best-practice guidance with the Rainforest Alliance's Sustainable Agriculture Standard and the Sustainable Agriculture Network.[51] The table provides

Overview of certifications and traceability standards applicable to plant fibres. Information based on publicly available documents by standard bodies. *It can be possible that information is missing or outdated.*

		Parameters Covered					
Specific fibre type or type of certification	**Name**	Origin	Quality	Environmental Sustainability	Social Responsibility	Traceability	Chemical Safety
Abacá	Non-food crops - Abaca - Code of Good Agricultural Practices (GAP), PNS/BAFS 266:2019, ICS 65.020		●	●	●		
Abacá	Abaca Sustainability Initiative (Rainforest Alliance / SAN-based)			●			
Hemp	Certificate of Sustainability (Ocacia)			●		●	
Hemp	Responsible Hemp Standard (RHS)	●		●	●		
Flax (Linen)	European Flax Certification	●	●	●	●	●	
Biobased content	RSB Standard	●		●	●	●	
Biobased content	ISCC (International Sustainability & Carbon Certification)	●		●		●	
General Textile / Content Standards	GOTS (Global Organic Textile Standard)	●		●	●	●	
General Textile / Content Standards	OCS (Organic Content Standard)	●		●		●	
General Textile / Content Standards	Regenerative Organic Certification	●		●	●		
Social & Facility Standards	Fairtrade Textile Standard			●	●		
Social & Facility Standards	SA8000				●		
Social & Facility Standards	WRAP (Worldwide Responsible Accredited Production)				●		
Social & Facility Standards	SMETA (Sedex Members Ethical Trade Audit)				●		
Environmental / Safety Management	ISO 14001			●			
Environmental / Safety Management	OEKO-TEX Standard 100			●			●

an overview of fibre-specific standards and adjacent schemes, including parameters covered. Feasibility should be assessed in detail, as limitations may exist. The alliance can provide further guidance on which standards are practical and commonly used for specific fibres.

Limited adoption of certifications and traceability systems is also driven by the volatile market demand, price fluctuations, and the predominance of smallholder farmers in the sector. Certification involves substantial upfront and recurring costs that many smallholders cannot afford, and potential economic benefits, such as price premiums, are frequently uncertain or insufficient, particularly in the short term.[52] It is also important to note the paradox that it is mostly the small start-ups and traditional producers that cannot afford formal certification but build their businesses on inherently sustainable practices. Many have therefore implemented internal traceability systems to document their value chains and sustainability performance, which should be aknowledged, particularly in the early stages.

To move the sector forward, more tailored certification pathways and traceability systems for alternative plant fibres are needed, alongside targeted financial and capacity support for small producers. Combining technical fit, pragmatic cost-sharing mechanisms, and market development will improve the likelihood that plant fibres can scale within certified value chains.

Rwandan woman cutting sisal, source: Sarine Arslanian / Shutterstock

Recommendations and outlook

Pineapple leaf fibre handling, source: Ananas Anam

Recommendations

This chapter outlines recommendations* for producers, industry partners, policy makers, investors and researchers to work together to promote the sustainable growth of the plant fibre sector and reimagining these traditional materials as modern, strategic resources for the circular bioeconomy. The aim is to ensure that fibre production systems actively contribute to sustainable development in economic, social, and environmental terms.

The following recommendations address both operational challenges that can be advanced in the near term and structural and environmental barriers that require longer-term policy alignment, investment, and systems change.

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* These recommendations build on recommendations already formulated in the 2023 UN Resolution on natural plant fibres and on the report “From waste to value, upcycling agricultural residues for sustainable textiles“ by the Sustainable Manufacturing and Environmental Pollution programme (SMEP) and UN Trade and Development (UNCTAD).

Addressing operational & supply constraints (short term)

The sector faces unstable quantity and quality of supply, processing and technology gaps, and limited traceability and data. Strengthening capacity from farm to market requires coordinated action among producers, researchers, industry partners, and local authorities to make fibre systems more resilient, inclusive, and reliable.

- **Build producer capacity and supply chain resilience.** Local authorities and researchers should aim to strengthen smallholder farmers and cooperatives through training, nurseries, and extension services to improve consistency and quality of fibre supply. Collective bargaining and transparent pricing mechanisms also need to be supported. Where appropriate, integrate plant fibre production into biorefinery approaches that valorise processing by-products (e.g. organic fertiliser, bioenergy) to close resource loops and improve economic viability.

- **Centre smallholders, Indigenous Peoples & Local Communities, women, and youth.** All stakeholders should recognise the role of these crucial groups in the production, use, and conservation of plant fibres. Build equitable markets that respect cultural heritage while enabling fair economic opportunity, and scale the sustainable production and use of plant fibres in ways that uphold community rights, consent, and agency.

- **Accelerate collaborative innovation in processing and technology.** Form consortia of producers, researchers, and industry partners to jointly plan R&D, processing pilots, and scaling, and incentivise cross-disciplinary research in sustainable fibre production and processing technologies. Facilitate North–South and South–South partnerships to share best practices, enable open technology transfer, and replication of successful models.

- **Develop technical standards.** Producers are encouraged to create and harmonise technical standards that cover fibre identification, grading, and performance characteristics suitable for textiles, pulp and paper, composites, nonwovens, or construction. Standardisation reduces variability, lowers transaction costs, improves compatibility with industrial processes, and builds confidence among manufacturers who need reliable performance specifications before integrating plant fibres at scale.

- **Strengthen environmental and social conditions and create transparency.** Producers and local authorities should consider promoting fair wages, safe working environments, and the formalisation of informal labour, while supporting alignment with international labour standards and community-defined expectations. Develop simple and accessible transparency mechanisms without creating disproportionate burdens for small producers. Expand data collection on environmental impacts and social performance—supported by LCAs and related assessments—to verify sustainability claims, support responsible sourcing, and build trust among buyers and consumers. Encourage the creation of tailored certification schemes for plant fibres.

Addressing structural constraints and environmental barriers (long term)

Most of the persistent barriers to scaling plant fibres lie outside the control of producers and industry partners but significantly impact their ability to invest, grow and create resilient production systems on an operational level. Creating more market demand, investment appetite and favourable regulatory frameworks are long term challenges which shape investment decisions and the feasibility of long-term supply relationships.

- **Strengthen market demand.** Producers are encouraged to demonstrate the performance and commercial viability of plant fibres through pilots, certification pathways, and application-specific testing to increase buyer trust. Promote market intelligence tools—pricing data, performance benchmarks, and volume forecasts—to reduce uncertainty for manufacturers evaluating fibre alternatives. Industry partners play a key role in supporting the development of stable offtake agreements and long-term purchasing commitments that give producers and processors the confidence to invest in capacity, technology, and regenerative practices.

- **Mobilise funding and investment for infrastructure and R&D.** Producers are encouraged to address the persistent financing gap by mobilising funding from public, private, bilateral, and multilateral sources, as well as blended finance and alternative mechanisms. Promote plant fibres as strategic materials within national and corporate bioeconomy strategies to attract long-term capital. Investors should consider supporting investments in processing infrastructure, machinery upgrades, and regional pilot facilities.

- **Improve industrial integration.** Industry partners are encouraged to adopt an open and collaborative mindset toward integrating plant fibres into existing production systems. Together with producers work on performance testing, material characterisation, and application-specific R&D that reduce technical uncertainty. With regards to ESG goals, industry partners should work towards fair certification cost-sharing models that do not disproportionately burden small producers and allow the use of alternative verification methods where third-party certification is not feasible.

- **Remove policy and regulatory barriers.** Policy makers are invited to recognise plant fibres as contributors to sustainable agriculture, biodiversity, food security, and climate resilience, and integrate them into national and sectoral policies. Introduce targeted tariff lines and, where appropriate, new HS Codes to improve market transparency and facilitate trade. Reform technical standards and performance benchmarks so they reflect plant fibre properties and do not unfairly favour conventional materials. Establish clear fibre classifications and labelling systems to strengthen market visibility. Create a level playing field for plant fibres and conventional materials through the recognition of microplastics, biodiversity, and social factors in impact assessment methodology. Expand public procurement and domestic incentives that prioritise low-impact, biobased alternatives across automotive, construction, packaging and textiles

- **Address climate risks and promote resilient production systems.** Researchers and local authorities can play a key role in supporting agronomic research focused on climate-resilient varieties, water-efficient cultivation practices, and agroecological approaches suited to different fibre species. In addition, promote production systems that enhance soil health, protect biodiversity, reduce water use, and prevent deforestation. Foster recognition of plant fibres within payments for ecosystem services (PES) schemes and climate-finance programmes to reward regenerative production systems and improve financial viability.

- **Foster youth-led enterprises and modernisation.** Producers and policy makers are encouraged to support programmes that make fibre production and processing more attractive to younger generations, including technical training, entrepreneurship incubation, and improved working conditions. Encourage mechanisation and workplace improvements and strengthen intergenerational knowledge transfer while enabling young innovators to lead in digitalisation, processing innovation, and new business models.


Henequen handling, Mexico, source: Roberto Michel / Shutterstock

Conclusion and outlook

Plant fibres provide a renewable source of cellulose, deeply rooted in culture and with diverse applications across automotive, construction, textiles and pulp and paper industries. If cultivated and managed responsibly, their contribution to regenerative agriculture, landscape restoration and rural development makes them unique materials for a future bioeconomy.

Realising the full potential of plant fibres requires addressing the structural, operational, and environmental barriers that currently limit scale—ranging from cost competitiveness and inadequate processing infrastructure to gaps in transparency and fragmented or unfavourable regulatory frameworks. Overcoming these challenges will depend on coordinated action among producers—including Indigenous Peoples and Local Communities—industry partners, researchers, and policymakers to move beyond isolated efforts toward a more integrated and resilient sector.

In the short term, progress depends on strengthening the foundations of existing fibre systems: improving producer capacity, stabilising supply and quality, upgrading processing and technology, establishing technical standards, and enhancing social conditions and transparency. These actions address the operational constraints that limit reliability and market confidence today. Over the longer term, scaling plant fibres requires tackling the structural barriers that shape investment and demand—mobilising finance, improving industrial integration, reforming policies and standards, and supporting climate-resilient production systems.

This report lays the essential groundwork for deeper market analysis and synergies in the plant fibre ecosystem. Now, the path forward calls for a coordinated, strategic effort built on pre-competitive collaboration, knowledge exchange and shared best practices. As a global multi-stakeholder hub, FIBRAL exists to guide this transformation—by convening the ecosystem, generating vital information, and aligning investment toward a common vision. With unified action, plant fibres can become a cornerstone of a climate-resilient, regenerative, and equitable global bioeconomy.

Pineapple leaf fibre drying, source: Jahangir Alam Onuchcha / Shutterstock

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ANNEX I

Abbreviations and glossary

Abbreviations and Glossary

DNFI	**Discover Natural Fibres Initiative**
ESG	**Environmental Social Governance**
EUDR	**Regulation on deforestation-free products**
FAO	**Food and Agriculture Organization**
GHG	**Greenhouse gas**
JACKS	**Jute, abacá, coir, kenaf, sisal**
LCA	**Life Cycle Assessment**
MMCF	**Man Made Cellulosic**
MT	**Metric tonne**
NFC	**Natural Fibre Composite**
NTU	**National Textile University Faisalabad**
OEM	**Original Equipment Manufacturers**
PES	**Payments for ecosystem services**
PhilFIDA	**The Philippine Fiber Industry Development Authority**
R&D	**Research & Development**
SDG	**Sustainable Development Goals**
SME	**Small and Medium-sized Enterprise**
SMEP	**Sustainable Manufacturing and Environmental Pollution Programme**
TEK	**Traditional ecological knowledge**
UNCTAD	**UN Trade and Development**
PEF	**Product Environmental Footprint**

Agricultural residue: By-products of crop cultivation and harvest (e.g., stems, leaves, husks, stalks) that can be used as a fibre source without requiring additional land cultivation.

Conventional materials: Commonly used, established industrial materials such as fossil-based synthetic fibres, glass fibres, wool, and traditional cellulose sources like cotton and wood - that are often associated with significant environmental impacts.

Hard fibres: Tough, coarse, lignified fibres from leaves of monocots (like sisal, abaca, coconut) used for strong cordage, ropes, and coarse textiles.

Indigenous Peoples and Local Communities: Groups with historical, cultural, and territorial ties to specific regions, often maintaining traditional knowledge and practices linked to sustainable resource management.

Nature-based solution: Actions that protect, sustainably manage, and restore ecosystems to address societal challenges, such as climate change, biodiversity loss, and sustainable livelihoods.

Plant fibre: Elongated fibre cells which form the structural elements that give strength and shape to the tissue of stems, branches and roots, but also to softer tissues such as leaves, flowers or fruits. They can also develop on the inside of fruits and seeds.

Processing residue: By-products of plant fibre processing (e.g. liquid or solid waste in the form of waste water, sludge, hurds, leaves etc.) that can be used as a source for value added products such as compost, fertilisers, bioenergy etc.

Production scales: When referring to different production scales in this report, we refer to the following: Lab scale: 0 - 1 MT p.a., small scale: 1 - 10 MT p.a., medium scale: 10 - 25 MT p.a. and industrial scale: > 25 MT p.a.

Raw fibre: Plant fibres after primary extraction, for instance decortication, and before any further refinement processes to make them useable for e.g. spinning or pulping.

Regenerative practices: There is no single definition of regenerative practices, as these are highly context specific and nuanced. They can be described as agricultural practices that proactively restore and enhance soil health, biodiversity, water cycles, and ecosystem resilience while producing agricultural or fibre outputs.

Small producers: In this report summarised as smallholder farmers, Indigenous Peoples and Local Communities, women- family- and youth-led enterprises.

Traditional ecological knowledge: Longstanding, dynamic knowledge, practices, and beliefs held by Indigenous Peoples and Local Communities that guide sustainable relationships with ecosystems.

Wild plants: Non-cultivated plant species harvested from natural habitats, often used for fibres, food, medicine, or other cultural purposes, that grow without direct human cultivation.

ANNEX II

Methodology and disclaimer

Methodology and Disclaimer

FIBRAL has compiled this report with care, combining data collection, analysis, and cross-checking wherever possible. While every effort has been made to ensure accuracy and reliability, gaps and inconsistencies in global market data are common, and some figures required modelling or estimation. The report has been reviewed by a panel of experts from both industry and academia to strengthen its robustness and credibility.

Market size and value

Most of the data presented in this chapter comes from our partner organisation, the Discover Natural Fibres Initiative, which regularly collects and publishes market information on commercially produced plant fibres.

We added production data for raw pineapple leaf fibres as well as raw banana and plantain fibres for the years 2022–2025. This data is based on primary data collection from our member network and estimation through extrapolation. To further validate these estimates, we conducted expert interviews with leading suppliers of these fibres to understand the maturity and systems of this industry in major production countries. For the coming years we intend to broaden the scope of fibres for which we collect data.

For the market prices, we carried out a literature review to determine average ranges across fibre types. Where possible, member organisations also provided direct price estimates. It should be noted that these figures represent only indicative ranges: fibre prices vary significantly depending on region, season, and quality specifications.

Market trends by key applications

This analysis is primarily based on an extensive literature review. In addition, we hosted an industry roundtable with representatives from the composites, textiles, and pulp & paper sectors. The discussion focused on barriers, emerging trends, and high-potential applications.

The graphic "*Uses of plant fibres across sectors and applications*" is derived from a literature review and supplemented with internal expert knowledge. The concept builds on the approach used in the Textile Exchange report, which mapped applications for synthetics, MMCFs, and animal fibres; here, we extended the scope to include the range of fibres covered by Fibral. The estimates should be considered indicative only: due to limited availability of detailed data, the graphic provides a rough approximation intended to illustrate potential applications rather than precise market shares.

Market trends by region

The regional analysis is also largely based on literature review, with supplementary data and insights provided by alliance partners in selected markets.

Market drivers and trends

To better understand the challenges and opportunities facing fibre producers, we conducted an online survey among our member network. Respondents—primarily fibre producers—highlighted the drivers they see as most influential. These findings were further complemented by a targeted literature review and expert consultations.

ANNEX III

Major end users

Major End Users

The following chapter will give an overview of the major end users of plant and other natural fibres. This list is by no means exhaustive and just a start to map this ecosystem. Please reach out to us if your company is not listed and you would like it to be added.

List of major end users by product category **Fibral member*

Company Name	Country of Production	Plant fibres and other natural fibres used
1a. Yarn		
Asiatex mills	Philippines	Abacá, pineapple
Din industries	Pakistan	Various plant fibres
Hilaturas Arnau	Spain	Various plant fibres
Sambandam Spinning Mills Ltd.*	India	Various plant fibres
Sapphire	Pakistan	Various plant fibres
Tearfil	Portugal	Various plant fibres
1b. Fabrics		
Bananatex*	Switzerland	Abacá
Fashion Link*	Vietnam	Various plant fibres
Green Whisper*	India, France	Banana
Pyratex*	UK	Various plant fibres
Pangaia*	UK	Various plant fibres
The Shaba*	Kenya	Sisal
1c. Vegan leather		
Ananas Anam*	Spain, Philippines	Pineapple
Banhide*	India	Banana
Borganb	Germany	Various plant fibres
District leather supply	USA	Hemp
Malai Biomaterials Design*	India	Coir and other plant fibres
Pinogreen	China	Pineapple
Planet of the Grapes*	France	Grape Vine
Revoltech	Germany	Hemp
Tomtex	USA	Various plant fibres

Company Name	Country of Production	Plant fibres and other natural fibres used
2. Bedding		
Buitex	France	Cotton, Jute
Enkev	Netherlands	Coir, Sisal, Hemp, Flax
Ko-Si	Slovenia	Coir, Sisal, Hemp, Flax
Nowofill	India	Bamboo, Kapok
Polfelt	Poland	Coir
Pyarelal Group	India	Coir
Rubco	India	Coir
3. Insulation		
Buitex	France	Cotton, Jute
Ekolution	Sweden	Hemp
Gutex	Italy	Wood
Hempitecture	USA	Hemp
Hunton	UK	Wood
Indinature	UK	Hemp
Isovlas	Netherlands	Flax
Saint-Gobain	France	Hemp, Wood, Cotton
Sisalwool	UK	Sisal
Steico	UK	Wood
Thermo Hanf	Germany	Hemp, Jute
4. Natural Fibre Composites		
Biofibix	Belgium	Flax
BMW	Germany	Various plant fibres
Changchun bochao auto parts Co., Ltd	China	Various plant fibres
Daimler-Chrysler (Mercedes Benz)	Germany	Various plant fibres

Company Name	Country of Production	Plant fibres and other natural fibres used
4. Natural Fibre Composites (continued)		
Ecotechnilin	France	Flax
Edward Clay & Son	UK	Hemp, Cotton, Jute
Egyptex (Mahmoud El-Tallawi)	Egypt	Various plant fibres
Flexform Technologies	USA	Various plant fibres
Forvia	Spain	Pineapple and other plant fibres
Tecnaro	Germany	Flax, Hemp and other plant fibres
Toyota	USA	Various plant fibres
Twe Group	Germany	Kenaf, Flax, Hemp, Cotton
Vepa	Netherlands	Hemp, Jute
5. Pulp and Paper Products		
Adhi Annam Coir Comforts Pvt. Ltd.	India	Coir
Ahlstrom-Munksjö	Finland, UK, USA	Abacá and other plant fibres
Albay-Agro Industrial Devel-opment Company (ALINDECO)	Philippines	Abacá and other plant fibres
Cafec Sanyosangyo	Japan	Abacá and other plant fibres
Celesa Pulp	Spain	Abacá and other plant fibres
Delfortgroup AG	Austria	Abacá and other plant fibres
Eco:fibr*	Germany	Pineapple
Bioware*	Costa Rica	Banana
Magnera	Germany, Philippine, USA	Abacá and other plant fibres
Mativ Holdings, Inc. group	North America, Europe, Asia	Abacá and other plant fibres
Miquel y Costas	Spain	Abacá and other plant fibres

Company Name	Country of Production	Plant fibres and other natural fibres used
5. Pulp and Paper Products (continued)		
Pulp Specialties Philippines, Inc.	Philippines	Abacá and other plant fibres
Purico Group	Germany, UK	Abacá and other plant fibres
Specialty Pulp Manufacturing, Inc.	Philippines	Abacá and other plant fibres
Suominen	Finland, USA, Italy, Spain, Brazil	Abacá and other plant fibres
Terranova Papers	Spain	Abacá and other plant fibres
Twin Rivers Paper Company	USA, Canada	Abacá and other plant fibres
Zhejiang KAN Special Paper Co., Ltd.	China	Abacá and other plant fibres

Category	Company Name	Country of Production	Plant fibres and other natural fibres used
6. Other Products			
Growing mats	Holland Bioproducts	Netherlands	Jute
Technical textile	Polyflies	Germany	Various plant fibres
Home textiles	Williams-Sonoma, Inc.*	USA	Various plant fibres
Shoes	Wildling*	Germany	Germany