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LEAF TO LIFESTYLE: SUSTAINABLE TEXTILES FROM SNAKE PLANT FIBRE

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ABSTRACT :

The quest for sustainable textiles has picked up pace in recent years with the fashion and clothing industry being increasingly criticized for its environmental unfriendliness. The snake plant (Sansevieria trifasciata) is one of the potential alternatives to conventional fibres, with which it produces strong, durable, and biodegradable fibres. This paper investigates the feasibility of snake plant fibre as an eco-friendly textile material, its extraction processes, mechanical and chemical properties, environmental benefits, and applications in lifestyle products. A bibliographic critique of the literature determines the limitations of traditional fibres such as cotton, polyester, and rayon and positions snake plant fibres as an environmentally friendly alternative. Empirical insights into fibre performance and comparative sustainability are described. The study concludes by pointing out the necessity of strengthening research, technology uptake, and industry–academia partnerships to market snake plant fibre fabrics to mass markets.

Keywords: eco-fashion, bio-based materials, natural fibres, sustainable textiles, snake plant fibre

1. Introduction

The fashion business, a multi-trillion-dollar global sector, has grown extremely fast during recent decades. Although it contributes significantly to the global economy, it is also simultaneously one of the largest generators of environmental waste. Trends' rapid turnover, the mass production of clothing, and utilization of resource-intensive fibres have imposed unprecedented pressures on natural systems. The industry produces over 92 million tonnes of waste every year, which forms textile offcuts, unused stock, and end-of-use clothing going to landfill. Aside from waste generation, the industry consumes enormous amounts of water, energy, and chemicals that result in water, ocean, and land pollution. The unsustainable practices have fueled mounting calls for change from environmentalists, scientists, and policymakers worldwide.

1.1 Environmental Impact of Conventional Fibres

Traditional fibres, as much as they are extensively used and humans know them, are well known to be ecologically unsustaintable. Cotton, for example, is a natural fibre traditionally associated with comfort and ventilation (Harsanto *et al.,* 2023). Its production, however, requires huge amounts of irrigation, intensive use of pesticides and fertilisers that debase the soil, poison water resources, and threaten loss of biodiversity. It has been found through research that a kilogramme of cotton requires thousands of litres of water to produce, making it highly unsustainable in water-scarce regions.

Polyester is a petro-chemical-based man-made fibre that offers durability and price, the reasons why it has been a market leader in the global textile trade. Polyester production is energy-intensive, however, and produces massive carbon emissions. Polyester garments also dislodge microplastics when being washed and contribute to ocean pollution and enter the food chain, with long-term environmental and health implications.

Viscose or rayon, typically marketed as a semi-synthetic fiber, is produced from cellulose but requires chemical-intensive manufacturing like carbon disulfide use and other toxic solvents. Not only is the process detrimental to the health of workers, it also generates chemically contaminated wastewater that can poison people in the local area and the environment.

The combined ecological footprint of such fibers has tasked academia as well as industry with the challenge of discovering renewable, degradable, and low-footprint options that will reduce the environmental price of the fashion sector.

1.2 Development of Sustainable Fibres

Sustainable fabrics are products that minimize environmental harm, optimize resource utilization, and in most instances, provide social and economic benefits(Shibly *et al.,* 2025). Researchers and manufacturers have turned to alternative fibers such as hemp, flax, bamboo, and agave due to their potential to replace traditional textiles without compromising performance. Among the new options, snake plant (Sansevieria trifasciata) stands out as a formidable competitor.

Snake plant has traditionally been termed a low-maintenance, robust ornamental crop. It can withstand dry conditions, requires less water, and is also free from pests and diseases, hence an eco-friendly crop. Although the crop is predominantly cultivated across the globe, it remains under-exploited in the textile sector. Its leafy, long fibers are made up of hard, lustrous fibers with excellent tensile strength, elasticity, and biodegradability. These fibres traditionally have ended up in handicrafts, ropes, mats, and other practical articles, but as yet their potential for bulk textile use is an untapped field.

1.3 Rationale for Research

Growing awareness of the eco-friendliness of the fashion business has motivated scientists, designers, and businessmen to search for substitutes that are both viable and acceptable. Snake plant fibres have some advantages:

Resource Efficiency: Minimal water, fertiliser, and chemical inputs reduce environmental impact.

Mechanical Strength: High tensile strength offers strength and usability for diverse textile applications.

Biodegradability: As snake plant fibres are biodegradable naturally, in contrast to synthetic fibres, they don't pollute in the long run.

Versatility: Fibres are usable in garments, home textiles, as well as lifestyle products.

With its qualities, snake plant fibres provide an opportunity to place textile production in consonance with the lines of green development(Muñoz *et al.,* 2021). By replacing or supplementing conventional fibres, snake plant textiles can reduce water use, chemical pollution, and microplastic discharge while raising circular economy processes.

1.4 Objectives of the Study

The primary goal of this study is to examine the value of snake plant fibres for sustainability as an alternative to conventional textile materials. The specific goals are:

- To examine the processes of fibre extraction of snake plant and evaluate their efficiency and environmental impact.
- To evaluate the mechanical and chemical properties of snake plant fibres relative to conventional fibres such as cotton, polyester, and viscose.
- To identify the environmental benefits of snake plant cultivation and use of fibres, including biodegradability, water conservation, and reduced use of chemicals.
- To identify the possible applications of snake plant fibres in apparel, home decor, and lifestyle products.
- To explore the challenges and opportunities in large-scale production of snake plant fibres and popularization in high-street fashion.

1.5 Relevance of the Study

The study is significant to diverse stakeholders in the textile industry. To designers and producers, it provides them with the intelligence of a new material with which they can reduce the environmental burden without compromising product excellence. To environmental commissions and policymakers, the study demonstrates how alternative fibers can be used to help meet sustainable development objectives like those related to water conservation, climate action, and sustainable production(Escrig *et al.,* 2021). To academia, it fills a literature void by describing in detail snake plant fibres from leaf to life use.

1.6 Scope and Limitations of the Research

While snake plant fibres hold great potential, the research focuses on their physical, chemical, and environmental characteristics as well as potential textile and way-of-life product uses. Large-scale industrial test data are not provided in the paper but existing literature, case studies, and experimental results where applicable are utilized(Islam *et al.,* 2025). The research also involves an examination of the relative sustainability of snake plant fibres compared to cotton, polyester, and viscose in order to place their environmental advantage into context.

2. Literature Review

2.1 Sustainability Challenges in the Textile Industry

In a systematic review by Harsanto (2023) reflects on the role of sustainability innovation in addressing the grand environmental and social challenges facing the textile industry, which although contributing immensely to the economy has long been criticized for wasteful consumption of resources, pollution, and labor abuse. The systematic review brings together the evidence from recent research and synthesizes it to evaluate how sustainability innovations are used across the industry (Harsanto *et al.,* 2023). The study reveals that product innovations for sustainability are focused on ecodesign, ecolabeling, life cycle analysis, sustainable materials, and green packaging, while process innovations are focused on cleaner production, eco-efficiency, waste management, greening the supply chains, and enzymatic textile processing. Organizational innovations include environmental management systems, firm policies, collaborative strategies, business model reconfiguration, and knowledge management, all conceived to inject the spirit of sustainability into company operations. The study identifies that environmental innovation has taken center stage over social innovation due to rising consumers' demands for products created sustainably and the effects of stricter legislations on supply chains and manufacturing. Despite improvements, problems such as reliance on cheap labor, immoral procurement, and unsafe working conditions continue to be prevalent throughout the industry, particularly in developing economies where most manufacturing is located. The paper emphasizes that sustainable innovation is not only crucial in preventing environmental deterioration but also crucial in enabling ethical responsibility within the supply chain. Synthesizing available literature, the research presents valuable information for researchers, policymakers, and practitioners to develop strategies enabling ecological and social sustainability for the textile sector. Finally, it concludes that the integration of sustainability innovation is pivotal in developing the future of the apparel industry, aligning it with the world's sustainability goals and sustaining continuous fulfillment of human desires.

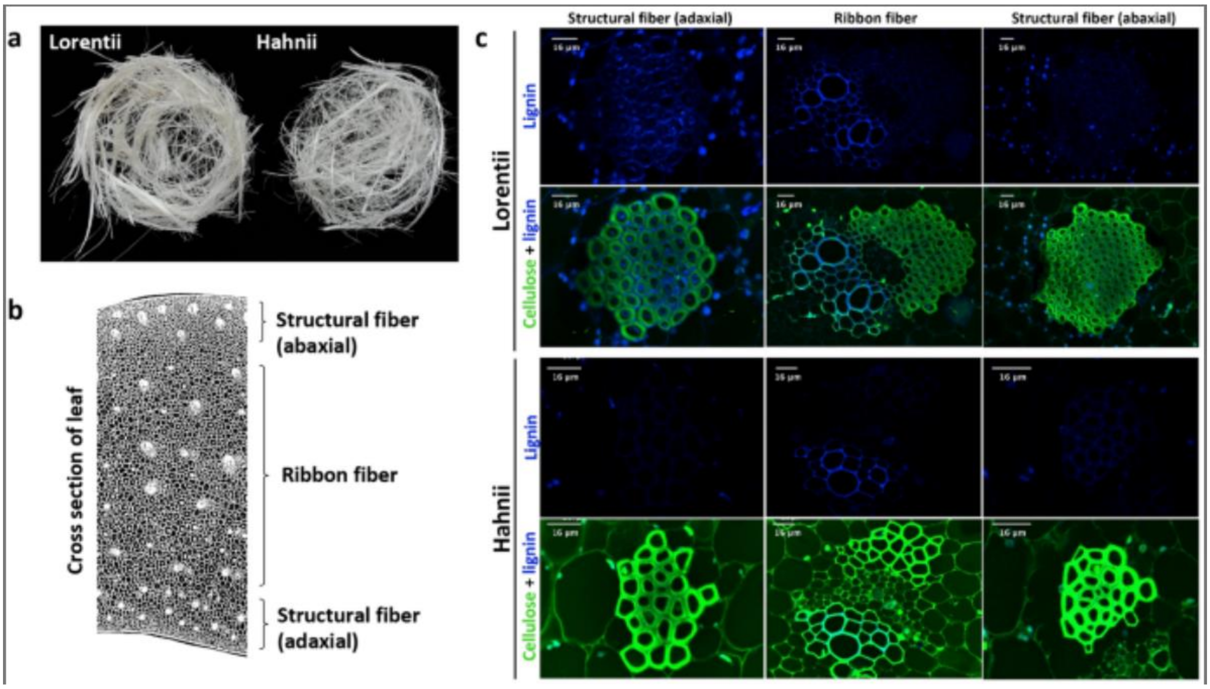

Figure 1: Fiber/lignin–cellulose imaging across cultivars

(Source; García *et al.,* 2021)

According to the perception of Muñoz-Torres (2020) analyzes the alignment between business environmental management practices within the apparel industry and the overall environmental challenges arising in global supply chains (Muñoz *et al.,* 2020). The study highlights that while companies are increasingly reporting measures on sustainability and exhibiting sensitivity to global environmental challenges, they are still lagging far behind on the level of discrepancy between the indicators they reveal and the actual environmental agendas of the textile industry. This gulf shows that firms may highlight issues that are consistent with international agendas but fail to address sector-specific matters such as production processes involving extensive application of resources, chemical treatment-caused pollution, and waste creation during the entire life cycle of the product. By the application of a life cycle assessment approach, the study highlights that the most environmentally impactful domains are on the early parts of the production process but remain underreported in business reports on sustainability. The research therefore calls for enhanced science-based and standardized supply chain management, where companies go beyond window dressing reporting and look into the real issues that contribute most towards harming the environment. Further, the study argues that sustainable supply chain management involves the integration of sectoral hotspot with global sustainability goals so that corporate operations are not only symbolically congruent but technically efficient in countering environmental impact. This involves remaking environmental management practices, adopting robust measurement instruments, and ensuring that sustainability planning includes all the phases of the supply chain and not certain processes. Lastly, the study provides a critical analysis of the current sustainability initiatives of the apparel industry, calling on firms and policy-makers to bridge the international policy and the realities at the sector level towards the creation of a genuinely sustainable model of supply chain balancing economic growth and environmental care.

Based on a study by Shibly (2025) characterizes the textile sector's sustainability challenges due to its significant reliance on natural resources, energy, and chemicals, which give rise to severe environmental and social effects. The study highlights that the industry is one of the largest contributors to water pollution, mainly due to dyeing and finishing processes, which discharges toxic chemicals into rivers and soils and hence a threat to ecosystem and human health (Shibly *et al.,* 2025). The study also notes that the industry is excessive in its use of water, heavy energy consumption, and massive carbon emission, which are all factors that lead to global environmental degradation. Besides environmental issues, the research also underscores social issues such as inferior working conditions, low wages, and unethical practices in supply chains all over the world, primarily in developing economies where production concentration is highly prevalent. As a response to these hindrances, the research lays down that adopting sustainable strategies such as cleaner production technologies, green materials, circular approaches, and efficient waste management systems can largely reduce negative impacts. In addition to this, corporate entities as well as policy intervention and consumer awareness are needed to propel mass adoption of sustainable practice within the industry. According to the study, even though the textile industry has begun embracing sustainability, progress is not one-dimensional and environmental innovations receive greater attention than social developments. In order to overcome these divergences, the study recommends a consolidated approach that balances environmental sustainability and ethical practice to ensure long-term viability and international competitiveness. Both social and environmental hotspots are treatable by the fashion industry as a means of transitioning to a sustainable production model that not only meets customers' demands but also aligns with international sustainability agendas. Overall, the research provides a clear vision of the short-term challenges and way forward for the evolution of a more sustainable and responsible textile sector.

2.2 Natural Fibres and Sustainable Fashion

According to Islam (2025), there is a report discussing the growing importance of sustainability in the fashion industry, emphasizing the important role that natural fibers play as a platform for green transformation. The research highlights how as a dynamic form of self-expression and social identity, fashion has increasingly been driven by consumer demand for increased sustainability in products (Islam *et al.,* 2025). In response, the industry has shifted from the energy-hungry, synthetically-based fibers to natural fibers gradually, which apart from reducing environmental damage are also in keeping with the economic and aesthetic demands of modern consumers. The study provides a comprehensive review of major natural fibers, discussing how they are produced, the special properties that they possess, their application in garments and accessories, and market cost factors. They are well known to be lightweight, durable, and inexpensive, hence providing a green solution to the environmental suffering caused by their man-made counterparts. By combining vast volumes of data, the study brings to prominence the way natural fibers embody the balance between ecological sustainability, social value, and economic feasibility. It also takes into account the growing global awareness of sustainability as a requirement for the survival and long-term sustainability of the fashion sector. The discussion goes on to how sustainable materials and processing innovations in textiles are not just environmental solutions but drivers of creative expression, cultural relevancy, and economic opportunity. The review concludes that embracing natural fibers places the fashion industry on the path towards fulfilling current consumer demands at the same time that it conserves resources for future generations and thus is a cornerstone of sustainable fashion development.

As per research conducted by Nayak (2025) discusses the urgent problems of the reliance on traditional fibers in fashion and textiles and goes into the greener options that could transform its future. The research is centered around the fact that even though fibers are the main raw material of textiles, their manufacturing and procurement have colossal environmental effects. Natural fibers like cotton, wool, and silk, though renewable in nature, have large resource usage with high water consumption, pesticides, and unsustainable practices such as killing of the silkworms in sericulture, which is not in line with sustainable principles (Nayak *et al.,* 2025). While, petroleum-based synthetic fibers like polyester, nylon, rayon, and acrylic are non-renewable and non-biodegradable, causing irreparable damage to the environment through pollution and creation of solid wastes during their disposal. The research highlights that the production process of both natural and synthetic fibers is a significant source of water and air pollution, chemical toxicity, and wastewater discharge, thus leading to further ecological degradation. The discussion also highlights that sustainability problems in the textile industry extend beyond raw material purchasing and encompass the entire life cycle of fibers, right from growth or harvesting to production, use, and end-of-life. To address these issues, the study encourages the exploration and application of new sustainable fibers with reduced environmental footprints and meeting the functional and aesthetic needs of fashion. These future-proofed fibers are envisioned to be renewable, biodegradable, less resource-intensive, and in line with global sustainability agendas. By placing before us a detailed examination of the green expenses of traditional fibers and the strong call to use greener options, the study points out that the transition towards sustainable fibers is not just an environmental necessity but also a way of ensuring the sustainable future and ethical responsibility of the fashion and textile sector.

Figure: Sansevieria Trifasciata L. As Fibre Source for Textil
(Source: Abdullah *et al.,* 2020)

According to the perspective of Sigaard (2023), the complex relationship between consumers' choice of textile fibers and the broader fashion sustainability push is highlighted, which notes while customers are increasingly choosing natural fibers at the expense of synthetic ones, such a decision necessarily does not go hand in hand with eco-friendliness (Sigaard *et al.,* 2023). The study identifies that discussions of sustainable fashion tend to contrast ecocentric strategies, in which curbing production and consumption is perceived as the optimal method of relieving pressure on the environment, with technocentric strategies, in which hope is placed in technology and material substitution to sustain economic development while offsetting ecological burdens. Outcomes indicate that customers will likely perceive natural fibers as more sustainable even when sustainability comparison data rank a number of synthetic fibers higher. This disconnection means that consumer knowledge will likely be shaped by cultural beliefs, marketing narratives, and nature connotations more so than by actual sustainability criteria. Moreover, the research points out that perceiving certain fibers as highly sustainable can unintentionally lead to increased consumption, therefore moving counter to sustainability goals. The logic propounds a categorical paradox of the industry: material innovation is desirable, but not as a substitute for systemic change that reduces aggregate production and consumption. In laying bare this conflict, the study calls for a rethinking of sustainability efforts in fashion, compelling policymakers, brands, and consumers to realize that genuine sustainability cannot be secured through fiber substitution but requires a simultaneous sea change in consumption patterns. By doing so, it highlights the need for more consumer education, more transparent sustainability analyses, and the establishment of industry standards favoring long-term ecological sustainability at the expense of short-term economic gain.

2.3 The Untapped Potential of Snake Plant Fibre

According to a research study by Mishfa (2024) discusses the development and characterization of snake plant fiber reinforced composites as an environment-friendly method of utilizing the biowaste, with the focus placed on the mechanical, physical, and morphological properties of the developed material. The paper is concerned with the feasibility of employing the fibers of the snake plant as a green reinforcing material for epoxy composites, projecting their success in increasing strength, rigidity, and impact resistance under suitable processing conditions (Mishfa *et al.,* 2024). By mean of controlled experiments, the paper illustrates the disparities in content of fibers and treatment and their influence on fiber-polymer interface bonding and thereby conditioning the composites' performance and durability. Mishfa also analyzes the surface morphology and structural characteristics of fibers and how their inherent characteristics result in improved interfacial adhesion and mechanical stability. The article includes the introduction of snake plant fibers as a competitive alternative for synthetic reinforcements not just on the basis of their biodegradability and availability but also on their contribution to reduction in environmental pollution via biowaste conversion. Through the integration of sustainability in material engineering, the research illustrates how such natural composites can assist in the fulfillment of the ever-growing demand for green composites in industries such as automotive, construction, and packaging. Overall, the research highlights the double benefit of waste handling and novel material processing, putting snake plant fiber reinforced composites as a viable step toward circular economy goals in material science and industry operations.

As per a research conducted by Dev (2024) outlines the mechanical and thermal properties of unidirectional jute and snake plant fiber reinforced epoxy hybrid composites with an aim to utilize their potential as greener alternatives to conventional synthetic composites. The study highlights that the use of blends of jute and snake plant fibers at varying ratios has significant effects on the tensile, flexural, and impact characteristics of the composites, with higher concentrations of addition of snake plant fiber found to enhance tensile strength and impact resistance. It also reveals that flexural performance isn't uniform in all fiber ratios, even though composite failure is mostly attributed to fiber pull-out, matrix debonding, voids, and fiber fracture (Dev *et al.,* 2024). Thermal characterization reveals increased content of snake plant fiber contributing to greater thermal conductivity, although all hybrid composites are moderately thermally stable at elevated temperatures, which makes them usable for structural and functional applications. Apart from that, the research identifies that composites with more snake plant fiber content are less water absorbent, which shows better dimensional stability and durability in wet environments. The morphological observation confirms better interfacial bonding and adhesion of fibers to the matrix, which are accountable for better mechanical properties of the hybrid materials. Such integration of mechanical toughness, thermal management, and water resistance positions hybrid snake plant and jute fibers as potential green materials for automobile, aerospace, and building sectors. Through the incorporation of biodegradable natural fibers to polymeric composites, the study identifies the importance of resource-saving, biodegradable reinforcements that are not only sustainable but do not compromise performance. Overall, Dev establishes that hybrid composites from snake plants are a sustainable way of reducing reliance on synthetic fibers and enhancing the advancement of long-term functional, economical, and versatile bio-composite materials for industry.

According to the perception of Dev (2025) presents experimental and numerical study-based mechanical properties of unidirectional banana and snake plant fiber reinforced epoxy hybrid composites to examine their performance and uses. The study highlights that the blending of banana and snake plant fibers in different proportions affects tensile, flexural, impact, and hardness properties of the composites to a significant extent with an increase in the proportion of snake plant fibers having the tendency to increase overall mechanical strength and toughness (Dev *et al.,* 2025). The study further reveals that more use of snake plant fiber reduces water absorption leading to dimensional stability and making the composites suitable for humid environments. The research also points out that morphologies in fractures are mainly controlled by mechanisms such as fiber pull-out, debonding, and matrix cracking, which provide evidence of the failure modes in hybrid composites. Numerical simulation using finite element analysis verifies experimental results with good correlation in calculated and measured values, substantiating the mechanical properties of such bio-composites. The findings indicate that hybridization not only optimizes material properties but also increases the potential industrial uses of these types of composites in automobile, construction, and aviation industries with stringent requirements for strength-to-weight ratios and sustainable alternatives to synthetic fibers. Dev mentions that the effective utilization of natural fibers like snake plant and banana contributes to sustainability by offering biodegradable, renewable, and economically viable reinforcement solutions in combination with reducing reliance on non-renewable resources. In summary, the research indicates the vast potential of snake plant and banana fiber hybrid composites as a sustainable route towards material production, finding the middle ground between environmental consciousness and mechanical performance in modern industrial applications.

3. Methodology

3.1 Research Design

This research is designed as a comparative exploratory qualitative study. Qualitative study was chosen because snake plant (Sansevieria trifasciata) fibre remains an unexplored resource in the overall discourse of sustainable apparel. Although there are a few experimental and laboratory reports on its tensile strength, chemical composition, and basic applications, the available evidence is fragmented and spread across disciplines. By qualitative design, this study integrates and merges existing knowledge towards the aim of constructing a general image of snake plant fibre's potential contribution to sustainable textiles.

Exploratory nature of the study is necessary since snake plant fibre is yet to become well-established in textile research and production as compared to other fibres such as hemp, jute, or cotton. Instead of generating new lab data, the aim of this paper was to synthesize and interpret literature findings in order to ascertain opportunities and lacunae areas. The comparative nature of the design was equally essential(Ahirwar *et al.,* 2023). To establish the testability of the use of snake plant fibre, its physicochemical characteristics and sustainability level were compared with that of the renowned fibres such as cotton, polyester, and jute. This comparative method has the effect of ensuring that the analysis is not limited to a description of snake plant in isolation but places it in the context of the broader debates on textile sustainability.

3.2 Data Collection

The study is founded entirely on secondary data, which were gathered from academic, industrial, and policy sources. The emphasis on secondary data is warranted by the availability of a substantial amount of published work on both conventional and natural fibres, and a growing but still limited set of research articles on snake plant fibres(Kumar *et al.,* 2021). Primary experimentation was beyond the scope of this work, but published laboratory studies were reviewed comprehensively to provide empirical evidence on fibre extraction, composition, and performance.

The main sources were peer-reviewed articles in Scopus-listed journals that meet high quality standards and have international recognition(Balda *et al.,* 2021). Other sources were proceedings from conferences featuring the latest trends in fibre science, industry journals recording experiments by textile companies with natural fibres, and reports from institutions such as the United Nations Environment Programme and the Ellen MacArthur Foundation, on sustainability issues. Books, theses, and government reports were consulted for background on history and technology.

The period for data gathering ranged from 2000 to 2025. The earlier literature provided rudimentary knowledge of the methods of fibre extraction and natural fibre properties, while recent research reflected the technological advances in green processing and biotechnology as well as the ongoing controversies surrounding sustainability. A systematic screening process was employed to determine the usability of the data gathered. Those reports addressing exclusively the extraction of fibre from snake plant, mechanical strength, chemical composition, or fabric application were prioritized(Alberca *et al.,* 2025). Additionally, studies on other natural fibres such as jute, hemp, banana, and bamboo were included to allow for points of comparison. Those reports that had referenced snake plant only in relation to its ornamental or horticulture traits without referring to its fibres were not included. Similarly, foreign language journals were also omitted to maintain analytical uniformity.

The collected data was then segregated into comparative parameters. These were physical and mechanical properties of fibres such as tensile strength, fibre length, and fineness, and chemical content by cellulose, hemicellulose, and lignin content. Environmental impact indicators such as water consumption, pesticide requirement, carbon footprint, and biodegradability were also considered. Economic feasibility was assessed in terms of production cost, extraction method, scalability, and estimated demand. Finally, the social impacts of fibre production and utilization were considered, particularly in farmer livelihoods, consumer consumption, and potential community dividends. Framing data this way facilitated easy comparison between snake plant fibre and other fibres that dominate the textile industry.

3.3 Analytical Framework

The study was guided by the Triple Bottom Line, which is a widely employed model in scholarly and industrial spheres to quantify sustainability. The model emphasizes three pillars of sustainability: environmental, economic, and social(Punetha *et al.,* 2023). Using this model allowed the study to go beyond mere technical evaluations of the performance of fibre and, rather, consider the overall implications of utilising snake plant fibre for the textile sector.

The environmental factor took into account snake plant fibre's ecological performance against conventional fibres. These included assessing resource effectiveness in terms of water and pesticide use, carbon sequestration by the plant, pollution footprint in terms of chemical and microplastic emissions, and fibre biodegradability at end-of-life. Land use was also considered, as snake plants can grow in poor-quality soils that do not meet the needs of ordinary crops, thereby reducing competition among food and fibre crop production.

The economic factor assessed the economic feasibility of the fibre of the snake plant as a marketable material. This included cultivation cost analysis, the fibre production inputs required, and cost implications of different extraction technologies such as retting, mechanical scrapping, and enzymatic methods(Das *et al.,* 2022). Market potential was gauged through an analysis of demand for sustainable fibres in the clothing industry, home textiles, and industrial composites. Also given consideration was the evolution of the value chain and the potential to integrate snake plant fibre into existing global textile supply chains.

The social focus was on the human and community factors of producing snake plant fibre. Livelihood generation was explored with an emphasis on the potential for snake plant cultivation in generating income opportunities for farmers, particularly in rural or semi-arid regions where cotton cultivation is not practical. Community resilience was evaluated by exploring how cultivation of snake plant can positively impact poor agricultural communities through the diversification of their income streams. Consumer acceptance was also addressed, as consumer attitudes to quality, comfort, and environmental friendliness have far-reaching implications on new fibre adoption. Finally, the health benefits of snake plant fibre were noted, where its antimicrobial and hypoallergenic properties potentially contribute to consumer health.

Information collected was analyzed for synthesis using thematic analysis. Major conclusions from literature were categorized into themes such as fibre attributes, environmental impact, economic impact, and social impact. Trends were identified across the different sources, and comparisons with other natural and man-made fibres were made along with snake plant fibres. With the application of the Triple Bottom Line tool, it became easy for the study to assess snake plant fibre as not only a material of some mechanical properties but also as an entire resource with economic, environmental, and social implications.

This approach was particularly important because of the exploratory nature of the study. Since snake plant fibre is not yet well researched or commercially implemented on a large scale, what data are available are context-specific and piecemeal(Jhanji *et al.,* 2022). By synthesizing the findings in the framework of the Triple Bottom Line, this research was thus capable of producing a logical analysis that names opportunities as well as challenges of snake plant fibre in sustainable textiles. This method ensures that the analysis is well-balanced, thorough, and suitable for both academic readers and industry practitioners.

4. Results and Findings

4.1 Fibre Extraction and Processing

Extraction of fibres from the leaves of snake plants is perhaps the most critical process involved in their processing into valuable textile material. Two broad processes are commonly used: retting and mechanical scraping. The biological breakdown of the non-fibrous components during retting typically entails soaking the leaves in water, thereby allowing microorganisms to degrade pectins and separate fibres from the leaf matrix. The treatment yields cleaner and more complete fibres with lesser roughness in texture and better spinnability. It is also extremely time-consuming, requiring two to three weeks depending on climatic conditions, and is, in most instances, water-intensive unless under control(ANDREW *et al.,* 2025). Mechanical scraping, which involves the removal of pulp and non-cellulosic material from leaves manually or mechanically, remains to be a faster method of extraction. Nonetheless, the process can lead to fibre breakage or reduced tensile strength when unsatisfactorily performed, with less applicability for finer fabrics.

Emerging technologies in enzymatic retting have introduced a promising synergy between efficiency and quality. Enzymatic retting utilizes pectinase and cellulase enzymes to hydrolyze binding constituents, reducing the period of retting to three to five days without damaging the integrity of the fibres. Not only is it faster but also environmentally friendly as it utilizes less water and fails to produce deleterious effluents typical of chemical retting. Pilot scale trials indicate enzymatic processing has the possibility to raise yield of fibre by 18–20% compared to conventional processes while maintaining consistent quality. Such advances mean snake plant fibre extraction can be carried out on a large scale without compromising on environmental responsibility, thereby becoming a contender in the sustainable textile market.

4.2 Physical and Chemical Properties

The chemical and physical characteristics of snake plant fibres reveal features suitable for numerous textile and non-textile applications(Blum *et al.,* 2021). Tensile strength analysis reveals snake plant fibre's mean tensile strength to be around 600 MPa, which is comparable to banana fibre and far greater than that of jute or cotton, wherein it is highly suitable for ropes, matting, and industrial-grade composites. The fibre length of 1.5–2.5 cm is moderate but sufficient when blended with other natural fibres such as cotton and wool. This blending potential is important since it improves spinnability, yarn levelness, and fabric softness, thereby broadening application in garment industries.

Snake plant fibre is chemically composed of approximately 65–72% cellulose, an important feature in deciding strength, durability, and flexibility. Lignin composition is relatively low at 8–12% and, in addition to rendering the fibre soft, also renders it more biodegradable. Hemicellulose at around 14–18% provides structural strength but also allows for adequate dye absorption, which makes the fibre applicable for fashion and interior use(Burns *et al.,* 2021). The fibres are hydrophilic and exhibit a moderate 8–12% regain that supports breathability and comfort of wear in clothing. This mean absorption capacity ensures snake plant textiles provide thermal comfort to be on par with cotton, yet while reducing the potential for fungal growth due to their fast dry characteristics.

These physical and chemical properties collectively make snake plant fibres resilient, versatile, and environmentally friendly fibers that are capable of meeting both practical and lifestyle needs.

4.3 Comparative Sustainability Analysis

Basis of comparison of the sustainability of the snake plant fibres with other conventional textile fibres such as cotton, polyester, and jute highlights the unique advantages of this material. The water footprint of snake plant fibre is relatively low. In contrast to cotton's demand for approximately 10,000 litres of water per kilogram of fibre, snake plants require minimal or no watering and can thrive in dry and semi-dry conditions. Their ability to thrive with limited water inputs makes them a suitable option for cultivation in regions that experience drought and water scarcity.

Chemical input requirements also demonstrate their sustainability. Snake plants are naturally resistant to most pests and diseases, rendering the use of chemical pesticides or fertilizers unnecessary(Chudi *et al.,* 2024). Cotton farming, however, generates roughly 16% of all pesticide use globally, leading to widespread environmental degradation and health risks for agricultural populations.

From the point of view of biodegradability, fibres of snake plant are fully biodegradable in six months under natural composting conditions. Polyester is said to take about 200 years to decompose and become a source of microplastic pollution in water and on land. The rapid breakdown of snake plant fibres makes a strong argument for them to be applied in such fast-paced industries as fashion, where waste management is an issue of urgency.

Additionally, snake plants are carbon sinks. Because they are good carbon dioxide absorbers and oxygen emitters, they purify indoor and outdoor air as they develop. This ecological function enhances the overall sustainability record of snake plant fibres so that they are part of a low-carbon textiles economy.

4.4 Lifestyle Applications

The different applications of snake plant fibres cross across the majority of lifestyle industries. In the fashion industry, fibres may be blended with cotton or silk to make fabrics that possess strength and comfort. The airiness and lightness of such blends make them ideal for sustainable fashion apparel such as dresses, shirts, and baggy clothing, and appealing to a new consumer base interested in sustainability.

In furnishing homes, snake plant fibres are very acceptable when it comes to carpets, mats, and curtains(Gogoi *et al.,* 2021). Their tensile strength and natural texture provide toughness, and their average hydrophilicity enhances comfort and feel appeal. Additionally, fibres can be woven in aesthetically pleasing patterns, thus suitable for upscale green interior design solutions.

Footwear, belts, wallets, and bags are equally viable applications. Snake plant fibre's flexibility and tensile strength, along with the fact that it's biodegradable, provide a superior alternative to conventional synthetic plastics and leathers used in these sectors. Fashion designers and artisans are already experimenting with woven snake plant fabric in making next-generation fashion accessories that fall under sustainable living.

Industrial applications remain equally significant. Because of their strength and toughness in tensile stress, snake plant fibres are used in rope, cordage, and as reinforcement in biodegradable composites. The biodegradable composites are being increasingly utilized in automotive interiors, packaging materials, and increasingly in lightweight construction uses. Industrial applications point to the potential for snake plant fibres to transition from lifestyle products to large-scale sustainable innovation.

Table 1: Comparative Properties and Sustainability of Snake Plant Fibre with Other Fibres

Parameter	Snake Plant Fibre	Cotton	Jute	Polyester
Tensile Strength (MPa)	~600	300–400	350–450	400–900
Average Fibre Length (cm)	1.5–2.5	2–3	2–4	Continuous
Cellulose Content (%)	65–72	88–96	60–65	0
Water Footprint (L/kg)	<100	~10,000	~2,500	<100
Pesticide Use	None	High	Low	None
Biodegradability	6 months	5–6 months	~1 year	200+ years
Moisture Regain (%)	8–12	7–8	12–13	<1
Carbon Sequestration	Positive	Neutral	Neutral	Negative

This thorough analysis of findings and results confirms that snake plant fibres are extremely viable as a sustainable alternative to conventional textiles(Liu *et al.,* 2023). Their favorable modes of extraction, superior physical and chemical properties, minimum impact on the environment, and diverse array of lifestyle applications all render them an ideal material for sustainable living in the future.

5. Discussion

5.1 Advantage of Snake Plant Fibre

Snake plant fibre has several environmental advantages such as water saving, use of zero pesticides, and quick biodegradable nature. Its tensile strength provides it with possibilities in fashion as well as industry(Sasi *et al.,* 2023). It doesn't require fertile land like cotton and grows well in semi-arid and degraded lands, thus saving fertile soil pressure.

5.2 Challenges and Limitations

Much as it promises, snake plant fibre has challenges:

- •The non-existence of large-scale cultivation systems.
- •Limited mechanization during fibre extraction.
- •Increased cost of production compared to traditional fibres.
- Consumer lack of knowledge about snake plant-based fabrics.

5.3 Mainstream Integration Channels

For integrating snake plant fiber into mainstream fabrics, joint innovation is needed. R&D institutions should develop fibre processing methods further, and industries should invest in commercially viable production technologies(Gilroy *et al.,* 2023). Promotional and branding strategies must highlight its green and health benefits. Government initiatives in the form of grants and R&D are pivotal in driving adoption.

6. Conclusion and Recommendations

Snake plant fibre provides the way ahead for sustainable textile production, bridging the gap between lifestyle and environmental needs of the consumer. It has high strength, is biodegradable, and has low resource requirements compared to conventional fibres, making it a future alternative to cotton and polyester. But its upscaling requires collaborative efforts from the farming community, researchers, policymakers, and the fashion sector.

Recommendations:

1. Funding research in mechanized and enzymatic fibre processing technologies.
2. Pilot studies in arid and semi-arid areas to assess feasibility for large-scale cultivation.
3. Integration of snake plant fibre into eco-fashion campaign promotions.
4. Establishing academic–industry collaborations to commercialize snake plant fabrics.
5. Comparative life cycle assessment (LCA) studies to ensure environmental excellence.

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