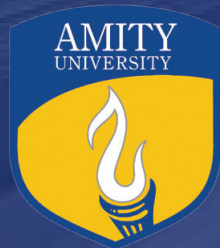


*Proceedings of  
International Conference  
on  
Fashion Apparel & Textiles 2023 (INCFAT'23)*

**THEME: "LiFE: Opportunities & Challenges for Fashion, Textiles & Design"**

**Date: 31<sup>st</sup> October 2023**



**Organized by  
AMITY SCHOOL OF FASHION TECHNOLOGY  
Faculty of Applied Arts/  
Fine Arts/Performing Arts/ Visual Arts  
Amity University Uttar Pradesh  
Noida-201313 (U.P) India**

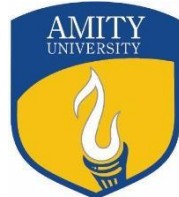
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***INCFAT' 23***

***Theme***

“LiFE: Opportunities & Challenges for Fashion, Textiles & Design”

*31<sup>st</sup> October 2023*  
**Amity University, Uttar Pradesh**

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## Message from Vice Chancellor



**Prof. (Dr.) Balvinder Shukla, Vice Chancellor, AUUP**

Patron- INCFAT'23

Professor – Entrepreneurship, Leadership & IT  
Vice Chancellor, Amity University Uttar Pradesh

I am delighted to learn that **Amity School of Fashion Technology** under Faculty of Applied Arts/Fine Arts/Performing Arts/Visual Arts, Amity University, Uttar Pradesh is organizing 7<sup>th</sup> “**International Conference on Fashion, Apparel & Textile 2023 (INCFAT'23)**” on the theme “**LiFE: Opportunities & Challenges for Fashion, Textiles & Design**” on 31<sup>st</sup> October, 2023.

INCFAT'23 is organized to deliberate on Fashion, Apparel and Textile Industry expectations from professional education in the field and to bring together academicians, researchers, and experts for facilitating, interaction and exchanging ideas for the same.

The climate has factually changed, with global warming wreaking its havoc around the world. Rivers are drying, glaciers are melting and many regions of the world are experiencing record-breaking temperature, inflicting much suffering all around. Against this backdrop of looming climate emergency, India has pioneered a homegrown initiative for sustainable and healthy lifestyle called LiFE – Lifestyle The LiFE action plan includes nudging individuals to practice simple yet effective environment-friendly actions in their daily lives (demand), enabling industries and markets to respond swiftly to the changing demand (supply), and to influence government and industrial policy to support both sustainable consumption and production (policy). LiFE as an international mass movement towards “mindful and deliberate utilization, instead of mindless and destructive consumption” to protect and preserve the environment through Fashion & Textiles.

In this context, I am confident that the informative sessions during the conference will be interactive, the participant will benefit immensely from the expertise and experience of eminent speakers from G20 countries.

I would like to express my appreciation and best wishes to all the participants for their active participation and valuable contributions to this conference. The knowledge and insights shared during the event will undoubtedly contribute to the advancement of research and innovation in the field of Fashion and Textiles.

My Heartiest congratulations to INCFAT'23 organizing team for organizing this conference on an important topic of academic interest and industry relevance.

My best wishes for the success of the INCFAT'23!

**Prof. (Dr.) Balvinder Shukla**

## Message by Conference Chairperson (INCFAT `23)



**Prof. (Dr.) Pradeep Joshi**  
**Group Addl. Pro Vice Chancellor**  
**Director General & Dean**  
**(Applied Arts/Fine Arts/Performing Arts/Visual Arts)**  
**Amity University**  
**&**  
**Conference Chair**

### Message by Conference Chairperson (INCFAT `23)

It gives me immense pleasure to welcome all delegates, industry members and esteemed speakers to online “**International Conference on Fashion, Apparel & Textile 2023 (INCFAT `23)**” (*theme “LIFE: Opportunities & Challenges for Fashion, Textiles & Design”*) being organized by **Amity School of Fashion Technology** under Faculty of Applied Arts/Fine Arts/Performing Arts/Visual Arts, Amity University, UP. Sub Theme(s) for technical session of INCFAT `23 are “Sustainable Fashion & Reuse, reduce and recycling in Fashion & Textiles & Emerging role of Digital Technologies and AI in Fashion & Textiles.

**INCFAT `23** proposes to deliberate on Innovation and Sustainability in Fashion & Textiles, Responsible Consumption and Production in Fashion & Textiles, Sustainable Materials in Fashion & Textiles, Smart Apparels and Sustainability in Luxury Fashion.

Textile and apparel sector is the most dynamic manufacturing sector where eternal demand for change keeps fashion alive. The Textiles and Apparel Industry in India has strengths across the entire value chain from fibre, yarn, fabric to apparel. Textile and apparel contributes 4% to India’s Gross Domestic Product (GDP) and constitutes 15% of the country’s export earnings. India with natural advantage in raw material (cotton, silk, cellulosic fibre) and easy availability of skilled labour, strong base of varied traditional design- colour-embroidery, combination provide key advantage to Indian textile & apparel Industry. India is among the world’s largest producers of Textiles and Apparel. India is one of the largest producers of cotton and jute in the world, 2nd largest manufacturer of PPE and producer of polyester, silk and fibre in the world. India is the fifth largest producer of technical textiles in the whole world. Textile and Apparel Industry is second largest employment provider in India after agriculture.

In today's competitive world, innovation is the key to sustain and grow. New Textile materials and technologies have been developed in the past decade which act as a fuel in the splurging growth of apparel sector. Artificial Intelligence & Technological advancement in various fields are creating opportunities as well as challenges; Even though the technology remains the main focus of research but the way fashion apparel are being marketed have seen a drastic change in the last decade. E-commerce is changing the whole equation of fashion retail. To sustain amidst the fierce global competition in textile & Apparel sector, focus of industry should be on New Materials Pioneering Technologies, Skill Development. Moreover, Innovative Marketing and Ecological Practices in fashion design, Entrepreneurship Development and Sustainable Consumption & Production is need of hour for promoting lifestyle for the environment.

I take this opportunity to thank all invited distinguished Industry Leaders, Academicians, Researchers, Delegates & faculty colleagues who are associated with INCFAT'23 and making this reality.

I wish **INCFAT`23** a great success.

**Prof. (Dr.) Pradeep Joshi**



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## Brief Profile of Invited Speakers

- **Mr. Ram Sareen, Chairman and Founder, Tukatech Los Angeles, CA U.S.A**  
Mr. Ram Sareen has served the garment industry with an extensive history characterized by one word: disruptive. This philosophy is ingrained in Tukatech, the fashion technology solutions company that Mr. Sareen founded in 1995. Tukatech is credited with successfully bringing digital pattern making to dozens of countries and are an innovative leader in virtual sample making for design and fit with real-time motion simulation. They were the first to develop and implement on-demand manufacturing processes and are known for advanced cutting room solutions. Tukatech's robust systems are implemented by fashion experts from all corners of the garment industry.
- **Mr. Vijay Mathur, DG & CEO and Executive Director, Apparel Training and Design Center**  
Mr. Mathur has over 43 years of experience in the Fashion & textile industry is Currently Director General and CEO in Apparel Training and Design Centers, managing 138 Training Centers and 10000 Training. Former Additional Secretary General AEPC, looking after garment exports of \$ 17 billion; policy making in Commerce, finance, labor issues. He was the Former Chairman Global Skill Management Pvt Ltd New Delhi; managing skill Assessment in Apparel skill space. Former Sales Manager in Maharashtra State Textile Corporation. Former Assistant Manager in National Textile Corporation. Worked in Glaxo Labs Ltd; JK Tyres.
- **Mr. Prassanna Pathmanathan, International Corporate Trainer, Life/Executive Coach, Speaker, Fashion Consultant & Founder President, Colombo Fashion Council**  
Mr. Prassanna Pathmanathan is a household name in the Sri Lankan fashion industry. He is the founder / President of Colombo Fashion Council. Mr Prassanna comes from IT/Business and marketing background thus, his passion in fashion has made him one of the thought leaders in the industry. He's a gold medalist from the University of Westminster UK, He received his MBA from University of Wales (UK) and he is also a Chartered Marketer. Prassanna is an international corporate trainer, marketing consultant and a lecturer and researcher. Mr. Prassanna's interest in fashion has made him explore many avenues in the fashion and pageant scene. He was the first Asian to judge Mr Earth worldwide pageant in 2011 and then onwards he has judged many beauty pageants around the world. He's the recipient of British Council's "Young Creative Entrepreneur Fashion and Design Award" in 2022 out of 230 contestants from over 25 creative sectors. Moreover, Prassanna is a fashion stylist and he lectures fashion marketing, promotions, branding, entrepreneurship and business planning for fashion
- **Ms. Pratima Pandey, Fashion Designer, Prama**  
Ms Pratima Pandey is the designer behind the vision of Prama. A graduate of the NIFT, she won the Grazia Young Fashion Awards in the category of eco-friendly fashion in 2011. Ms Pratima derives her sense of fashion from her belief that clothing should be classic, ageless, and should speak of the craftsmanship of each person involved. Her garments are for the confident woman feminine, classic and elegant. Ms Pratima's affair with chanderi began in 2011 with the collection Arabian Days and she has used this traditional woven fabric of interlaced cotton & silk ever since. Its light and fragile texture are in line with her sensibility of feminine style enabling graceful cuts. The brand Prama is drawn from the name of the brand's maker Pratima Pandey, and in Sanskrit means wisdom and beauty. Prama's collections are narratives-romantic tales that tickle our imagination.
- **Prof (Dr.) S.M. Ishtiaque, Emeritus Professor, IIT, Delhi**  
Dr. S.M. Ishtiaque is a Professor in the Department of Textile Technology at Indian Institute of Technology Delhi. After completing his PhD from the Czech Republic in 1983, he joined ATIRA, Ahmedabad and then worked as Project Manager in House of Podar Enterprises (HOPE) Textile, Indore before joining IIT Delhi as Assistant Professor in 1985. He became Associate Professor in 1991 and Professor in 1995. He has been on various administrative positions at IIT, as Acting Dy. Director (Administration), Dean of Students Affair, Head, Department of Textile Technology, Chairman Hospital Advisory Committee, Associate Dean of Students Affair. He is also the Member Board of Directors (Textile Industries), Member of Council, NITRA

Ghaziabad and Member Research Advisory Committee, NITRA Ghaziabad and BTRA Bombay. He is consultant to several Textile Industries in abroad and India and has been invited for lectures in various countries. He was the Director, Northern India Textile Research Association, Ghaziabad, Ministry of Textiles, Government of India from 1997-2000. Presently, he is the coordinator of IIT Punjab.

- **Prof. (Dr.) V.K. Kothari, Emeritus Professor, IIT, Delhi**

Prof V K Kothari is Professor Emeritus in the department of Textile Technology, Indian Institute of Technology Delhi. He has published more than 150 research papers in international journals/book and is a renowned for his work in technical textiles. He is heading several sponsored projects and committees formed by the Ministry of Textiles.

- **Dr. Swapna Mishra, Chief Operating Officer, and Officiating CEO, Textile Sector Skill Council**

Dr. Swapna Mishra is Experienced Professional with a Doctor of Philosophy (Ph.D.) in Textile Technology from I.I.T. Delhi. Having a demonstrated history of working in the textile industry, engineering education, and Skill Development in the Textile Mill and Handloom Sector. Skilled in Education, Textiles, Skill Development, Materials Science, Nanomaterials, Polymers, Lecturing, and Nanotechnology. Dr. Swapna is a skilled professional with over 25 years of experience in teaching, research and skill ecosystem in India. She is heading skill initiatives in the textile mill and handloom sector.

- **Professor Niccolò Sbaraglia, Polimoda Fashion School, Italy**

An economist specialized in statistics; a production manager in luxury accessories, also specialized in product communication. After eight years of running his own two companies in New York City, T-project showroom and PLUMA- ITALIA, he accepted the role of professor teaching the subject *Craft to Business* at Polimoda Fashion Institute in Florence. Also trend forecaster-leather jackets for LGM KERING group. While managing PLUMA, he also holds the position of Leading Teacher at Business and Communication department at Polimoda Fashion Institute. Teaching both undergraduate and master courses with a focus on production, craftsmanship, and statistics. An amazing experience achieved making it possible to transfer his know-how to international students, receiving in turn a great amount of energy from them. Polimoda is an international school where different cultures constantly influence each other; both students and teachers see a great deal of innovation and participation in the creative process because of the unique mix of cultures, identities and attitudes of the community. Born and raised in Florence where art and fashion were founded, believes in the power of art and fashion to bring about dialogue to all cultures of the world.

- **Dr Amy Twigger Holroyd, Associate Professor of Fashion and Sustainability at Nottingham School of Art & Design, Nottingham Trent University, UK**

Dr Amy Twigger Holroyd is Associate Professor of Fashion and Sustainability at Nottingham School of Art & Design, part of Nottingham Trent University in the UK. She has explored the emerging field of fashion and sustainability since 2004, initially via her craft fashion knitwear label, Keep & Share. Amy's work has been featured in various exhibitions, books and publications, from Vogue to Fashion Theory. Her research today focuses on fashion transitions: the participatory exploration of alternative, open and plural fashion systems that respect the Earth's capacity to support life. Amy has authored and edited several books, including her monograph *Folk Fashion: Understanding Homemade Clothes* (I.B. Tauris, 2017) and *Historical Perspectives on Sustainable Fashion* (Bloomsbury, 2023).

- **Mr. Munish Tyagi, CEO, Nuovatex Projects.**

Mr. Munish Tyagi is a senior and global Textile and Apparel industry consultant, based at New Delhi. He has a rich and diversified experience of serving the contemporary Textile indy in India and overseas, over last 35 years, and with working footprints in 10 countries. Presently, he is a global thought leader in the domain of Textile Sustainability and, emerging areas of Technical textiles. Mr Tyagi has accrued 35 years in -depth and proactive experience in planning and running the operations of large Textile corporates, including GPI Textiles of global Ispat group, Taichobang Textiles in Gujarat, leading Vardhman Group, Alps and Satia textile groups in north India. He was associated with planning and setting up one of the largest textile mill complex of outlay Rs 350 crore in 1995 of GPI Textiles in Himachal Pradesh, and which remained a technology Benchmark for a decade.

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TECHNICAL SESSION-I

*THEME* -REUSE, REDUCE AND RECYCLING IN FASHION & TEXTILES

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# Reduce, Reuse, Recycle in the Fashion and Textile Industry

**Sabira Fernandes**

*Whistling Woods International, Mumbai*

*Sabira.fernandes@whistlingwoods.net sabirafernandes@gmail.com*

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## ABSTRACT

*The three Rs in the Fashion industry ‘Reuse, Reduce, Recycle’ are essential principles for promoting sustainability and minimising environmental impact. The Amity Conference’s theme: “LiFE: Opportunities & Challenges for Fashion, Textiles & Design” resonates as my paper will focus on raising awareness of the ecological consequences of daily choices, encouraging individuals to make greener decisions. It is the minutest changes in everyday life that can collectively result in a positive impact on the environment and contribute to a more sustainable future. My paper will touch on the commercial side of sustainability, the personal aspects in conservationism, including lifestyle changes, education and regulatory challenges.*

*The three Rs have been a mantra for a while now, and with India hosting the G20 2023, renewed impetus and focus has been placed on sustainable activities. The Fashion and Textile Industry is known for its resource-intensive and sometimes, if not often, wasteful practices. LiFE the acronym for Lifestyle For the Environment is a much needed momentum. The UN SDGs (Sustainable Development Goals) too have stressed on environment sustainability, along with the G20 goals which emphasise LiFE goals. At the Glasgow COP26 in 2021 and reiterated at the 2022 NDC, India assured carbon neutrality by 2070, where other countries pledged 2040.*

*The emphatic need is protection and care of the eco-system and our move towards preserving this one planet that sustains life. The solution is individual and governmental – to reduce consumption, reuse as much as you can, repurpose and recycle whenever possible. The future of our species depends on us.*

**Key Words:** *Reduce, Reuse, Recycle, Fashion, Sustainability, Future*

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## INTRODUCTION

The G20 Delhi Declaration stressed the urgency of mobilising trillions of dollars for climate change, climate funding, clean energy technologies. Close on the heels of ecological conservation is the immediate and urgent need to conserve the excesses in the Fashion Industry. Promoting a revolutionary transformation in the fashion and textile industry, the oft repeated mantra of the three Rs – Reuse, Reduce, Recycle. These are deemed as essential principles for promoting sustainability and minimising the environmental impact of this industry, which is known for its resource-intensive and often wasteful practices.

Fast fashion and the age of social media translates to clothes worn to be photographed for social media. Repetition of clothes is considered an abomination! As slaves to fashion and fashion trends, we need to curtail excesses, reshape our minds and change the narrative of acceptance of single-use wear. Recycled and repurposed garments are not merely for ‘craft-classes’ but a

statement in carbon neutrality and our dwindling natural resources. In expounding the three Rs we will also discuss commercialisation, the personal aspects of conservation, including education, regulatory challenges, while also discussing the pitfalls to conservationism.

### 1. REDUCE

The immediate need is reducing wastage in overall garment and textile manufacturing. Energy efficient manufacturing processes needs to be promoted and over production, water and chemical usage needs to be curtailed. It is important to adhere to the Paris Agreement, COP26, NDC 2022, G20 and the UN SDG goals.

Fashion Designers need to *Design for Sustainability* and reduce waste by creating durable and timeless clothing, using sustainable materials, and incorporating eco-friendly production processes. Similarly, brands can reduce the number of garments produced by forecasting demand accurately, avoiding excessive inventory, and



adopting a "just-in-time" production approach.

On the infrastructure side *energy efficient manufacturing processes* help lower carbon footprint. Mindful *infrastructure planning* with factories and production areas utilising solar energy, skylights and an open structure can benefit from lower heating/cooling bills. Use of indigenous material in buildings as against glass-clad, in a tropical zones like India is prudent. Adopting water-efficient technologies and practices can help reduce water usage. Minimising the use of harmful chemicals in textile production, such as dyes and finishes, by opting for eco-friendly alternatives is wise.

### How can 'Reduce' be put to fruition

At the design level and individual level measures need to be taken to lower the carbon footprint

- a. *Design for Durability*: Create clothing items with high-quality materials and construction techniques that have a longer lifespan. E.g., using reinforced stitching in jeans to prevent tears
- b. *Capsule Wardrobes*: Encourage consumers to build capsule wardrobes with versatile pieces that can be mixed and matched, reducing the need for a large wardrobe
- c. *Zero-Waste Patterns*: Design clothing patterns that generate minimal waste during production. This can involve pattern-making techniques that use fabric efficiently, leaving little to no scraps
- d. *Scrap Management*: Find ways and means for recycling and reusing scrap and waste material
- e. *Sustainable Fabrics*: Use sustainable materials like organic cotton, Tencel, or recycled polyester, which have a lower environmental impact compared to conventional materials.

## 2. REUSE

Fast fashion and the age of social media translates to clothes worn to be photographed and repetition of clothes is considered an abomination! As slaves to fashion and fashion trends, we need to curtail excesses, reshape our minds and change the narrative of acceptance of single-use wear. Recycled and repurposed garments are not merely for 'craft-classes' but a statement in carbon neutrality. We need to care for our dwindling natural resources.

### How can 'Reuse be put to fruition

- a. *Second-hand Clothing Market*: Encourage the purchase and resale of second-hand clothing through thrift stores, online marketplaces and consignment shops
- b. *Rental Services*: Reduces the need to purchase new items
- c. *Upcycling*: Transforming old/discarded clothing items into new pieces, extending their lifespan
- d. *Scrap usage*: Finding means to repurpose garment scraps into new items
- e. *Repair and Alterations*: Promote the repair and alteration of clothing to extend their usability
- f. *Thrift Shopping*: Promote shopping at thrift stores or consignment shops
- g. *Clothing Swaps*: Encourage exchange of clothing giving garments a second life
- h. *Pre-loved clothes*: Buying pre-owned outfits.

## 3. RECYCLE

The sari is the most recycled garment – it is handed down generations, borrowed, lent, and if in cotton, repurposed to bed linen or swaddling clothes. Even the common coinage of 'lifecycle of a t-shirt' – it is worn formally when new, then at home, later as nightwear and finally cut into pieces to be used as rags, before being discarded. The breakdown of fibres in this process also reduces decomposition time.

### How can 'Recycle' be put to fruition

- a. *Textile Recycling Programs*: Establish recycling programs that collect and process old and discarded clothing, linens and textiles, turning them into new materials or other products
- b. *Closed-Loop Recycling*: Explore closed-loop recycling systems where textiles or garments are collected, sorted, and recycled into new fibres or fabrics, reducing waste
- c. *Recycled Fibre Use*: Fashion brands can use recycled materials/recycled polyester or cotton, reduce the need for virgin resources. E.g., using recycled polyester made from plastic bottles, in activewear
- d. *Sustainable Packaging*: Use recyclable and biodegradable packaging to minimise waste

- e. *Circular Fashion Brands*: Support and purchase from circular fashion brands that prioritise recycling and sustainable practices in their supply chain.

#### 4. EDUCATION AND AWARENESS

*Consumer Education* is one of the foremost means of increasing awareness and encouraging responsible consumption. *Sustainable Fashion Campaigns* could promote ethical production. Finally, *transparency* by brands about their supply chain and sustainability efforts, allowing consumers to make informed choices.

#### 5. REGULATION AND POLICY

Advocating and support of government initiatives is necessary. Regulations and policies need to promote sustainability in the fashion industry, such as eco-labelling and carbon pricing. Other supplementary policies like *Extended Producer Responsibility (EPR)* should be implemented so as to hold brands responsible for the disposal and recycling of their products.

#### 6. PRACTICAL SIGNIFICANCE

The practical significance of implementing Reuse, Reduce, Recycle principles in the fashion and textile industry is multifaceted. It extends to various aspects of sustainability, environmental impact, environmental benefits, cost savings, ethical practices, community engagement, circular economy promotion, economic benefits, social responsibility and increased consumer awareness. Embracing these principles not only contributes to a more sustainable and responsible industry but also opens up opportunities for businesses to thrive in a changing market landscape.

##### a. Environmental Impact

- *Resource Conservation*: Reducing the production of new textiles and garments to conserve resources such as water, energy, and raw materials
- *Waste Reduction*: Reusing and recycling textiles minimises the amount of clothing ending up in landfills, reducing environmental pollution and the release of harmful chemicals associated with textile decomposition
- *Lower Carbon Footprint*: Promoting recycling can significantly reduce greenhouse gas emissions associated with manufacturing and transportation.

##### b. Economic Benefits

- *Cost Savings*: Embracing these principles can lead to cost savings for both consumers and businesses. Consumers can save money by buying second-hand or renting clothing, while businesses can reduce production costs and waste disposal expenses
- *Market Opportunities*: Sustainable fashion is a growing market and brands can adopt these principles and tap into consumer demand for eco-friendly products
- *Supply Chain Efficiency*: Reducing overproduction and implementing efficient recycling processes can streamline supply chains and reduce inefficiencies.

##### c. Social Responsibility

- *Ethical Practices*: Emphasising ethical principles, along with ethical labour practices and fair wages for workers in the fashion and textile industry results in competitive advantage
- *Community Engagement*: Recycling and reusing textiles can create local job opportunities in collection, sorting, and recycling, benefiting communities
- *Health and Safety*: Reducing the use of harmful chemicals and promoting sustainable practices can protect the health and safety of workers in the industry and surrounding communities.

##### d. Circular Economy Promotion

- *Circular Supply Chains*: Promote a more circular economy where products are designed to be reused, remanufactured or recycled, reducing the need for virgin resources
- *Innovation*: Encouraging designers and manufacturers to think creatively about reusing and recycling materials fosters innovation in product design and manufacturing processes.

##### e. Consumer Awareness

- *Education*: Implementing these principles raises awareness among consumers about the environmental and social impacts of their clothing choices, leading to more informed and responsible buying decisions
- *Behaviour Change*: As consumers become more conscious of the three Rs, they may develop habits of

buying less, reusing more and actively participating in recycling programs.

#### f. Regulatory Compliance

- *Compliance with Regulations:* Many countries and regions are implementing regulations related to sustainability and waste management. Companies that adhere to these principles may find it easier to comply with evolving regulations
- *CSR:* Corporate Social Responsibility norms in India ensure that organisations look at carbon footprint and environment safety, among others
- *External certification:* ISO 14001 standards of environmental management systems.

### 7. COMPANIES EMBRACING THE PRINCIPLES OF REDUCE, REUSE, RECYCLE

Companies across various industries have been actively embracing the principles of the three Rs to promote sustainability and reduce their environmental impact. Clothing manufacturers design durable products, use recycled material, have programs which sell refurbished/repaired clothing and may use recycled materials.

Home furnishing companies (*IKEA, Home Store*) design products for long term use, and take back products for an exchange or for recycling, and use sustainable materials across their products. *Unilever* has committed to reducing its plastic packaging and increasing its use of recycled plastic in packaging. Electric vehicles reduce greenhouse gas emissions prima facie. *Tesla* incorporate recycling practices into their battery manufacturing process, and has battery recycling and refurbishment programs.

In India, several companies embrace the principles of Reuse, Reduce, Recycle in various sectors, and under the guise of CSR as mandated by governmental norms. Focus is on reducing environmental footprint and promoting responsible sourcing. Sustainable agriculture practices, reducing waste and conserving water, promoting waste reduction and recycling in communities in their agricultural supply chain.

In the corporate sector, even IT, adoption of eco-friendly practices in campuses, reduction of energy consumption through energy-efficient building designs and renewable energy sources. Manufacturing companies look at

recycling, buybacks, sustainable packaging options. SMEs and MSMEs also promote traditional artisanal crafts, which inherently involve a reduction of waste and reuse of materials. They also use natural and sustainable fibres in products. *Banyan Nation* is a Hyderabad-based recycling and waste management company. They specialise in recycling post-consumer plastics to reducing plastic waste.

Larger conglomerates have several sustainability projects. *Reliance* has "Recron" which promotes the use of recycled PET in textiles, reducing the environmental impact of polyester. The *Mahindra Group* with interests in automotive, agribusiness, and more, has a sustainability focus: "Project Hariyali" for afforestation and "Clean India" for waste management. Mahindra Electric EVs promotes reduction in greenhouse gas emissions.

### 8. CORPORATE SOCIAL RESPONSIBILITY (CSR)

With CSR as a factor, many companies have taken to looking at their carbon footprint. Conglomerates to smaller companies now have a government mandated CSR budget and actively look at sustainability. The UN SDGs also plays a high role as India has committed to the 16 SDGs and companies in various industries are adopting sustainable practices and actively embracing the principles of Reuse, Reduce, and Recycle as part of their commitment to environmental stewardship and CSR.

### 9. PITFALLS OF THE THREE RS

Is path forward all rosy, healthy and green? I was watching a reel by @megawattwise on Instagram and he talks of old solar panels and wind turbines; "Where do they go?" he asks. The answer: to the same landfill to be buried under the earth. So, is it all 'green?' How does this parallel in the Fashion and Textile Industry. Where does it really all go in the end? Are we addressing and closing the loop?

- Limited impact on certain environmental issues:* The Reduce, Reuse, Recycle approach primarily targets waste reduction and resource conservation. It may not directly address other pressing environmental issues like habitat destruction, air and water pollution, or climate change
- Cultural and behavioural challenges:* Encouraging people to adopt the three Rs

mindset can be challenging as it requires a shift in cultural norms and consumer behaviour. Many individuals may still prioritise convenience and short-term cost savings over long-term environmental benefits

- c. *Incomplete waste hierarchy*: The waste hierarchy typically includes more steps than just Reduce, Reuse, Recycle. It also includes options like "Repair" and "Compost." Focusing solely on the first three steps may miss opportunities for further waste reduction and sustainability
- d. *Energy and resource dependent*. Recycling requires energy and resources for collection, transportation, and processing. In some cases, the environmental footprint of recycling can be significant, especially when dealing with certain materials, like plastics
- e. *Contamination and quality issues*: Recycling processes can be compromised by contamination and cross contamination which can reduce the quality of recycled materials and make them less valuable or even unusable
- f. *Economic challenges*: Recycling programs can be expensive to implement and maintain and the economic viability of recycling can be influenced by factors such as fluctuating commodity prices and the availability of markets for recycled materials
- g. *Limited scope for certain materials*: Some materials are challenging to recycle effectively and not all materials can be recycled in an economically or environmentally sustainable way. This limitation can lead to increased waste for certain types of products or materials
- h. *Promotion of disposable culture*: Overemphasis on recycling can sometimes lead to a mindset that it's acceptable to use disposable products since they can be recycled. This can perpetuate a culture of waste rather than encouraging sustainable consumption
- i. *Energy use in production*: While recycling reduces the need for raw materials, it doesn't eliminate the energy and resources required to manufacture products initially. To truly address environmental concerns, we need to focus on reducing the energy and resource intensity of production processes

- j. *Overconsumption* is a significant driver of environmental issues.

## 10. CONCLUSION

By adopting principles, the fashion and textiles industry can work towards reducing its environmental footprint, conserving resources and contributing to a more sustainable and circular economy. Consumers play a crucial role in driving change by making conscious choices and supporting brands that prioritise sustainability. Consumers may also get complacent. The three Rs is not easy, it may be the future of sustainable fashion but the process could be long and not all materials are manufactured for a quick change or even, breakdown. Repair and Compost need to be assimilated to the options. Fashion and textile go through its iterations in clothing, it's time we focussed more on conservation. The solution is education – changing mindsets and policies – for enforcing the change. We are getting there, albeit slowly.

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# Designing of Scarf with Parthenium extract by Resist Printing Techniques

Sonal Chaudhary<sup>1</sup>, Dr. Shalini Juneja<sup>2</sup>

<sup>1</sup>Research Scholar, Department of Design  
Banasthali Vidyapith, Rajasthan 304022

<sup>2</sup>Associate Professor, Department of Clothing and Textile  
Banasthali Vidyapith, Rajasthan 304022  
sonalchaudhary3333@gmail.com

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## ABSTRACT

*In this Era, the consumer demand for innovative changes in existing product range is need of the hour. The exploration in fashion and trends is never ending process. Traditional resist printing methods from India are crucial to producing innovative designs for fashion shows. Since the tie and dye method of traditional Indian resist printing leaves the fabric with an interesting textured appearance and unique dye results, it is a beautiful, creative, and widely used technique. For the present work two resist printing techniques were selected. Tie and dye and traditional hammering technique was used to develop designs on cotton fabric. The dye used was natural dye extracted from parthenium weed. New designs for scarf were created. Then these were scrutinized by researcher and panel of experts. The most preferred designs were developed into prototype. Then acceptability and marketability of the designs for scarf were assessed through 5-point rating scale. It was observed that majority of the respondents accepted the newly developed products and rated the prototypes from average to excellent.*

**Key Words:** Tie and dye, Scarf, Hammering Technique, Gajar ghas.

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## 1. INTRODUCTION

Since the 12th century, India has been known for its printed and coloured textile, and as the fabric got royal patronage, the skill developed. India has a very long legacy of employing natural dyes. The process of natural dyeing and printing involves using colours that are derived from natural sources such as flora (leaves, stem, seed, bark, flowers, etc.) and fauna to dye and print textiles.

Natural dyes are obtained from nature thus, no manufacturing process is required to make them. These dyes are simple to break down in nature after usage and do not harm the environment when they are destroyed (Alam *et al.*, 2020). Natural dyes are mostly used to colour clothing, food, medicine, and cosmetics. Candles, leather, wood, paper, shoe polish and other items that need to be coloured also utilize small amounts of dyes (Gulrajani, 2001).

The annual ephemeral herb *Parthenium hysterophorus* L. is a member of the Asteraceae family. (Saini *et al.*, 2017). *Parthenium* infestations affect over 35 million hectares of land and are a serious issue in all orchards, crop fields, and even forests (Sarkar *et al.*, 2010.) *Parthenium* adjusts

to different agroclimatic circumstances and practically disperses itself to a variety of developing environmental circumstances (Bezuneh, 2015). This plant was once used to cure infertility as well as fevers, migraines, rheumatoid arthritis, stomachaches, toothaches, and insect stings (Bhateria *et al.*, 2014). It is used for the treatment of a high body temperature anaemia, injuries, ulcerated sores, and heart problems. It has antifungal properties also (Kishor *et al.*, 2010). It is abundantly seen in wastelands and on the sides of roads. Under favoured circumstances, it may endure drought conditions to a considerable extent as well. About three generations of *Parthenium hysterophorus* L. are completed per year. Congress grass is said to have tremendous generational power. Due to its higher seed production capability and prolonged dormancy period, the weed that has been left in its natural state in the same region functions as a seed bank (Girish *et al.*, 2020). It is known for its economic worth and industrial applications, such as the removal of metal, the eradication of aquatic weeds, the generation of biodiesel from cow dung, and the development of biopesticides (Bashar *et al.*, 2021).

Nature offers us multiple possibilities of colours to dye fabrics. Naturally produced colour carries subtle and

harmonies shades one such possibility can be explored through leaves of Parthenium plant. The plant is also used for colouring textiles. Parthenium leaves have possibility to give natural colours on textile fabric. The leaves of Parthenium extract also gives variety of shades and colours on silk fabrics. Synthetic colours could never imitate them.

Textile designing by resist dyeing is used around the world encompassing a variety of process, tools and materials and subsequent results. Now a days resist dyeing and printing is becoming more popular and has captured the interest of artist and consumers. Lots of people are earning their livelihood by practicing this art. The most well-known techniques of resist printing are tie and dye and hammer printing.

By using theories and other techniques to produce patterns that diverge from the past, tie dye products designed need to be new and distinctive. The creation of the same intriguing and contemporary standardised patterns should be made possible by innovative method of dyeing (Pujeeb ,2020). Traditional tie-dyeing techniques often involve string binding with needle and thread, direct binding, random binding, clamp dyeing, etc. Designing the patterns and colours using natural substances is the first step in a straightforward design process. These are the tie-dyeing's distinctive characteristics, which are passed down from generation to generation (Mayusoha, 2015)

An endeavour was made in this work to find the appropriate resist technique with natural dyeing. The explored techniques are further utilized to give application to the study by designing scarfs with resist printed fabric. The present study explores the possibility of resist printing of cotton fabric to create interesting visual appearance and make this fabric colourful Thenceforth the present work was planned with following objectives:

## 2. OBJECTIVES

1. To assess the consumer preference for designing scarf
2. To develop the design sheets of scarf
3. To develop the most preferred designs into prototype
4. To evaluate the acceptability and marketability of the prototypes.

## 3. DELIMITATIONS

Only cotton fabric was used for the study

Only Pomegranate mordant was used for the study

The study was delimited to 50 respondents

Natural dye extracted from parthenium leaves was used

Only tie and dye and hammer printing technique was used

## 4. METHODOLOGY

### Phase -1

**Collection of Study Material-** The study material was gathered from primary and secondary sources.

**Sample Selection** – 50 respondents were taken for the study.

**Data Collection-** The locale of the study was Banasthali Vidyapith, Rajasthan A well- structured questionnaire tool was conducted to obtain exhaustive information for designing of Scarf.

**Analysis of Data-** The data thus collected was then analysed and inferences were drawn to the facilitate designing product development.

### Phase -2

**Development of Design Sheets** – According to latest market trend tie dye pattern, fabric was selected by the researcher herself.

**Selection of Design Sheets for product development-** All the design sheets were evaluated by females from age group 18 to 40 years. Out of 20 designs, 3 most preferred design were selected by researcher and panel of experts for development of prototypes.

**Development of Prototype** – The three designs scoring highest were developed by technique of resist printing.

### 1. Preparation of Fabric

Scouring process was done for removal of hydrophobic impurities and also to improve the wettability of the fabric. Soda boil method was selected for scouring process on cotton fabric.

### 2. Mordant

The natural mordant was used for the process. The Pomegranate peel was selected for mordanting. The pomegranate peels were boiled into the water. Then



boiling water was drained. Then the fabric was dipped into the water for half hour to 1 hour. After that the fabric was dried into the shade.



*Figure: 1 Pomegranate peels(left) and Mordant Fabric (right)*

### 1. Dyeing

#### Extraction and dyeing with Parthenium leaves

The tied fabric was dyed with the parthenium leaves extracted dye. The parthenium leaves were collected. Then the leaves were dried and converted into powder form. Then boiling was done again in a large vessel.

After boiling the leaf powder was add into it. Then boiled for 1 hour and it was strained

The process was repeated again and the tied fabric was added into the container for 40 minutes. Then rinsing and drying was done.



*Figure 2: Tied sample (left) and dyed sample (right)*

### 3. Hammer Printing

The printing table was prepared for hammer printing. Various trials of hammer printing on cotton fabric were done with leaves of Parthenium. Standardized method of hammer printing was developed by researcher herself for design and development of scarf. The developed method was used for prototypes.







**Figure 3: Hammer Printing**

**Phase 3**

**Evaluation of colour fastness of Samples**

The fabric was evaluated for following colourfastness test

1. Colourfastness to Sunlight
2. Colourfastness to Washing
3. Colourfastness to drying
4. Colour fastness to Ironing

**Evaluation-** The prototypes were evaluated on the basis of technique, style, suitability of fabric. For this panel of 20 experts including staff and students of Banasthali University were selected randomly. A four-point scale were constructed for the same.

IV- Excellent III- Very Good II- Good I- Fair

Percentage and weighted mean were calculated for each prototype. The design which got maximum score, was ranked first and so on.

Weighted Mean Score was calculated for each parameter by given formula

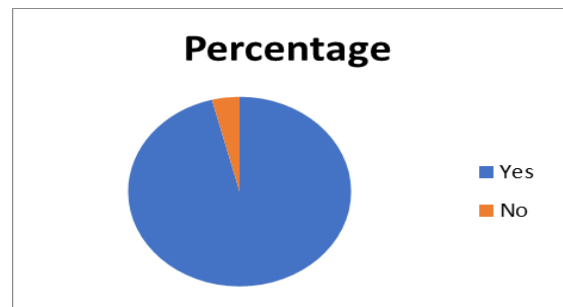
$$\text{Acceptability Index \%} = \frac{\text{High score}}{\text{Maximum score}} \times 100$$

**Marketability –** In order to asses market potential, cost for each product was developed. The cost was calculated by adding the cost of raw material, labour charge and 10% profit.

**Analysis –**Data was tabulated and analyzed by calculating the percentage, weighted mean and ranking method.

**5. RESULTS AND DISCUSSION**

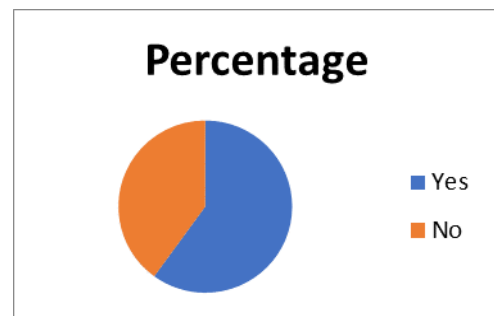
**Result of preliminary survey-**



1. Awareness about the Tie and dye technique

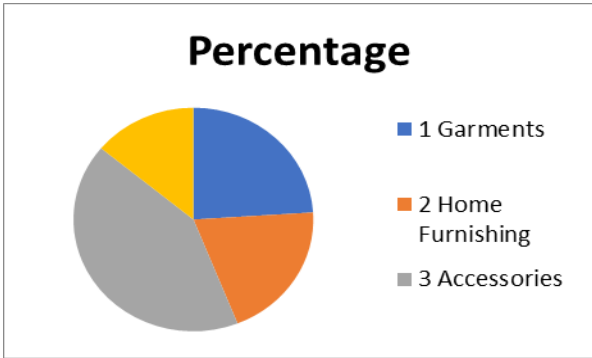
Data in above figure indicates that majority of the respondents have idea about tie and dye technique. Only 4 percent respondents were not having idea about tie and dye technique.

2. Awareness about Hammer Printing



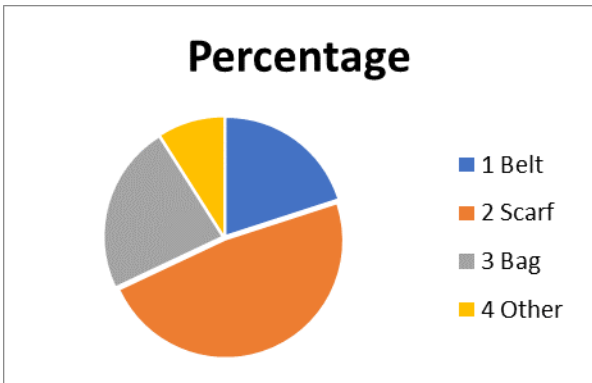
*Figure 2 shows that 60 percent respondents are aware about the hammer printing. 40 percent respondents did not know.*

**3. Consumer Preferences for product**



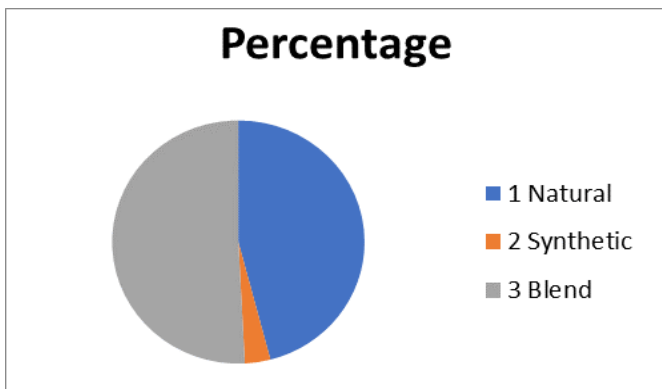
Data in figure no. 3 shows that 42% respondents preferred accessories followed by garments (24%). 20% respondents preferred home furnishings and only a few were in favour of others.

**4. Type of Accessories Preferred**



For the preference of accessories, 48% respondents preferred scarf, 23% preferred bag, 20% preferred belt and 9% preferred others.

**5. Type of fabric**



Majority of the respondents (62 percent) preferred natural fabrics for scarf. 56 percent respondents gave preference for blend fabrics and only a few (4 percent)

respondents preferred synthetic fabric.

**6. Preference for Tie and dye method**

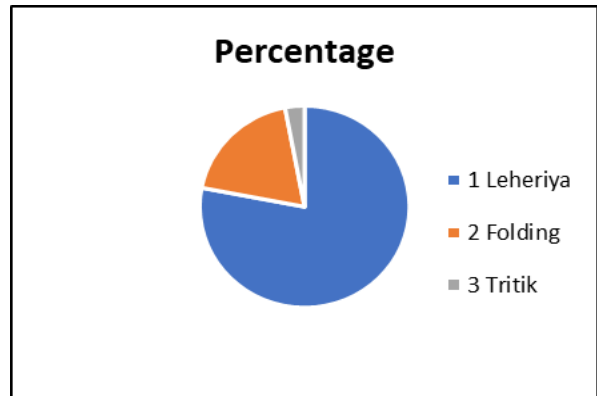


Figure shows that 78 percent respondents preferred leheriya technique, 19 percent respondents preferred folding technique and 3 percent tritik technique respectively.

**7. Preferences for types of dyes**

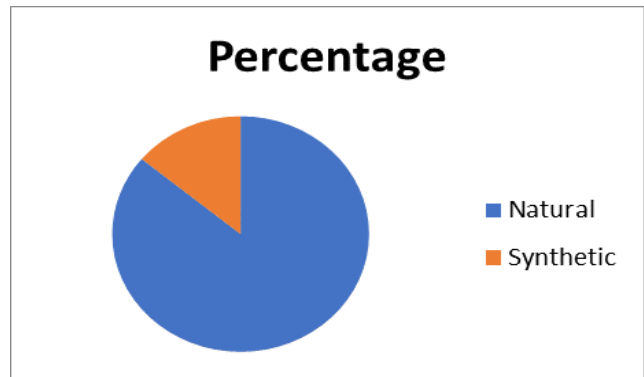
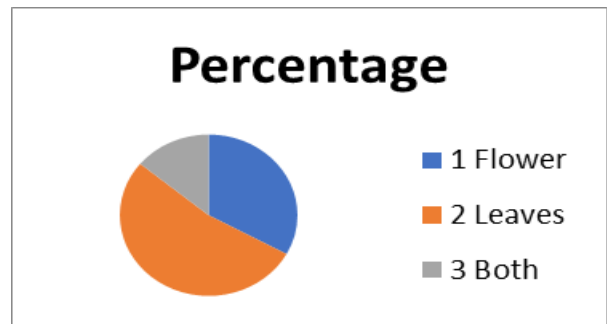


Figure shows that 86 percent respondents preferred natural dye and 14 percent respondents preferred synthetic dye respectively.

**8. Preference for Hammer Printing**



For the preference of hammer printing, 53% respondents preferred leaves, 33 % preferred flowers and 14 % preferred both.

**Evaluation of developed design sheet for scarf**

Twenty design sheets of Scarf were prepared using tie and dye and hammer Printing and also evaluated on the basis of fabric, suitability of Hammer Printing design and overall appearance.

**Evaluation of tie and dye effect****Table 1**

S. No	Design Sheet	Weighted Mean
1	Design sheet 6	4.8
2	Design sheet 13	4.86
3	Design sheet 20	4.78

The weighted mean scores of a few chosen design sheets based on the tie and dye effect are shown in Table 1. Design sheet 13 was the most preferred by the 4.86 weighted mean score. The weighted mean ratings for design sheets 6 and 20 were 4.8 and 4.78 respectively.

**Suitability of Hammer Printing design****Table 2**

S. No	Design Sheet	Weighted Mean
1	Design sheet 6	4.86
2	Design sheet 13	4.82
3	Design sheet 20	4.88

**Assessment of Colour Fastness of developed product.**

S.No	Mordant	Sample	Washing		Drying		Ironing	
			Colour Change	Staining	Sun drying	Shadow drying	Wet	Dry
1	Pomegranate	Controlled	3	3	4	4	4/5	5
2	Pomegranate	Sample 1 (tie and dye)	3/5	3	3	4	4/5	5
3		Sample 2 (Hammer Printing)	3	3	3/5	3/5	3	3/4
4	Pomegranate	Sample 2 (Tie and dye and Hammer Printing)	3	3/5	3/4	4	4	4/5

Note: 1/2- 1 Very Poor; 2- Poor, 3 -Fair, 3/5 – Moderate, 4-Good; 4/5- Very good; 5- Excellent

The above table show that design sheet no 20 got highest preference (4.88) followed by design sheet no 6(4.82). Least preferred design was design no 13.

**Overall appearance****Table 3**

S. No	Design Sheet	Weighted Mean
1	Design sheet 6	4.80
2	Design sheet 13	4.92
3	Design sheet 20	4.9

The weighted mean scores of the top three design sheets based on overall appearance are shown in the above table. With a weighted mean score of 4.92, design sheet no13 was considered the most acceptable. The weighted mean ratings for design sheets 6 and 20 were 4.80 and 4.9 respectively.

**Average weighted mean score**

S. No	Design Sheet	Weighted Mean
1	Design sheet 6	4.82
2	Design sheet 13	4.88
3	Design sheet 20	4.80

Table 4 displays the average weighted mean scores of the best three design sheets, which were used for developing prototypes. Design sheet 13 had the greatest weighted mean score of 4.88. Out of all the selected designs, sheet no. 20 got the lowest weighted mean score of 4.80.

### Evaluation of developed Scarf

Scarf were developed from selected design sheets. Scarf were tie and dyed with natural dyes and hammer printing was done. Tie and dye patterns were used on the scarf which were selected by the respondents. Figure no. 4 depicts the developed prototypes.

### Consumer acceptability for the prototypes

Developed prototypes were shown to the respondents for analysing these on the basis of three criteria i.e., aesthetic appeal, clarity of tie and dye effect and hammer Printing and cost using five-point rating scale. The results are shown below:

**TABLE-1: Weighted mean scores of prototypes on the basis of aesthetic appeal**

S. No.	Prototype	Weighted mean
1	Prototype 1	4.78
2	Prototype 2	4.34
3	Prototype 3	4.63

Out of all the prototypes, prototype 1 was considered to be most appealing (4.73). Weighted mean scores for prototypes 2 and 3 were 4.34 and 4.63 respectively.

**TABLE -2: Weighted mean scores of prototypes on the basis of clarity of tie and dye effect**

S. No.	Prototype	Weighted mean
1	Prototype 1	4.50
2	Prototype 2	4.80
3	Prototype 3	4.30

Out of all the prototypes, prototype 2 was found to have the best print clarity, with the greatest weighted mean score of 4.80. The weighted mean score for prototypes 1 and 3 was 4.50 and 4.30 respectively.

**TABLE 3: Weighted mean scores of prototypes on the basis of hammer Printing**

S. No.	Prototype	Weighted Mean
1	Prototype 1	4.52
2	Prototype 2	4.44
3	Prototype 3	4.82

On the basis of printing effect, prototype 3 was most preferred than other prototypes since it got the greatest weighted mean of 4.82. Prototypes 1 and 2 received weighted mean scores of 4.52 and 4.44 respectively.

**TABLE 4: Average weighted mean scores of developed prototypes**

S. No.	Prototype	Weighted Mean	Rank
1	Prototype 1	4.58	2 <sup>nd</sup>
2	Prototype 2	4.79	1 <sup>st</sup>
3	Prototype 3	4.48	3 <sup>rd</sup>

Prototype 2 obtained highest score i.e. 4.79 and was preferred most by the respondents while prototype 3 got the lowest score (4.48) and was ranked third. Prototype 1 got 2<sup>nd</sup> rank with a score of 4.58.

**TABLE 5: Cost of developed Scarf**

Sample	Cost
Scarf 1	150
Scarf 2	120
Scarf 3	180

The cost for each prototype was calculated. The above table depicts that cost of scarf 1 was Rs. 150/-, scarf 2 was Rs.120/- and scarf 3 was Rs. 180/. All the products were accepted by the respondents and they were ready to buy the product in the above range.

## 6. CONCLUSION

It was found that the study of designing of scarf with the help of tie dye technique and hammer Printing using with natural dye was an innovation to develop something unique for resist printing industries with natural dye. It was found that all the scarf developed were liked by the respondents and were ready to buy in the estimated cost. Thus, on the basis of the study it can be deduced that resist printing (tie and dye and hammer printing) can be used to enhance aesthetic appeal of cotton fabric and provide a new look to it.

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# Analysis of Mekhela Chaddor Craft Cluster for Augmentation of the Craft

Shikha Kapoor, Amar Mithapalli, Deepshikha Sengupta

Avantika University,  
Shikha.kapoor@avantika.edu.in

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## ABSTRACT

*India's handloom industry stands at number two after agriculture. There are more than three million workers and out of this more than one million are from Assam. Assam's handloom industry showcases the diversity of India's culture. The Bodoland Territorial Region of Assam is the abode of Bodo people along with other native communities of Assam. Their cultural heritage reflects the tribal origin. Mekhela Chaddor has been traditionally worn by Assamese women and most of the women of Bodo village are involved in the weaving of Mekhela Chaddor. Since many weavers are from this region and as per our knowledge very few researchers have focused on the craft clusters of this region. It's vital to understand the problems faced by the weavers carrying out the weaving tradition from generation to generation. This paper analyzes production process of Mekhela Chaddor and the problems faced by the weavers. The study was carried out in the Bodo village by observation and well-structured interviews administered to 20 respondents out of 22. A variety of Mekhela Chaddors in silk and cotton are woven at 22 units of weaving cluster at Bodo village. Observations indicated that weavers were facing several constraints and the study revealed problems related to handloom industry, raw material supply, design aspects and basic livelihood of the weavers. Based on the study various initiatives are identified which aimed at enhancing the marketing and distribution to this remote area situated in northeastern region of India which may directly or indirectly result in growth of the craft.*

**Key words:** Handloom Industry, craft cluster, Mekhela Chaddor, Weaver's problems, Assam, Bodoland territorial region

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## 1. INTRODUCTION

“When human heart and hands work in tandem that is grace in the making. Hand woven cloth has beauty and grace that is significant” (Sadguru).

Assam, a state located in the north-eastern part of India sharing interstate boundaries with Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, and West Bengal, thus covering a length of over 78,438 sq. km and holds a place among the “Seven Sisters” [1]. Assam is primarily known for its wildlife, archaeological sites consisting of many temples and religious artifacts. The state that is significant with its cultural heritage, local heritage, and its well-known Assamese attire along with their own draping style, thus making their culture effectively distinguishable from others. The Assamese people take pride in their exotic clothing and traditional jewelry they wear. The traditions are being followed by the forefathers and are highly respected and maintained even now. Chaddor is a traditional sarong (a type of saree comprising two pieces of cloth draped on the top and the bottom), thus it is a two-piece set with a skirt or a

sarong worn with an unstitched cloth (chador or dupatta) over the shoulder. The similarity is called “dhoti and gamocha”. A few of the major tribal communities that have been dominant until the present are Bodo, Dimasa, Missing, Rabha, and Karbi [1]. When it comes to Assam's Scheduled Tribes, the Bodos are by far the largest community. The tribal heritage has been playing a vital role not only in keeping the heritage but also in the process of production of and the traditional garments along with their own fabric production. The production of Mekhela is done with handlooms and jacquard looms, the weavers who are involved in this process of production and acquiring the raw material (silk and cotton) are inhabitants of the tribal communities and the villages on the outskirts of the city. Assam is home to many ethnic groups and a mixture of cultures. It is rich in folk music and handicrafts, thus having its own representation in motifs, prints, and dances. A few of the prominent elements include Chaddor with traditional motifs, prints, and draping style. With the growth and evolution, the handlooms are slowly transformed into Jacquard and power looms. Mekhela Chaddor, Gamocha

and other traditional Assamese clothing are made on traditional handlooms, which have been an integral part of Indian culture for ages. The handlooms used to produce traditional clothing of the indigenous people are now making products for commercialization also. Social welfare of weavers and allied workers as well as the growth of a social bond with traditional textiles made on handlooms are essential topics for research [2]. For the handloom industry to be strengthened, sustained, and elevated this study addresses the issues and challenges faced by the weavers of Bodo village. As per our knowledge a very few researchers have discussed the problems faced by the weavers regarding the manufacturing process.

Therefore, the main objective of the paper is to study the manufacturing process of Mekhela Chaddor in Bodo village craft cluster, Identify and analyze problems of weavers relating to the production process, and evaluation of challenges faced by weavers to propose potential solutions.

## 2. LITERATURE REVIEW:

Weaving had been a household tradition for many in India. In the northeastern parts of India people prioritize the handloom as highly as agriculture as a means of meeting basic requirements [2]. The number of weavers employed in the handloom industry is second highest after agriculture. Assam has one million two hundred sixty-nine thousand of such handloom households with one million two hundred eighty-three thousand weavers out of which one million one hundred seventy-nine thousand are females and one hundred four thousand are male weavers [3]. A promising scenario exists for the social empowerment of women weavers. Regardless of caste or community, Assamese rural women dominate the handloom industry [2]. The woven products range from Mekhela Chaddor to Gamocha, materials for home furnishing, fabrics for dresses and other products [3]. In addition to cotton and silk other fibers can also be used for weaving. Muga silk, a beautiful silk made in Assam, is the most typical type of silk used as a raw material for weaving Mekhela Chaddor. The whole traditional process of weaving and its preparation is a difficult and drawn-out procedure [4]

The handloom industry has seen low productivity, low salaries, low levels of literacy, established middlemen, and very little formal bank financing flow. Many individuals, including decision-makers, concur that the handloom sector is struggling. Nevertheless, the strength,

persistence and resilience of handloom weavers, a capacity for innovation suggests that the handloom industry can yet be rejuvenated [5]. The handloom clusters confront numerous obstacles when it comes to promoting and distributing their products. The 'Make in India' activities of the tribal societies in the far-flung regions of India's Northeast depend on concerted efforts to enhance product promotion and distribution [6]. The handloom industry's contribution to the advancement of the country is losing importance. Narzary J, studied the handloom industry of BTAD [7] and stated that the sector is in fact dealing with several issues, including those involving human resources, materials, processes, equipment, finances, distribution, and management. Most often, the designs of Assamese hand-woven textiles that we see today are a result of the impact of several cultural groups who have inhabited the area. This extended and ongoing process of mixing tribal and Assamese styles results in a highly unique situation that occasionally tends to alter the overall view and expression of a design [8].

The rural farm economy, hotels, services like, marketing, maintenance, transportation, financial and yarn producers are just a few of the industries that handlooms are inextricably linked to. Many handloom centers or clusters are popular tourist destinations that draw people from across India and other countries as well. Additionally, during the off-season for agriculture, farm laborers find work in the handloom industry. The industry features self-supporting mechanisms, including training for upcoming weavers [9]. Goswami K. in his study Impact of Globalization of Silk Industry in North-East India proposed that globalization resulted in some economic gain from the rapid increase of exports, while adversely affecting the domestic market for raw materials [10]

Handloom industry is still breathing because of the weavers carrying out the tradition even in today's modern world [11]. The handloom industry in India occupies a distinctive position in the economy and is crucial to the rural poor's economic advancement. Due to its profound cultural and artistic value, handloom will inevitably maintain its market share. To maintain both its traditional significance and its market share, it must compete aggressively in all spheres. Thus, a vibrant and competitive market for handloom products is essential for the rural weaving community's economic success [12].

### 3. METHODOLOGY:

The study was carried out in the Bodo village of Bodoland Territorial Area Districts (BTAD), Assam. The area under study is a craft cluster an Integrated Textile Park sponsored by Government of India, established in 2017 in the Bodo village, Baksa, BTAD, Assam. There were 22 weaving units comprising of 320 looms, more than 300 weavers and workers with each unit being managed by one supervisor. Methods used for the research are empirical and analytical. In this research data collection plays a vital role as it serves as the foundational process through which empirical evidence is gathered and analyzed to address the research objectives. This study relies on primary data collected by the authors. A total of 20 supervisors out of 22 were individually interviewed by the authors through a well-structured interview with the following questions that were used to find out the problems related to the manufacturing process, production and raw materials for weaving of Mekhela Chaddor.

1. What is the production capacity of this unit?
2. What is the actual production?
  - a. What is the availability/attendance of weavers during the year?
  - b. January-March sowing
  - c. April to June
  - d. July to September
  - e. October-December harvesting
3. Which raw material are being used mostly for production?
4. From where do you procure the yarns for weaving and how much?
5. List the adversities you face while sourcing of raw materials for production?
6. Do you face any recurring problem related to looms and machinery or their parts being used to produce Mekhela Chaddor?
7. Any problem you face with respect to weavers and allied workers involved in the production processes?
8. What are the basic facilities provided to the workers and the weavers?
9. Are there any special benefits given to the workers /

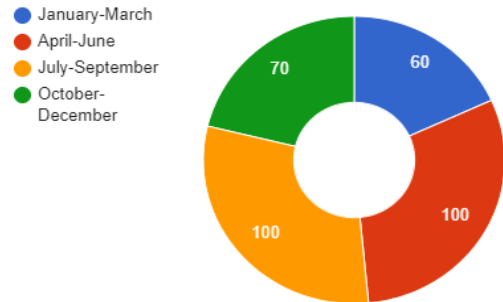
weavers?

10. How is the work culture / work environment at the units?

Few of the analysis are listed below:

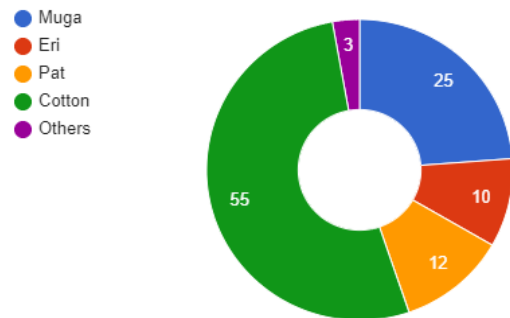
1. What is the availability/attendance of weavers during the year?

Attendance of weavers around the year (percentage)



2. Which raw material are being used mostly for production?

Types of yarns used for weaving (percentage)



3. From where do you procure the yarns for weaving and how muc?

Yarns are mainly procured from the following places (percentage)



Some more related information was collected from observation of the authors as well as the interviews that



were taken for this study is as follows:

**Handlooms and Other Equipment:** The handloom looms had few, if any, technical issues and were in good working order. Guwahati-based experts and components would be sent if any component broke or malfunctioned.

**Raw Material Sourcing:** Dyed yarns for weaving are mainly procured from Sualkochi, Sivasagar, Majuli and Lakhimpur these places at a long distance from Bodo village. There are limited transit alternatives with low frequency local buses. The purchase of cards to be hole-punched for designs is similar. The cards are sourced from Guwahati or Shiv Sagar. Shiv Sagar is located 350 km from the craft cluster, while Guwahati is 150 km away.

**Weaving, Colors, Patterns:** Mekhela Chaddor is woven on Jacquard looms. MS Paint was the program used to create the graphs of the designs. Creating the graphs used to take a long time because of the frequent power cuts and a lack of power back up. Making punch cards also took a while as it is directly correlated to the construction of graphs. As a result, there were few new designs and patterns thus weavers were reusing the old cards for further production. Commonly used motifs for Mekhela Chaddor were jappi the typical Assamese cap, miri gos butta is a pattern of miniature tree motifs, kabootar is the pigeon motif, king khap is a layout of two lions facing each other, joon biri is like a crescent moon, Gaamkharu the wrist band, elephant design, karbi is a motif of two birds sitting on a tree, Phool buta the flower motif, gach is the tree and few more. Colors and patterns are used as per the orders and the discretion of the supervisors and weavers made by repetition

**Production:** Each loom had a capacity of 4meters fabric per day on average. The amount of production was not fixed as it depends on the design, its details, availability of raw materials, order deadlines and availability of weavers depending on the time of the year.

**Work Culture:** It was observed that the weavers and allied workers had an enthusiasm for working and liked to work with a healthy communication with each other while working. Most of them were women and they used to look forward to coming to work each day. The basic amenities like drinking water

**Customization of products:** Customization of products depends on the availability of yarns, cards, and the required colors, that was sometimes difficult or time consuming due to the long distance.

#### 4. DISCUSSIONS AND SUGGESTIONS:

A better connectivity to this remote region of Assam will help to procure the raw materials faster that will directly impact the speed of production.

Reduction in power cuts at night will help the weavers to fill the gaps of production by working overtime.

Increasing the number of residential apartments will allow more weavers to stay close to the units and they can spend more time to meet the deadlines if need arises.

An increase in the storage capacity would help to create a larger inventory for common colors of the yarns used in weaving of the Mekhela chador.

Setting up of a dyeing unit will also help in the upsurge of the production as any required color of the yarn would be easily available.

#### 5. CONCLUSION

This paper has identified problems related to the manufacturing process of Mekhela Chaddor and suggested a few solutions regarding these adversities. Nature is at its best in Assam that has an abundance of resources from nature as well as the rich cultural legacy preserved by a diversity of tribes and communities of Assam. Handloom weaving is a part of Assamese culture thus it requires a collaborative effort from the government, designers, private organizations, NGOs, and the people of India to strengthen the handloom industry. To conserve the handloom heritage for future generations an understanding of difficulties faced by the weavers and devising strategies for self-sustenance are required. To meet increased consumer demands weavers also need to be proactive for a rise in production levels, quality, and efficiency. This study has solely examined the problems of manufacturing process affecting the productivity. The issues pertaining to marketing, designing, and lifestyle of weavers are not discussed in this paper.

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# Sustainability in the Carpet Industry: An Innovative and Integrated Approach

Nidhi Yadav<sup>1</sup>, Dr. Neha Singh<sup>1</sup>, Vishal Trivedi<sup>2</sup>

Ph.D. Research Scholar, Swami Vivekanand Subharti University, Meerut, India  
HOD, Deptt. of Fashion, Textile & Interior Design, Swami Vivekanand Subharti University, Meerut  
Assistant professor (II), ASFT, Amity University, Noida

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## ABSTRACT

*Sustainability is a global challenge that requires innovation in every aspect and is critical for long-term business success. The Environment, economics, and society are the three important aspects that support sustainability. Textile floor covering was one of the most demanding industries throughout history and holds the same position today because it represents luxury and shows traditional heritage. This paper is designed to provide insights into the sustainable alternatives available in the carpet industry. It includes knowledge of sustainable and Eco-friendly materials used for making carpets, and environment-friendly manufacturing processes and carpet recycling and reusing. The carpet industry is committed to creating and promoting partnerships to develop waste management solutions that provide opportunities for the reuse of materials from end-of-life products, implement design for recycling & reusing, and increase consumer and business awareness of the value of sustainable, permanent materials. This paper also emphasized innovation, which is achieved by the recycling of post-consumer carpet, associated industries who are involved in reusing and recycling of materials with a strategic approach.*

**Keywords:** Carpet Industry, Sustainability, Eco-friendly material, Recycling, Innovation

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## 1. INTRODUCTION

All across the world, sustainability is a major issue. One of the primary initiatives towards creating green and environmental friendly production techniques is to reduce the waste produced by manufacturing units, service industries, and municipal solid wastes, as well as the consumption of raw materials. The textile industry is one of global importance because it generates a high level of employment, foreign exchange revenue, and essential products for human welfare. To begin with, sustainability in the textiles and clothing industry goes beyond using organic ingredients and efficient technology and techniques. Most textile enterprises produce large amounts of hazardous waste and endangered bodies need to be taken care of, there is an urgent need to use innovative production methods and techniques. Similarly, the carpet industry is one of the oldest and most important parts of the textile sector. Recycling and innovations in the textile floor-covering industry is one of the major concerns. Because of urbanization and industrialization, the quantity and types of solid waste materials have increased and producing large amounts of landfills. The decomposing portion of landfill waste that produces greenhouse gases (GHGs) may not be fully accounted for, according to recent

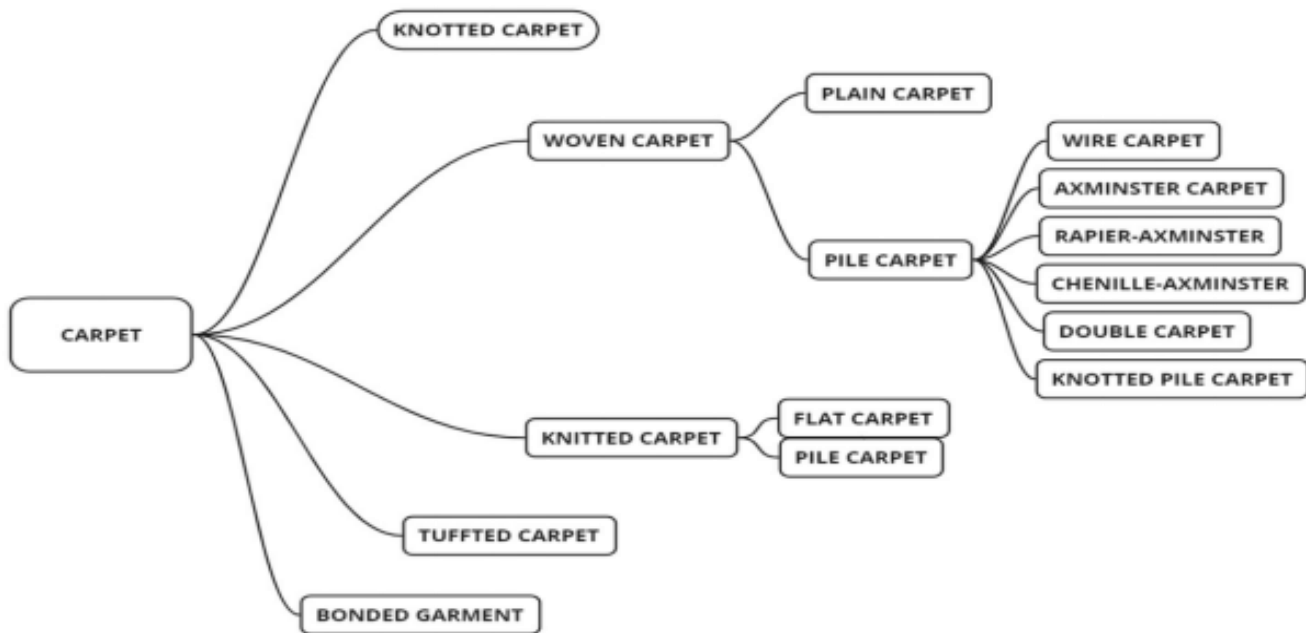
findings by the International Panel on Climate Change (IPCC), and this could become a crucial problem in our attempt to keep atmospheric temperature increases to 1.5° cover pre-industrial levels. (Blair and Matararachchi, 2021). One issue in the textile industry that has a significant impact on the environment is how items are disposed of once their useful lives are over. The textile industry's sustainable growth depends critically on the prudent handling of solid textile waste. (Stanescu 2021). Thankfully, there is currently a positive trend toward more potential uses for recycled carpets, especially in the areas of fibre extraction, pollutant reduction, and output elimination. Additionally, there is a push to incorporate recycling into products if they are considered to be end-of-life. This paper emphasized sustainable fibres for making carpets, the reuse and recycling of post-consumer carpets, and making innovative products out of them.

### Carpet Manufacturing and its Type

A carpet is a luxurious floor covering that is essentially a two-layered textile fabric with a pre-woven backing or lower layer bonded to the upper layer, known as the "pile." Adhesives, fabrics, and dyes are among the elements mixed together in these two layers. Usually, PVC or latex is used for the backing. The majority of applications for latex are in homes. Compared to latex,

PVC is easy to recycle and is typically seen in corporate environments. The portion you can see and walk on is

made of fibres. There are different types of carpets:



**Fig. 1: Types of Carpets**

- Knotted pile carpets: In knotted carpet The weft threads are knotted between at least two warp threads using short lengths of pile thread
- Woven: Although woven carpet requires greater expenditure to make, it is stronger and has a longer lifespan than tufted carpet. The back layer of the carpet is woven into the fibres using a conventional process. Plain and pile are the two varieties of woven carpets. Axminster, Wilton, and flat weave are the three methods for developing woven carpets.
- Tufted floor coverings: Tufted carpets differ basically from traditional types because they have a pre-woven backing into which the tufts are inserted. The fabric that is woven for the carpet backing must be strong, consistent, and able to maintain its shape.
- Knitted Carpet: Knitted carpets are classified as either pile or flat, much like woven carpets. Flat carpets lack a system of threads that pile up and are made using knitting machines. But piled carpets are made of two materials at the same time: a pile and a ground knit fabric.
- Plain carpets: warp and weft threads of a plain carpet are made up of no thread system that would make up the pile. Plain types of carpet are usually manufactured by hand in plain weave.
- Pile carpets: In addition to their fundamental weave, pile carpets feature an extra thread system that constitutes the carpet's upper side. The pile threads on the surface of loop-pile carpets are arranged in loops. The pile strands in cut-pile carpets seem sheared on the carpet's surface.
  - i. Wire carpets: There is a layer of soft wire heaps on these carpets.
  - ii. Axminster carpets: In order to create a pile, many warp pile threads in a single longitudinal nep row are pulled out or raised in these woven cut-pile carpets.
  - iii. Rapier-Axminster carpets: A Jacquard system controls the selection of the coloured pile threads, while a rapier inserts the pile threads. A single rapier is represented by each pile nep.
  - iv. Chenille carpets: The weft pile yarn is created from premade chenille ribbons.
  - v. Double carpets: These carpets are made by cutting open a double fabric that is created in a single manufacturing step to create the upper and lower sides.

## 2. SUSTAINABLE RAW MATERIALS (FIBRES AND YARNS)

A carpet is generally made from wool, jute fiber, or man-made synthetic fibers. Sustainable resources are used to make carpets, including Eco Trust backing and regenerable and recycled yarns. These materials can be recycled into new products after usage, completing a closed-loop system. From an environmental perspective, in carpet manufacturing, raw materials do matter. Some raw materials are manufactured safely and decompose naturally after disposal, while other raw materials are exceedingly dangerous to use and fabricate and poison the environment when wasted. In the carpet industry, synthetic and natural fibres are utilized. The majority of carpet fibres are composed of synthetic or blends of synthetic and natural materials. There are primary types of carpet fibers described below that are used in carpets and also have a sustainable approach:

- i. Nylon is the most popular carpet fiber, it resists fading, mildew, and staining. There are two kinds of nylon fibers: 6 and 6.6. Both are simple to wash and color. The primary distinction is that nylon 6.6 melts at 263 degrees, while nylon 6 melts at 216 degrees. Nylon 6.6 is a superior choice for temperature-performance items because of this. All things considered, nylon has good economic value and is a highly sought-after material in the recycling process.
- ii. Polypropylene: Another name for polypropylene is olefin. Olefin is another durable and colorfast fiber. This is the fastest-growing fiber being used nowadays. It's inexpensive. Excellent at resisting stains, polypropylene is a fantastic fibre for both indoor and outdoor carpets.
- iii. PTT (Triexta Polyester) Carpet Fibers Polyethylene Trimethylene Terephthalate - PTT (Polytrimethylene Terephthalate) is a polyester fibre that is more resilient than PET; it is also referred to as SmartStrand and Corterra. PET is weaker than PTT, and PTT is easier to clean. However, the cost of production is likewise higher.
- iv. PET (Polyethylene Terephthalate): Water bottles are among the recycled plastics used in the construction of many polyester carpets, often known as PET (polyethylene terephthalate). By strengthening the fibre and extending its lifespan, polyester can become a more environmentally friendly material. Additionally, polyester is readily recycled and naturally stain-resistant.

- v. Wool: Wool feels comfortable underfoot and has a rich appearance. Wool is the greatest option if you want a carpet that will last.
- vi. Acrylics: Acrylics are the texture and appearance of wool They tend to fuzz, though, and are of lesser quality. Acrylic carpet is resistant to static, moisture, mildew, fading, and staining, but the downside is it's not very durable.

### Carpet's detrimental effects on the environment

Carpet waste has the same detrimental effects on the environment as any other type of plastic. Nylon is a strong, robust fibre that is produced from crude oil, and it makes up around 75% of carpets. Large amounts of water and energy are also used in the nylon manufacturing process. To put it briefly, the production of conventional nylon is not environmentally friendly. Due to the large volume of carpet trash generated throughout the production process, landfills face environmental challenges. When they are not occupying landfill space, they are frequently burned, releasing potentially hazardous contaminants along with greenhouse emissions.

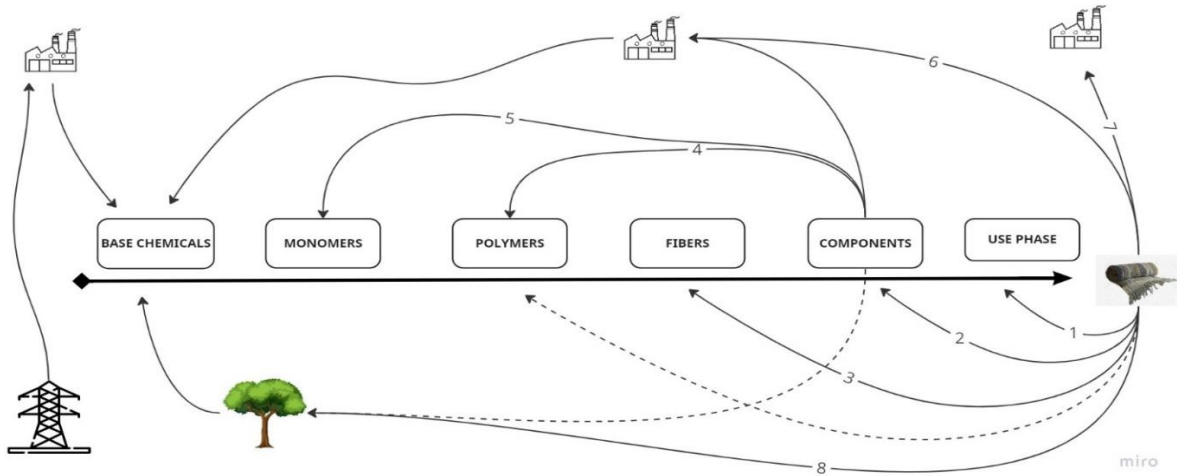
### The Need for Recycling and Reusing and Recycling Process

When a carpet is recycled, its various materials are identified using an infrared light spectrometer. After that, the carpet is either cut to remove the backing from the face or it is shredded, then cleaned. Once the materials have been separated, they are either transferred to specialized plants or undergo additional processing. Nylon 6 face fibres can be recycled into new carpets, polypropylene can be melted down into pellets and shipped to other businesses, and Lower-quality polymers are created by down-cycling other plastics. Today, the two main obstacles to carpet recycling are the variety of materials used and the ineffective post-consumer carpet collection process.

The ecology is negatively impacted by the carpet industry's present life cycle. Reusing and recycling the resources used to make carpets would help us save the environment and move towards a circular economy where trash is turned into new products. However, recycling carpets is not an easy process because it has a number of components with various chemical

compositions that need unique procedures to disassemble and recycle each component separately. Building the necessary infrastructure is necessary to recycle carpets

effectively. As well as also need legislation and funding to make progress.



**Fig. 2. Approaches for Carpet Material Recycling**

Approach 1: Reusing carpets whenever feasible

Approach 2: Going back to the key parts: disconnection from the backing and use-layer

Approach 3: When feasible, directly reuse fibres

Approach 4: Polymer reuse from components made of a mono-material

Approach 5: Recycling of mono-material components chemically Returning to Monomers” .

Approach 6: For polymer combinations that cannot be recycled directly into monomers, return to "Base-Chemicals."

Approach 7: Avoid landfills while combining energy recovery

Approach 8: Complete biodegradation of fibres and various other materials

**Carpet Recycling: Responsible Disposal**

Sustainability is more important now than ever. carpet recycling has increased every year. By bringing together interested stakeholders – entrepreneurs, carpet industry companies, NGOs, governments, and academia, they all come forward to act as a catalyst for the development of new markets, machinery, products, and processes that recycle and repurpose the priceless post-consumer carpet raw materials. Recycled post-consumer carpet is made

into fibres, plastic pellets, broadloom and carpet tiles, and a variety of other products for use in the automotive, transportation, building, and home and garden industries. Buying these products also helps everyone in our communities since we are reducing the amount of recycled post-consumer carpet that ends up in our landfills. Currently, more than 20 percent of recycled post-consumer carpet in the US is used to make carpet backings and face fibre. There are some companies that are engaged in benefiting our society through carpet recycling and reusing.

- i. American Fibre Cushion: they make a vast array of 100% recycled synthetic fiber cushion and pad products.
- ii. Aquafil USA (Premium Carpet Fibre): We can now shear more than two million pounds of carpet fibre annually to feed our ECONYL® Regeneration System thanks to the installation of the machines.
- iii. Interface: Interface is the world’s largest designer and maker of carpet tiles.
- iv. J+J Flooring Group: Established in 1957, is a leading manufacturer of commercial-specified flooring. Products are Broadloom and Modular Carpet, Textile Composite Flooring.
- v. Los Angeles Fiber: is among the biggest waste

carpet collectors and processors in the world. Their fibre products find use in a wide range of industries, including plastic and flooring.

- vi. Geo Hey: offers sediment and erosion control products Using material from recycled carpet
- vii. Tandus Centiva: a global leader in innovative and sustainable solutions for flooring and sports surfaces.
- viii. Shaw: The infrastructure to recover and recycle as much end-of-life carpet as feasible has been established under Shaw's leadership.
- ix. Reliance (carpet Eco-Cushion) Reliance has been the world's biggest recycler of post-consumer carpet for the past 15 years.
- x. Quit-Tech: The goal is to recycle post-consumer carpet to create long-lasting, environmentally friendly building materials like Quiet-Tech insulation batts, which are used in commercial buildings' walls and ceilings to provide acoustic and thermal insulation.

### 3. CONCLUSION

In more recent times, sustainability has grown in importance because we need to understand that our purchase decisions affect the environment. This goes for everything from personal consumption to the design of spaces. Reusing and recycling carpets can improve the earth, but each of us has to contribute in a way that allows for change to occur. The findings reported in this article offer valuable insights into the recycling and reuse of post-consumer carpet waste into an array of innovative and practical items that span a wide range of industries and are unrelated to textiles. The carpet reuse process is the most cost-effective approach to recycling and involves cleaning, trimming, and recoloring for second-life usage because it results in large reductions in greenhouse gas emissions and the consumption of energy and raw resources. Last but not least, a product's environmental performance may be enhanced by

technological innovation at every stage of the value chain, allowing materials to be fully circular and maximizing the use of renewable and recycled resources.

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# Fashion Involvement and Post Consumer Textile Waste Management

Dr. Shefali Massey<sup>1</sup> and Dr. Geetika Jaiswal<sup>2</sup>

<sup>1</sup>Assistant Prof., Deptt. of Textiles & Apparel Designing, College of Home Science, GBPUAT, Pantnagar

<sup>2</sup>Assistant Prof., North Carolina A&T State University  
shefalimassey.tad@gbpuat.ac.in

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## ABSTRACT

*Traditionally, the fashion industry was home-based. However, the major change came around early 19<sup>th</sup> century with the industrial revolution particularly with the invention of the sewing machine, and the development of yarn spinning and fabric weaving industry. So, with industrial revolution, ready-to-wear industry began to evolve and textile and clothing related business began to develop around specific geographical locations, known as ‘business clusters’. During this stage, supply chain was consolidated, manufacturing was mostly located in developed nations, competition was less, consumerism was low than what we see today. With the advancement in transportation and communication technology, business clusters dismantles and manufacturing moved from developed countries to developing countries. In the past 20 years, clothing production has approximately doubled due to higher demand from a growing middle class around the world. Meanwhile, garment usage lifetime has decreased on the consumer side. This embodies the “fast fashion” phenomenon. Repair, Reuse, and Repurpose garments is the one way that consumers can make an impact in the fashion industry by changing their own consumption habits around constantly buying and discarding clothing.*

*The current study found that does fashion involvement of consumers guides the post textile waste management? The research brings the outcomes of relationship of consumer behaviour with sustainable fashion. Also, the study has profound implications for retailers and manufacturers that they should incorporate better sustainable practices into manufacturing fashion apparel. The retailers may also develop strategies to shift consumer behaviour to reduce the post-consumer textile waste.*

*Key words: Sustainable fashion, post-consumer, textile waste management, fast fashion, supply chain*

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## 1. INTRODUCTION

The textile and apparel (T&A) consumption has considerably increased in the past two decades. According to Ouda et al. (2016), the world’s population will reach 8.2 billion in 2025, with half of the population living in urban areas. The growing industrialization and significant increase in middle income group in developing countries like China, India etc., increased textile consumption and waste generation. Foreign Direct Investment in countries like India, opened way for international brands to enter Indian Textile & Apparel market by setting up joint ventures with local brands.

Over the past two decades, globalization of the fashion industry has considerably reduced clothing prices and given greater access to clothing across world, thus making clothing a more affordable item for consumers (Rivoli, 2005). In the 2000s, greater transformation of the fashion industry occurred due to the growth of fast

fashion (Gabrielli, 2013). This resulted in the rise of materialism/consumerism, and ultimately fast fashion. The apparel industry has short product life cycles, vast product differentiation and is characterized by great pace of demand change along with long and inflexible supply processes. Although, the textile and apparel (T&A) industry has contributed in the growth of global economy, fast fashion industry and growing consumerism has posed several environmental challenges. The current buying habits of consumers contributes to 39 million tonnes of post-consumer textile waste that is generated (at a minimum) worldwide each year mainly in the form of garments (Dory, 2018). With growing purchasing power, consumers shifted from need-based purchasing to aspiration-based purchasing (Shah, 2019; Rosmarin, 2020).

The overconsumption and mass production of clothing in form of fast fashion not only damages the environment but also creates various negative impacts socially



(Goworek, et.al, 2012). The fast fashion model encourages consumers to view clothing as disposable items. Annually, the customer wastes is around 460 billion approximately around the globe and millions of garments end up in a landfill (Rathinamoorthy, 2019) Unfortunately, huge amounts of textile waste are landfilled just because of thought less types of acquisition. It is estimated that more than 1 million tonnes of textiles are thrown away every year, with most of this coming from household sources. Past studies have demonstrated that consumers determine disposal and recycling channels based on convenience and accessibility. At least 50% of the textiles that one throws away are recyclable, but in practical only 25% of wastes are recycled (Vadicherla, 2014). The management of textile waste is a formidable problem. The overall guiding principles for waste management which are environmentally favoured are reduction, reuse, recycling, energy recovery, and disposal of waste (Weber, 2016). Few research has been done in developing countries context and there is a high need to reflect on consumer consumption and waste management practices.

India is a country where waste disposal practices especially post-consumer waste is not systematically followed, reused or recycled. Thus, the present research study investigates the effect of consumer's fashion involvement and textile waste management practices.

## 2. METHODOLOGY

A quantitative survey was deemed appropriate for conducting this study. Online surveys offer several advantages, such as, ease of data gathering, quick method, automation in data input and handling, minimum cost, higher response rate etc. The respondents from 20 to 40 years of age from Mumbai (India) were recruited. Snowball sampling technique was used in selecting study respondents. Participants were asked to invite people they know to take part in the study, who were then asked to invite their friends and family. In order to control bias, screening questions were added to the survey like location of participants, age, and respondent's participation in recycling in past 6 months. Total 178 usable data points were collected and analysed by using appropriate statistical tools.

The final survey instrument comprised of two parts: (a) first part of survey collected respondent's demographic information; (b) second part of survey studied and collected data on how consumers manage and dispose apparel. Standardised measurement scales were used in

collecting data and were measured on a five-point Likert scale, 1 being strongly disagree and 5 being strongly agree. Further, screening question was added to ensure that respondents have atleast some background knowledge related to textile recycling concept.

## 3. RESULTS

### a) Demographic characteristics of respondents

It was found that majority of the respondents were female (76 %) and male respondents were 24%. Eighty three percent of the respondents belonged to Gen Y millennials i.e., born between 1980-2000. Maximum percentage of the respondents were graduates (72%) followed by 16% post graduates. Only two percent of the respondents gained doctorate degree in their respective fields. The questions were asked regarding their annual income also and it was found that 83% of the respondents had their annual income between INR 70,137 - INR 8,45,955.

**Table 1: Demographic profile of respondents**

Demographic Characteristics of Participants	Percent	Number (n)
<b>GENDER</b>		
Female	76%	135
Male	24%	43
<b>AGE</b>		
Born between 1965-1979 (Gen X)	17%	30
Born between 1980-2000 (Gen Y-Millennials)	83%	148
<b>EDUCATION</b>		
High School	8%	14
Bachelor's	72%	128
Masters	16%	28
Ph.D	2%	4
Other	2%	4
<b>FAMILY ANNUAL INCOME</b>		
US\$ 1,025.00 or less (INR 70,069.00)	6%	11
Between US\$ 1,026 - US\$ 12,375 (INR 70,137 - INR 8,45,955)	83%	148
Above US\$ 12,367 (INR 8,46,023)	11%	20
Total Number of Participants, N=178		

### b) Textile waste management practices

Analysis of **textile waste management practices** showed that there was a statistically significant difference in the waste management practices of consumers with different levels fashion interests [F(2, 175)=6.247, p=0.002]. Post hoc comparisons indicated that the mean value of waste management practices was significantly different between high-low fashion interest

groups ( $p=0.006$ , 95% C.I.= [-0.46, 3.58]) and medium-high fashion interest groups ( $p=0.009$ , 95% C.I.= [-3.50, -0.38]), while no statistically significant difference between medium-low fashion groups ( $p=1.000$ ).

The pre-existing assumption is that as the fashion consumption increases, the concern for the environment decreases. However, our results clearly indicate that consumers with medium to high level of interest were more engaged in textile and apparel waste management practices more than consumers with low level of fashion interest. Fashion involved consumers have more concern for the environment which is reflected in their buying behaviour.

#### 4. USEFULNESS OF THE STUDY

This study has given a more profound understanding of fashion involvement of Indian consumers, including knowledge about their management of post-consumer textile waste. Imposing pro-environmental behaviour among young Indian consumers can increase customer awareness of the environment responsibility and protection. Creating awareness campaign regarding resell, recycle and reuse can promote high percentage of managing post-consumer textile waste effectively. In addition, fashion designers, clothing manufacturers and retailers can work together to encourage sustainable fashion practices and products among young adults.

#### 5. CONCLUSION

The apparel industry is one of the biggest and rapidly growing industries in developing countries like India. The fashion involvement of young Indian consumers and their post purchase behaviour have gone unnoticed until recently. This research was carried out to establish a connection between fashion involved consumers and their post-consumer textile waste management behaviour. The study outcomes clearly indicated that high fashion conscious/involved consumers have better textile waste management practices than the consumers having low levels of interest in fashion. The Indian consumers who have a high level of fashion interests are very well aware about environmental issues and seek

better practices for clothing purchase and disposal. Textile waste management is a significant challenge to the whole world. The current study provides an insight to the manufacturers to incorporate sustainable practices in production as fashion conscious consumers will get attracted to sustainable fashion products.

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TECHNICAL SESSION II

*THEME* -SUSTAINABLE FASHION

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# Unconventional Sustainable Textile Fibres and Their Potential in the Luxury Fashion Industry

Shaista Atiq<sup>1</sup>, Dr. Simmi Bhagat<sup>2</sup>

<sup>1</sup>Ph.D. Scholar, Department of Fabric and Apparel Science, Lady Irwin College, University of Delhi, India

<sup>2</sup>Associate Professor, Department of Fabric and Apparel Science, Lady Irwin College, University of Delhi, India  
shaista.atiqphd@lic.du.ac.in

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## ABSTRACT

*In light of growing trend towards sustainability in the fashion industry, the search for eco-friendly textile fibres continues to gather attention. The significance of natural fibres and their contribution towards sustainable development was also acknowledged by the United Nations in a resolution passed by the General Assembly in December 2019. This paper presents a review of selected, cellulose-based bast and leaf fibres which were traditionally used to create exclusive one of a kind textiles. The properties of such fibres and their potential use as textile fibres for the sustainable luxury sector have been discussed. Lotus fibre, Pineapple leaf fibre, Ramie and Banana fibre have been found to be suitable for creating delicate, luxury apparel. Coarser fibres such as Nettle and Hemp find their application in home furnishings as well as for making winter garments.*

*This paper also attempts to address the relationship between the concepts of luxury and sustainability, which were traditionally considered to be incompatible ideas having divergent meanings. An in depth analysis of the literature reveals that luxury and sustainability are more closely related to each other than we originally believed. Both these concepts are characterized by qualities like durability, longevity and also craftsmanship, which can preserve social and cultural values as well as traditional production techniques. This relationship between the two concepts can encourage the applications of unconventional textile fibres for the environmentally conscious consumers of the luxury sector.*

*This paper concludes that using these unconventional fibres in the sustainable luxury industry can provide two positive effects: it can lighten the burden on conventional textile fibres while also fostering local craftsmanship, and helping to safeguard priceless skills for future generations.*

**Keywords:** *Unconventional textile fibres, Sustainable Luxury, Eco-friendly natural fibres*

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'Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987). Sustainable development is a concept that came to the forefront because of the growing awareness of an impending ecological crisis. It aims to enable us to fulfil our potential in the present, all the while preserving the biodiversity and ecological balance. Sustainability is a holistic concept. The report presented by the World Commission on Environment and Development in 1987 noted that in order to pursue the idea of sustainable development, the productive potential of the ecosystem should be in harmony with the growth and population size. It further noted that the exploitation of resources and the orientation of technological development should be done mindful of the future as well as present needs (WCED, 1987).

Although the terms 'sustainability' and 'sustainable' appeared for the first time in the Oxford English Dictionary during the second half of the 20th century (Du Pisani, 2006), they have managed to become the contemporary buzzwords, driving innovation in different facets of our lives. The practice of sustainability has encouraged individuals to make lifestyle changes, which in turn has led to innovations in design, technology, engineering, business, and politics. The concept of sustainability has encouraged people to use technological and scientific processes so as to efficiently utilize the limited resources available to mankind.

In 2015, the United Nations member states adopted The 2030 Agenda for Sustainable Development, which underlines the 17 Sustainable Development Goals (SDGs). These Goals serve as an urgent call of action by all countries in a global partnership ("THE 17 GOALS | Sustainable Development", n.d.). Out of these, goal

number 12 calls to ensure sustainable consumption and production patterns. It encourages an efficient use of natural resources and energy, development of environmentally friendly infrastructure and creation of fair paid jobs under good labour conditions. This helps improve the quality of life and devise development plans to reduce economic costs and both environmental and social impacts (Gabriel and Luque, 2020).

## **1. SUSTAINABILITY AND THE TEXTILE INDUSTRY**

The textile industry forms one of the biggest and most significant industrial sectors of the world. Besides catering to one of the three basic needs of mankind, it contributes significantly to the economic growth in the global economy. Being a labour-intensive industry, it allows the developing countries to exploit the availability of cheap labour to their advantage.

The textile industry has an intricate and highly complex manufacturing system involving a massive supply chain. It involves stakeholders from several sectors-agricultural, chemical, dyes, manufacturing, textile and apparel industry, retail and service sector, and waste treatment (Ghosh and Mohan, 2021). The life cycle of a textile product involves different stages, each of which has the potential to significantly impact the environment. Traditionally the textile industry has been notorious for causing environmental pollution. The majority of this pollution is attributed to the discharge of contaminated wastewater generated during the production processes, especially with chemically intensive processes including dyeing, finishing, slashing, and other operations (Thangavelu & Subramani, 2016; Bhatia, 2017).

The first step in the textile supply chain is the procurement of raw material, which is the textile fibre. This textile fibre could be either natural such as Cotton, Silk, Wool etc or it could be synthetic such as Polyester. Both natural, as well as synthetic fibres, leave a significant impact on the environment. Cotton, the most widely produced natural fibre in the world is a water-intensive crop. The global average requirement of water required to manufacture 1 kg of cotton is 11,000 litres (Hoekstra and Chapagain, 2009). It is also often criticized for being heavily pesticide dependent. Synthetic fibres, on the other hand, require less water during their production process but leave a higher carbon footprint due to their non-biodegradable nature (Geetha and Srimala, 2016).

Fibres form the basic unit of the textile industry. Therefore, in order to achieve sustainable development in the textile and clothing industry, the focus should be on searching for potentially sustainable textile fibres. The growing eco-consciousness among consumers has led to a rise in research and development of alternative natural textile fibres which are less hurtful to the environment than conventional fibres.

The importance of natural plant fibres has also been recognized by the United Nations in a resolution adopted by the General Assembly in December, 2019. They note the potentially positive contribution of such fibres towards achieving sustainable development and therefore assist in the implementation of the 2030 Agenda for Sustainable Development. The resolution acknowledges the challenges emanating due to excessive dependence on plastic and artificial fibres can be addressed by encouraging the use of natural plant fibres which have been recognized to be easily recyclable, biodegradable and renewable, with relatively low levels of greenhouse gas emissions. The United Nations further encourages its member states to develop and implement policies and plans to incentivize the sustainable production and use of natural plant fibres and to preserve indigenous knowledge and technologies associated with such fibres (United Nations General Assembly, 2019).

## **2. LUXURY AND SUSTAINABILITY**

Luxury and sustainability are often assumed to be incompatible concepts due to their conflicting notions (Voyer and Beckham, 2014). The idea of luxury is often associated with excess, personal pleasure, superficiality and ostentation, whereas sustainability evokes altruism, sobriety, moderation and ethics (Widloecher, as cited in De Angelis et al., 2017). Whenever luxury products are discussed, it is an established fact that these products are characterized by their excellent quality and craftsmanship. These qualities contribute towards durability, longevity and unique aesthetic design (Joy et al., 2012; Fionda & Moore, 2009). Instead of being influenced by the latest fashion fads, luxury brands follow a strategy wherein the primary focus is placed on adapting traditions to create products that will last, thereby maintaining the brand's heritage into the future (Bendell and Kleanthous, 2007). Luxury goods are consciously made while maintaining high-quality standards so that they can be used for a longer time. Such goods are often inherited through generations. These inherent qualities of durability and longevity possessed

by luxury goods align with the core principles of sustainability (Kapferer, 2010).

As mentioned earlier, craftsmanship is also a key aspect of luxury. This aspect involves the use of quality materials to handcraft products that are deeply rooted in the cultural identity of the people. This leads to the preservation of unique manufacturing techniques to deliver top quality products with a sense of timelessness. Luxury is based on utilizing rare resources as raw materials (Kapferer, 2010; Öymen Kale et al., 2016) and expertise to create products out of these scarce resources which are shielded by sustainability. Therefore combining the concepts of luxury and sustainability can potentially reduce the utilization of natural resources; this is because the high prices of luxury goods limit their demand on the part of consumers, and the durability of the products would ensure responsible consumption (Ranfagni and Guercini, 2018). M. A. Gardetti, (2020) conclude that incorporating sustainability into the luxury sector will not only focus on the conservation of natural resources but also preserve social and cultural values, craftsmanship and production techniques

### 3. UNCONVENTIONAL NATURAL FIBRES

The following sections present a short review of selected bast and leaf fibres which were traditionally used to create exclusive, one of a kind textiles. Most of these were an integral part of the unique identity of that particular region/community. These textiles were truly eco friendly and sustainable and were part of the indigenous identity of the people involved in the production and consumption of these. The use of these fibres started declining with the introduction of cotton and other manmade fibres which proved to be much more economically viable for large scale production. The focus of this paper is on cellulosic based fibres which have been documented to have been used for the production of regional textiles. This review summarizes the fundamental properties of these unconventional natural fibres aimed at their potential use as textile fibres. The properties of the fibres extracted using mechanical methods have been reported. Since commercializing these traditional fabric making techniques has often been found to be difficult due to the high costs incurred, such textiles can find a place in the luxury fashion industry.

#### 1. Lotus fibre

The lotus flower is highly regarded in many different cultures throughout the world. In eastern religions such

as Hinduism and Buddhism, it is known as a symbol of purity, rebirth, enlightenment and self-regeneration (Battaglia, 2019). Hindu deities are often displayed with lotus flowers as their seats. The lotus is also one of the eight auspicious symbols of Buddhism representative of creation and cosmic renewal (Sinha, 2019). It is the national flower of India and Vietnam. Legends state that lotus weaving began centuries ago in Myanmar when a woman noticed the filaments coming out from the lotus stem and got the idea to reel them together. She was a skilled weaver and was able to successfully weave a robe, which she offered to a respected Buddhist monk. Over time the act of offering lotus robes to monks and pagoda statues came to be known as the most sacred act of faith and devotion due to the skill involved in weaving them. The lotus weavers believe that lotus fabric possesses the same healing powers as that of the lotus plant that can remove diseases from their bodies (Myint *et al.*, 2018).

Preparation of fabric from lotus fibres is a time consuming and painstaking process. Fibre extraction, spinning it into yarn, and weaving the fabric are all done by handmade processes which is why it has remained a rare and perhaps the world's most eco-friendly textile. The fabric looks and feels like a blend of linen and silk (Gardetti and Muthu, 2015). The main component of the lotus fibre is cellulose. A study conducted by Wang *et al.* (as cited in Gardetti & Muthu, 2015) to investigate the physical properties of Lotus fibres has provided a theoretical base for developing the fabric. The density of lotus fibre was found to be, much less than cotton, ramie and wool fibres, but similar to silk and acrylic. The linear density of lotus fibre was reported to be, finer than ramie and silk fibres, and similar to cotton and cotton type chemical fibres. The study also indicated that the lotus fibre is very fine and can be used to spin high count yarns. It was also reported that the lotus fibre has a very good absorbent quality. A study done by Pandey *et al.* (2020) found the fibre extracted from lotus to be finer than the best quality cotton, silk, and Pashmina. The length range for lotus fibres is reported to be about 31-50 mm and fineness range 3.963-4.516  $\mu\text{m}$  (Zhao *et al.*, 2015; R. Pandey *et al.*, 2020).

The process of extraction of the fibre and preparation of the fabric is a laborious and tedious process. Approximately 32,000 lotus stems are required to produce just 1.09 yards of fabric, whereas to make a costume, around 1,20,000 stems are needed (Pandey *et al.*, 2020). The fabric is handwoven on traditional



Cambodian frame looms in 100 yards (90-meter) batches, which takes about a month and a half to complete (Gardetti and Muthu, 2015).

Because of the time-consuming nature of the process, pure lotus cloth is rare and expensive, but it is slowly building its customer base in the Sustainable luxury sector. A one-meter long cloth made from lotus threads is worth about 450 USD (Balaji, 2019). Lotus yarns are also often mixed with cotton and silk to reduce the overall cost. (“Lotus Weaving, Myanmar — The Textile Atlas”, n.d.)

## 2. Pineapple leaf fibre

Pineapple is one of the most well known tropical fruits. Pina Cloth, derived from the leaves of Spanish Red pineapple has been a part of history in the Philippines since the 16<sup>th</sup> century. By the 19<sup>th</sup> century, pina cloth came to be known as a symbol of wealth, luxury and refinement and became a part of the cultural identity of the Filipino educated class (Roces, 2013). The whole process of making pina fabric, starting with the extraction of fibre, to weaving and sometimes embellishing it with delicate hand embroidery was extremely labour intensive. The fibre was extracted using traditional methods, which were then joined together end to end to make a continuous filament (Montinola, 1991). Weaving and embroidering pina were female tasks and were part of the identity of elite women (Roces, 2013). Due to the painstaking nature of the process, the pina cloth was expensive and was a one of a kind luxury product worn only by those who could afford it. Upper body garments for both men and women and handkerchiefs were most frequently made although some accounts also report long robes worn by priests fashion from pina fibre (Roces, 2013). The decline in the production of pina cloth began after the mid-1880s due to the availability of cheaper, mass-produced fabrics (Osorio, 2018) and with shifting preferences of young Filipino men in favour of westernized attire. In 1953 Barong tagalong the national Filipino dress which was traditionally made from pina cloth became popular as formal wear (Roces, 2013).

Pineapple fibres are extracted from the leaves of the pineapple plant. These leaves are an agricultural waste product of pineapple harvesting, which implies that no additional inputs are required for the production of raw material. Utilizing these leaves to create textile fibre will help in significantly reducing the waste production. Although mechanized extraction and retting have been

explored, hand extraction is the most prevalent method for extracting fibre from the pineapple leaves (Karthik *et al.*, 2015). The fibre yield of pineapple extracted from fresh leaves is in the range of 2.5-3% (Pandit *et al.*, 2020; Franck, 2005). Pineapple leaf fibre has a high cellulose content of 56%-82%, which contributes to excellent mechanical properties. It has high specific strength and stiffness and is hydrophilic in nature (Ismoilov *et al.*, 2019). In addition, it has a high lignin content of 8%-12% (Franck, 2005). Moisture regain of pineapple leaf fibre is about 12 %, due to this pineapple leaf fibre has a higher dye absorbing tendency as compared to cotton fibres (Karthik *et al.*, 2015). The pineapple fibres are ivory white in colour with a smooth texture, resulting in a fabric that is translucent, delicate and high in lustre. They can be successfully dyed with direct, reactive, vat and azo dyes with better fastness properties as compared to that of cotton (Pandit *et al.*, 2020).

## 3. Banana fibre

Banana is one of the most important fruit crops in the world. Since it does not have a fruit-bearing season, bananas are available all year round and are therefore important for global food security. Once the banana fruit is ripe and harvested, the pseudostem has to be cut down and discarded as agricultural waste for the purpose of encouraging new growth from the underground stem. The pseudostem which is useless after the harvest is a rich source of fibres. Manila hemp is extracted from the abaca plant which is closely related to the banana plant and is known to be an exceptionally strong fibre (“Manila hemp”, n.d.). Hendrickx (2007) report that *Bashōfu*, a fabric made from the banana plant was first reported to be used in making women's court garments in 1546 Japan, and had become the main textile of common people by the end of 19<sup>th</sup> century. It was a lightweight cloth ideally suited for the hot and humid summer of the region. Based on an envoy's account from 1719, Hendrickx (2007) state that every household in *Ryukyu* (Southwest Japan) cultivated their own banana plants to weave *bashofu* fabric to be used by the men and women. It was considered to be as valuable as silk. Since commoners were not allowed to wear silk, *bashofu* became their fabric of choice due to its silk-like sheen and lustre.

Fibres can be extracted from the pseudostems of the banana plant using biological or mechanical methods. The fibre extracted mechanically with a decorticator machine needs to be subjected to the degumming process to remove gum and non-fibrous materials (Subgyo and

Chafidz, 2020). Banana fibres mostly consist of cellulose. Its composition is 64% cellulose, 19% hemicellulose, and 5% lignin, with a moisture content of 11% (Jagadeesh *et al.*, 2015) and moisture regain of 9.8-12% (Subagyo and Chafidz, 2020). Balakrishnan *et al.* (2019) found the dyeing behaviour of banana fibres to be similar to that of cotton and were able to apply the process for reactive dyeing of cotton to banana fibre with excellent colour yields and good to excellent wash fastness.

The fibre can vary in fineness and texture depending on which part of the banana stem is used. Thick, sturdy fibres can be extracted from the outer layers of the pseudostem and softer fibres can be taken from the innermost layers (“Behind the Fiber: Transforming Banana Tree Waste Into Fabric | by Made Trade | Medium”, 2019). The finer quality fibres are delicate and lustrous and relatively expensive.

Rossol (2019) notes that banana fibre has potential applications in fashion and other textile-based industries. Their study concluded that the slow production process and high cost does not make the fibre viable to be used at large within the fashion industry. It could, however, be viable in a luxury capacity. The fibre is soft, with a natural sheen, often considered as a vegan plant-based alternative to silk. Several sources describe the successful blending of banana fibres with cotton (Velumani *et al.*, 2021), jute (Chattopadhyay *et al.*, 2020), pineapple fibre and raw silk (Steele, 2019).

#### 4. Ramie

Ramie, also known as China grass or sometimes Chinese nettle, is a fibre-yielding plant of the nettle family. Since prehistoric times, the ramie plant has been cultivated for fibre in eastern Asia. Ramie fabric was known in Europe during the Middle Ages and was used in ancient Egypt (Britannica, 2021). In the Hansan region of South Korea, Ramie has been used to weave *Mosi* cloth, a lightweight and absorbent textile, since the 9th century. *Mosi* weaving is recognized by UNESCO as an important Intangible Cultural Heritage (“Decision of the Intergovernmental Committee: 6.COM 13.45 - intangible heritage - Culture Sector - UNESCO”, n.d.). Xia Bu, a handwoven fabric made from ramie, was a popular fabric used for luxury clothing for special events in different parts of China. The word “Xia” in Chinese means summer and “Bu” means Cloth which appropriately describes the ramie fabric, which is cool to touch, breathable and absorbent. There are several examples

found of poets describing the beauty and fineness of Xia Bu fabric in Chinese poems. One such poem by Tang Dynasty poet Li Bai, describes ramie clothes worn by the female dancers as “Light as clouds, with colour as silver” (Luo, 2020).

Ramie's fibres are extracted from the bark of the plant with a similar process as that of linen. The fibre is very fine and silk-like, white in colour and has a high lustre (Franck, 2005). Ramie fibre contains 83–96% cellulose along with other non-cellulosic constituents such as gums, waxes, fats, etc (Pandey, 2007). The elimination of gum content from the harvested fibres is the major concern with ramie. The presence of this gum, up to 30% gm per weight of fibre, renders the fibres unsuitable for spinning (Debnath, 2017). Conventional degumming methods involve treatment with Caustic soda (Franck, 2005), which can be hazardous. Several investigations have been made to develop environmentally friendly methods. Jiang *et al.*, (2018) successfully investigated a steam explosion (STEX) treatment followed by Sodium Percarbonate soak for degumming of Ramie. Paul & Bhattacharyya (1979) tested different bacterial cultures for efficient removal of gum and were able to develop a combined microbial and chemical process that was simpler and more economical than the chemical process.

Ramie fibre is a strong fibre, with a tensile strength eight times that of cotton and seven times greater than silk (Franck, 2005; Kochchar, 2016) which can increase by up to 25% on wetting (Franck, 2005). To improve its characteristics, ramie is often blended with other fibres. Debnath (2017) report that ramie fibre can be blended with cotton to achieve increased strength, colour and lustre, whereas to achieve higher wet strength, it can be blended with rayon. They further add that ramie can be blended with silk fibres as a substitute for linen. Fabrics made of 100% long and fine ramie fibres are lightweight and silky. Pandey (2007) found that Ramie fabrics possess excellent properties of heat resistance, moisture absorbance, and mildew and moth resistance. Ramie is a high potential textile fibre because of its strength and durability and is increasingly being recognised in the fashion industry as a premium, high-quality product, with excellent wearing qualities.

#### 5. Nettle

Nettle is a common herbaceous plant with 30 to 45 different varieties. It is considered to be a perennial weed and is more resistant to adverse weather than other crops. Nettle fibre is a cellulose fibre with a long history that

can be traced back to the Bronze Age when it was used to make cloth. The Lusehøj textile, a 2800-year-old textile, found in 1861/2, in Voldtofte, Denmark which was initially believed to be flax was conclusively identified to be made of Nettle (Bergfjord *et al.*, 2012). There are anecdotal pieces of evidence found of Nettle fibre being used in Great Britain up to about 1860 for making a strong, durable cloth. When cotton was in short supply in Germany during World War I, nettle fibre was discovered to be an excellent replacement (Harwood and Edom, 2012). A study done to identify and distinguish between common north European bast fibres in historical ethnographic textiles reveals that nettle might have been a more commonly used textile material during historic and prehistoric times than has been previously assumed (Suomela *et al.*, 2018).

The process of extraction of nettle fibres begins with retting, as in the case of other bast fibres, followed by decortication. Huang (2005), suggest a method involving 15 stages of chemical and biological processes for efficient degumming and cleaning of harvested fibres to prepare them for the spinning process. Microbiological retting of decorticated fibres was explored by (Bacci *et al.*, 2011) which resulted in the production of a higher quality fibre than water retting. Physical properties especially the strength of nettle fibres is higher than other natural fibres such as cotton, silk and wool (Debnath, 2015).

The dyeing procedure followed for other bast fibres can be applied to nettle also. In the case of reactive dyes, the same recipe as that for flax can be successfully followed (Franck, 2005). Matthew (2009, as cited in Debnath, 2015) report that Nettle can be blended well with other fibres to develop fashion apparel and they can withstand laundering at high temperatures. Due to its unique appearance, a heavyweight fabric made from nettle can be an ideal option to make winter garments. Besides apparel, nettle also finds potential application in the home textiles industry as a durable textile.

## 6. Hemp

Hemp (*Cannabis sativa*) belongs to the family Cannabaceae and is cultivated for its fibre (bast fibre) or its edible seeds. It is one of the oldest known textile fibres with the earliest evidence of its use dating back to 8500 years ago. Hemp cultivation began in Europe around the 1500s, and due to its adaptability to a variety of climate conditions and soil composition, it was brought to the New World by colonists. It was an

important industrial plant fibre source and was used for naval applications such as ropes and sails. Due to competition from other fibres such as cotton and other man-made fibres; the demand for hemp has been drastically reduced. High production costs and narcotic abuse of cannabis has also contributed significantly to this decline (Gedik and Avinc, 2020).

Hemp was also an important fibre for the Chinese. According to Scott (as cited in Rhee, 1977) hemp was used to make clothes and other articles such as flags and cordage as early as Shang Dynasty (1600 to 1046 BC). It was the primary fibre used for clothing by ancient Chinese before cotton was introduced during the Song Dynasty (960 to 1127 AD). This claim has been corroborated by several archaeological discoveries as well as accounts in ancient Chinese texts. Hemp was also associated with burial rites, with corpses being shrouded in hemp before interment. The fibre diameter, cross-sectional area and the weave structure of hemp textile fragments reveal that the Chinese had the knowledge of cultivation and weaving of Hemp cloth at a very early date (Lu and Clarke, 1995).

The main component of hemp fibre is cellulose, at about 77% of the total weight. Pectins, lignin, vegetable waxes and fats, and various water-soluble substances constitute the rest (Franck, 2005). The fibre extraction from the hemp stem involves a series of processes- retting, breaking, scutching and hackling, similar to flax. Among these, retting has a strong influence on properties such as colour, strength, uniformity etc (Gedik and Avinc, 2020). Hemp fibre has unique properties as a textile fibre, such as aseptic properties, high absorbency and hygroscopicity, good thermal and electrostatic properties, good UV protection properties, and lack of any allergenic effect, which set it apart from other fibres (Kostic *et al.*, 2014). Hemp is ideal as a furnishing fabric, especially for drapes. Hemp fabric made using traditional methods were too coarse for apparel, but improved processing techniques can enable improvement in textures with the purpose of enhancing wearability. It can be used either in the form of 100% hemp fabric or blended with cotton, wool, flax or synthetics (Muzyczek, 2020).

## 4. CONCLUSION

The textile industry is acutely aware of the need to adopt sustainable practices so as to ensure the long term viability of the entire supply chain. In recent years, there has been an increasing focus on implementing eco-

friendly manufacturing processes. But one cannot deny the significance of addressing this issue at the very first stage i.e. selection of raw material. The research on unconventional/novel fibres is driven by the desire to evade the detrimental effects of producing cotton and manufacturing synthetics such as polyester.

The majority of the unconventional fibres discussed above have not been commercialized. Although the raw material is abundantly available, their utilization for application in the textile sector is still being researched. In most cases, the extraction processes are laborious and uneconomical to be applied on a large scale, since the existing processing techniques are not feasible for mass production.

The current review concludes that the unconventional fibres have not yet been established to be a suitable large-scale replacement for cotton. However, they have a lot of potential to reduce the burden on cotton production in the future. These fibres also have a huge potential in the sustainable luxury market, since the luxury industry prides itself in using higher quality materials and craftsmanship in their processes. Due to its inherent characteristics, the luxury industry has the capability to cultivate and maintain sustainable business environments. Luxury products often are characterized by craftsmanship based on unique skills that artisans hone after practising those crafts for long periods of time. Sustainable luxury can nurture these skills and promote local arts and crafts. The ideas of luxury focus more on the experience and process rather than on the end product. Although high quality, durable and timeless products are characteristics of luxury goods, the positive experience that people derive from possessing such products has always been the driving force for this industry. As a result, the goods are known to be of high quality and therefore come at a high price range. The worth of the product can therefore be determined by the craftsmanship that has gone in the making, the experience the user derives from it and how sustainable the end product is. With the emerging demand for sustainable luxury, this sector has the ability and resources to provide an environmentally friendly and sustainable alternative to lessen the dependency upon conventional textile fibres which have proven to be detrimental to the environment in the long run. This demand is being driven by consumers who are more and more concerned about the impact of their consumption patterns on the environment.

The commitment of the luxury industry to incorporating

these natural fibres can help promote these handcrafted unique textiles as a means to encourage sustainable production using natural raw material and keeping the precious skills alive for generations to come.

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# Reviving Sustainability: The Evolution and Importance of Circular Fashion in Modern Times

Vijita Singh Aggarwal and Liza Nagpal

Guru Gobind Singh Indraprastha University, New Delhi

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## ABSTRACT

*The fashion industry is a dynamic and ever-changing world that profoundly influences our lives, cultures, and economies. However, it has a hidden dark side: it's one of the biggest contributors to environmental problems on a global scale. Over the past few decades, the fashion industry has seen explosive growth, driven by the rise of fast fashion, global manufacturing, and online shopping. Unfortunately, this rapid expansion has come at a great environmental cost, with massive amounts of clothing waste and a significant carbon footprint.*

*In response to these growing environmental concerns, the fashion industry has started to embrace sustainability. It has begun adopting practices like using eco-friendly materials, developing sustainable textiles, and implementing greener manufacturing processes. These efforts represent a shift away from the old-fashioned linear fashion model, which prioritized profits over environmental responsibility.*

*A significant turning point occurred in 2017 when the Ellen MacArthur Foundation introduced the concept of the circular economy on a global scale. This new approach has revolutionized the fashion industry by changing how we think about consumption and production. Circular fashion, unlike the traditional model, focuses on regenerating resources, extending the lifespan of products, and minimizing waste. It challenges the notion of disposable fashion and promotes responsible resource management.*

*This research paper takes a close look at the historical roots of circular fashion, where resourcefulness and responsible resource use were the norm. It also explores why transitioning from the linear to the circular fashion model is not just a good idea but an urgent necessity. Circular fashion isn't a passing trend; it's a sustainable solution to the environmental and ethical challenges facing the industry today.*

*By examining the past, present, and future of circular fashion, this research emphasizes the importance of adopting circular practices. It calls on everyone involved in the fashion industry, from producers to consumers and policymakers, to recognize the urgent need for sustainability and the powerful impact of circularity.*

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## 1. CURRENT SCENARIO OF THE FASHION INDUSTRY

The fashion industry has transcended its conventional role as a mere provider of clothing, becoming an integral aspect of modern life that goes far beyond mere attire. Today, fashion serves as a powerful means of self-expression and plays a pivotal role in shaping one's personality (Chakraborty & Sadachar, 2023). It is a dynamic and ever-evolving sector that not only reflects the spirit of different historical eras but also adapts rapidly to changing preferences, continually striving to cater to the desires and needs of consumers. Throughout history, fashion has undergone remarkable transformations, mirroring the societal, cultural, and economic changes of each era. From the opulent and restrictive clothing of the Victorian era to the liberation of the Roaring Twenties, fashion has always been a

reflection of the times. This evolution continues today, with the fashion industry's ability to swiftly respond to contemporary trends and technological advancements. As each decade leaves its distinct mark on fashion, the industry's role in our lives continues to evolve. Fashion trends are inherently ephemeral, continually evolving to satisfy the ever-changing desires and needs of consumers. The fashion industry invests substantial resources in market research and trend forecasting to gain a better understanding of its customers. Brands launch new collections and styles at a rapid pace, ensuring they remain relevant in a highly competitive market (Fletcher, 2016). This constant evolution enables individuals to express their identity, stay in tune with the times, and adapt to the cultural shifts of our era. The fashion industry, with its finger on the pulse of society, acts as a conduit for personal expression and societal change (Chakraborty & Sadachar, 2023). However, the

fashion industry's relentless pursuit of new trends has indeed given rise to a slew of serious environmental concerns that merit closer examination (Kaikobad et al., 2015). Central to these concerns is the mass production of clothing and accessories, which, despite its undeniable role in satisfying our insatiable appetite for fashion, bears the heavy burden of contributing significantly to pollution, resource depletion, and the generation of vast amounts of waste. One of the most glaring environmental consequences of this industry is pollution, which manifests itself in various forms throughout the fashion supply chain. Starting from the cultivation of raw materials, such as cotton, which often involves the intensive use of pesticides and water, and extending to the dyeing and finishing processes, the fashion production cycle is rife with opportunities for environmental harm. Chemical runoff from dyeing facilities contaminates water sources, rendering them unfit for consumption and harming aquatic ecosystems. Moreover, the discharge of toxic chemicals into the atmosphere exacerbates air pollution, contributing to respiratory ailments and other health issues in communities near manufacturing hubs (Kaikobad et al., 2015). The fashion industry's reliance on these harmful processes underscores the pressing need for more sustainable and eco-friendly production methods. Furthermore, the fashion world's embrace of the "fast fashion" model has proven to be particularly detrimental to our environment. Characterized by the rapid production and disposal of low-cost garments, this approach has made it easier than ever for consumers to stay on-trend, but at an enormous ecological cost. The relentless cycle of churning out cheap clothing contributes significantly to our throwaway culture (Brydges, 2021). As consumers dispose of clothing items after only a few wears, landfills become inundated with discarded textiles. Synthetic materials, like polyester, which are prevalent in fast fashion, are especially problematic as they can take hundreds of years to decompose, further exacerbating the waste issue. The fashion industry's pursuit of ever-evolving trends has not only shaped personal style but also exerted a profound and often detrimental influence on our planet's health. The environmental concerns that arise from this relentless chase for the latest fashion are multi-faceted and far-reaching. In response to the environmental challenges posed by the fashion industry, there's a growing movement toward sustainable fashion practices. Sustainable fashion aims to reduce the negative impact of clothing production and consumption on the environment

and society. It involves using eco-friendly materials, minimizing waste, and prioritizing ethical labor practices (Gazzola et al., 2020). This shift towards sustainability is essential for the industry to adapt and thrive in the long run. By adopting sustainable practices, fashion can reduce pollution, minimize resource depletion, and decrease waste generation. Additionally, sustainable fashion promotes responsible consumption, encouraging consumers to buy quality, longer-lasting clothing rather than indulging in disposable fashion trends. Embracing sustainability not only helps protect the environment but also ensures the fashion industry's continued relevance in a world increasingly focused on ethical and environmentally responsible choices (Kaikobad et al., 2015).

## **2. CIRCULAR FASHION- A TRANSITION FROM LINEAR TO CIRCULARITY**

In the world of fashion, a transformation has been quietly taking place—a shift from traditional linear practices to a circular approach. This change didn't happen overnight; it has its roots in the rich history of ideas and principles that sought to reduce waste, extend product lifespans, and promote sustainable practices in the industry. The story begins with the work of visionaries like Stahel and Reday-Mulvey in 1981. They introduced the concept of an "economy of loops" and a "circular economy," laying the early groundwork for the idea that products shouldn't have a linear lifecycle that ends in disposal but rather a circular one that promotes reuse and recycling. Stahel, in 1994, took this concept further by connecting the circular economy to resource cycling and material-specific efficiencies. This was a pivotal moment as it emphasized the importance of minimizing waste and making the most of available resources within the fashion industry. It became clear that the fashion world could reduce its environmental footprint by rethinking how materials were sourced, used, and repurposed. In 2002, McDonough and Braungart introduced the notion of "cradle-to-cradle" thinking. This groundbreaking idea distinguished between linear "cradle-to-grave" material flows and cyclical "cradle-to-cradle" flows. It emphasized the importance of recycling and regenerating materials within a closed-loop system (Hvass & Pedersen, 2019). This concept laid the foundation for a more sustainable approach to fashion production, one that considered the entire lifecycle of products. However, the real turning point in the fashion industry's journey towards circularity came with the emergence of the Ellen MacArthur Foundation in 2010. Founded by British



sailor Ellen MacArthur, the foundation aimed to accelerate the transition to a circular economy across various sectors, including fashion. In 2015, the foundation launched the Circular Fibers Initiative, with a specific focus on fashion. This initiative sought to revolutionize the entire textiles system within the fashion industry. It emphasized the need to redesign products and processes to minimize waste and promote circular practices. It was a call to action for the fashion world to rethink how garments were made, used, and disposed of. Two years later, in 2017, the foundation expanded its efforts with the "Make Fashion Circular" initiative. This collaborative endeavor brought together major fashion brands, designers, and stakeholders. Its goal was to accelerate the transition to a circular fashion system by addressing multiple facets of the industry. It looked at everything from how clothing was designed to the technologies used for recycling and even consumer behavior. One of the most significant outcomes of the foundation's efforts was the 2019 release of the "A New Textiles Economy" report. This report presented a comprehensive vision for a circular fashion industry. It called for the elimination of harmful practices like fast fashion and advocated for circular design and sustainable materials. It was a blueprint for a more sustainable and environmentally friendly future for the fashion industry (Fashion and a Circular Economy, 2019). Today, the fashion world is in the midst of a transformation. Designers and brands are reimagining product design, giving priority to durability, reparability, and recyclability. Recycling initiatives are on the rise, with brands investing in technologies to repurpose used clothing into new products. Collaborative efforts like the "Fashion Pact" and "Circular Fashion System Commitment" are driving change within the industry (D'Altria & Aus, 2023).

### **3. NEED FOR CIRCULARITY IN THE FASHION INDUSTRY**

In the dynamic landscape of the fashion industry, the imperative of embracing circularity has become increasingly evident for both the efficient functioning of the sector and the sustainable well-being of our planet. The contemporary fashion ecosystem is marked by an alarming trend of overconsumption and disposal, where resources are extracted and garments produced at an unprecedented rate. However, the paradox lies in the fact that despite this surge in production, the utilization of each garment, in terms of the number of wears, has significantly decreased. This discrepancy is rooted in the

prevailing culture of fast fashion, where trends change rapidly, encouraging consumers to adopt new styles swiftly. The consequence is a wardrobe inundated with clothing, often barely worn, contributing to a staggering amount of textile waste (Shrivastva & Jain, 2021). The inefficient utilization of resources, both natural and human, in the production of garments is a glaring issue. The linear model of 'take, make, dispose' dominates the industry, resulting in environmental degradation, resource depletion, and a mounting waste crisis. A critical factor contributing to this unsustainable cycle is the disconnect between the rapid pace of fashion trends and the decreasing lifespan of individual garments. The rise of 'fast fashion' has led to a culture of disposability, where clothing items are discarded after only a few uses. This phenomenon has detrimental effects not only on the environment but also on the economic and social aspects of the industry (Kaikobad et al., 2015). Circularity, with its emphasis on the principles of reduce, reuse, and recycle (the 3Rs), presents a compelling solution to this predicament. The concept of 'reduce' advocates for a more conscious approach to consumption, encouraging consumers to invest in quality garments with enduring styles, thereby decreasing the demand for constant production. 'Reuse' entails extending the life of garments through repair, resale, or redistribution, promoting a shift towards a more sustainable and circular fashion system. Finally, 'recycle' addresses the end-of-life stage, where textiles can be repurposed into new materials, reducing waste and minimizing the environmental impact. The 3Rs are not merely an environmental ethos but also a pragmatic strategy for both producers and consumers (Hvass & Pedersen, 2019). For producers, embracing circularity can foster resource efficiency, reduce production costs, and mitigate the environmental footprint associated with the fashion industry. Consumers, in turn, stand to benefit from a shift towards circular fashion by making more informed and sustainable choices, reducing the volume of clothing in landfills, and contributing to a more sustainable future. It's imperative to recognize that the roots of circularity in fashion are not novel; our grandmothers, in times past, exemplified a circular approach by using garments until they served every conceivable purpose, even repurposing them into dusting mops. The cyclical nature of fashion in ancestral times inherently embraced the principles of reduce, reuse, and recycle, fostering sustainability without the need for conscious effort. As we navigate the complexities of the modern fashion landscape, there is a pressing need to reimagine and reintegrate circularity not

as a fleeting trend but as a steadfast and enduring commitment. Circular fashion should not be relegated to a short-term fix but rather embraced as a long-term goal that aligns with the ethos of responsible consumption, environmental stewardship, and the preservation of cultural practices from our past. In weaving the fabric of a sustainable fashion future, circularity stands as an integral thread, binding together the principles of efficiency, responsibility, and longevity.

#### **4. CHALLENGES AND BARRIERS**

The quest for a circular economy within the textile and fashion industry, although recognized as imperative, encounters a myriad of challenges and barriers, each nuanced and intricate. The complexities embedded in the globalized and highly fragmented supply chain of the fashion industry present a formidable hurdle to achieving circular transparency (Sandvik & Stubbs, 2019). The industry's intricate web of stakeholders and activities dispersed across the supply chain necessitates a delicate balance of commitment, communication, and engagement among diverse entities, making the realization of circular goals a multifaceted challenge. The challenges extend to the very heart of the fashion creation process – the designers. Despite their influential role, fashion designers often find their decisions tethered to the profit targets of the companies they serve. The use of recycled materials, while a sustainable option, remains confined to a niche market, and the associated costs often surpass those of virgin counterparts (Manshoven & Opstal, 2022). Quality concerns act as an additional deterrent for companies considering the adoption of recycled materials, reflecting a notable gap between sustainable intentions and practical implementation. Insufficient awareness and education among the workforce concerning sustainability further hinder the organizational shift towards a circular economy. Perceiving waste as a cost rather than a resource constitutes another formidable obstacle. Many businesses fail to recognize the latent potential of waste as a valuable resource, impeding initiatives aimed at closing the resource loop. Economic considerations often drive a preference for purchasing virgin materials over recycling, given the perceived costliness of recycling processes (Han et al., 2016). Technological limitations in material detection and sorting contribute to manual sorting operations, involving extensive labor and complicating recycling efforts. The absence of technologies for efficient sorting and recycling emerges as a critical barrier to developing a circular economy. In

the realm of textile-to-textile recycling, myriad challenges surface. The diverse mix of materials, colors, and finishes present in fabrics complicates recycling processes. Even when materials can be recycled, either chemically or mechanically, scaling up these processes and ensuring economic feasibility remain questionable. The lack of advanced technologies in this domain accentuates the obstacles to achieving circularity. Consumer interest and awareness stand out as pivotal barriers, with the lack of commitment to returning used products hindering circular economy initiatives. Convincing customers, accustomed to linear business models, to participate in circular models is particularly challenging, especially in a globalized business landscape. Efforts towards end-of-life circularity face hurdles in the absence of effective collection and sorting schemes. Current sorting technologies encounter challenges in accurately sorting complex materials at high speeds (Huynh, 2022). Retailers, integral players in the reverse logistics process, grapple with issues such as cost, the need for additional workforce, and the demand for streamlined processes. The development of innovative sorting technologies and efficient information systems is crucial for overcoming these logistical challenges and making informed decisions to facilitate circularity. In essence, the journey towards a circular fashion economy is fraught with diverse challenges, necessitating concerted efforts across the industry and its stakeholders to address these barriers and pave the way for a sustainable and circular future.

#### **5. DRIVERS AND ENABLERS**

Embracing circular fashion necessitates a profound reimagining of business models within the industry. Shifting from the traditional linear approach to a circular framework involves the active engagement of all stakeholders in the supply chain – manufacturers, retailers, suppliers, and consumers. This transformation extends beyond established connections, urging the industry to forge new ties with stakeholders beyond the conventional supply chain, marking a departure from traditional business norms (Dissanayake & Weerasinghe, 2022). Critical to the success of this transformative process is the collective awareness, knowledge, and commitment of all stakeholders operating within the fashion supply chain. A set of key enablers emerges as fundamental in facilitating and expediting the adoption of circular practices:

**Technology and Innovation:** At the forefront of circular

fashion lies the integration of advanced technology and innovation. This encompasses the development and implementation of groundbreaking solutions that redefine traditional processes. Sustainable materials, manufacturing techniques, and innovations in recycling and waste reduction are propelled by technology, serving as a catalyst for change (Huynh, 2022). The fashion industry's embrace of technological advancements empowers it to enhance efficiency while minimizing its environmental impact.

**Efficient Reverse Logistic Process:** A well-organized and efficient reverse logistics process forms a cornerstone for the success of circular fashion. This process involves the management of product returns, recycling, and reuse. Establishing streamlined mechanisms for collecting, sorting, and redistributing used garments ensures that products at the end of their life cycle are reintegrated into the production loop (Brydges, 2021). Efficient reverse logistics not only reduces waste but also contributes significantly to the circularity of materials, fostering a more sustainable industry.

**Awareness and Education:** The transition to circular fashion demands a fundamental shift in mindset, and awareness and education are pivotal in driving this change. All stakeholders within the fashion supply chain need to be well-informed about the environmental impact of their choices and actions. Manufacturers must make sustainable choices in production, retailers should prioritize eco-friendly options, and consumers need to make informed purchasing decisions. An educated and aware ecosystem is critical for the successful implementation of circular fashion practices.

**Policy Implementation:** Policies play a crucial role in steering the industry towards circularity. Governments and regulatory bodies can incentivize sustainable practices, impose regulations on waste management, and encourage the use of eco-friendly materials. By providing a policy framework that supports circular fashion, authorities contribute significantly to creating an environment where businesses are motivated to adopt more sustainable practices. Effective policy implementation acts as a guiding force, aligning industry practices with broader environmental goals (Mizrachi & Tal, 2022).

**Enhancing Consumer Participation:** Consumer participation stands as a pivotal factor in the circular fashion landscape. Informed and engaged consumers,

cognizant of the environmental implications of their choices, drive demand for sustainable and circular products. Engaging consumers in the circular fashion model involves not only providing them with eco-friendly options but also fostering a culture of responsible consumption and disposal. The industry's ability to align with consumer values and preferences plays a vital role in the widespread adoption of circular practices (Vehmas et al., 2018).

## 6. CONCLUSION

In summary, the story of the fashion industry is like a fascinating tale that unfolds over time. It began with expressing culture and style and has now grown into a huge industry. However, the way we make and throw away clothes today is causing big environmental problems. Luckily, sustainable fashion, which focuses on being eco-friendly, came to light. Early influencers like William Morris and Mahatma Gandhi set the stage for this movement. In recent years, the Ellen MacArthur Foundation played a crucial role in promoting circular fashion, which is all about changing how we make, use, and recycle clothes. Circular fashion is a big change from the old way of making and throwing away clothes. It's about reducing waste by reusing and recycling. The urgent need for this change comes from making too many clothes that don't last long, especially with the rise of fast fashion. There are challenges, though. The fashion industry is complex, and many people need to work together for this change to happen. Challenges include complicated supply chains, designers' decisions, not enough awareness, and seeing waste as a problem rather than a resource. Technology limits and people not being sure about changing also make it hard. But, there's hope. We have solutions that can guide this change. Technology and innovation are helping with new ways to make clothes sustainably. A good system for returning, recycling, and reusing clothes is crucial. Also, we need to teach and make people aware of why this change is important. Policies from governments can support these changes, and involving people in choosing sustainable options is key. In simple terms, circular fashion is not just a trend; it's a strong commitment to being responsible with what we wear, taking care of the environment, and preserving our cultural practices. Making this change needs everyone to work together, be creative, and shift how we think. By choosing circular fashion, the fashion industry can become a leader in sustainability, showing that we care about our planet and our future.

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# Sustainable Fashion

**Dr. Priti Dhankhar**

*Ass. Professor in Home Science, DAV Girls College Kosli Rewari,  
prishambhavi12@gmail.com*

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## ABSTRACT

*We are all aware that human activity puts the stability of our ecosystem and planet in jeopardy. Concerns over conserving the environment and sustainability is growing in today's culture. The only chance we have to save the environment is to go green and eco-friendly. Designers and fashion industry leaders from all around the world are now actively working to save natural resources including trees, animals, land, and the ocean. We ought to comprehend and follow natural and organic fashion. We may encourage eco-fashion by recycling, reducing and reusing clothes, using natural fabrics and dyes, using accessories derived from nature, and engaging in organic production free of pesticides and chemicals. We need to be informed about numerous natural and eco-friendly fashion trends. Despite the extra expense, many proudly demand natural dyes and fabrics strengthening the sustainable approach. They spend a lot of money on products made of organic cotton, jute and silk. Designers, manufacturers, fashion icons, and even the government should take their accountability for driving this shift of sustainability from manufacturing units and designer desk to ordinary consumer or public perception. The main objective of this paper is not only to create awareness about sustainable fashion but also to know about some common terms regarding eco-friendly approach.*

*Keywords: sustainable fashion, eco-friendly approach, eco- system, organic cotton, designer desk.*

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## 1. INTRODUCTION

Since the beginning of time, humans have been constantly destroying natural resources for their own personal gain. Dropping trees, clearing vast tracts of forest, using chemicals, and other such practises all upset the ecological equilibrium and brought about a lot of unwelcome changes in nature. Increases in autos and unchecked industrial growth are also causes serious environmental disaster. Dust, methane, carbon dioxide, carbon monoxide, oxides of nitrogen, sulphur dioxide, mercury, fluorides, and metallic traces are the primary pollutants in the atmosphere. Nuclear pollution is also in addition to it. Improper disposal of garbage is also a great source of pollution. Despite official statistics showing that acceptable tree cover covers 22% of the country's total land area, the National Committee on Environmental Planning claims that the amount of entire land surface covered by trees is no more than 12%.

The clothing and textile industry contributes significantly to global economic growth and is the second-largest source of employment worldwide. Fashion is a never-ending process, and fashion design is a fascinating profession with excellent earning potential. By using environmentally friendly methods, one can move closer to a sustainable future. We can ensure a sustainable

future for our future generations by using eco-friendly practises in textile production and labour laws, among other things. Future generations would greatly benefit from a world of green fashion if the entire fashion industry became environmentally friendly.

Consumers can put significant pressure on designers and manufacturing facilities to adhere to eco-friendly patterns in order to protect the environment and the earth by embracing eco-friendly or green fashion. People in society understand how important going green is. The fashion industry has recognised the value of becoming green, and designers and artists from all over the world are actively working to conserve the planet's natural resources, including its land, trees, oceans, water, and animals. Numerous businesses produce footwear, apparel, jewellery, and accessories using recycled, natural, or organic materials. High profile individuals and individuals from all over the world are making environmental statements by donning environmentally friendly clothing, jewellery, and accessories. There has to be a significant movement in support of all of these.

Generation Z (Gen Z) can be defined as the first global generation that was born digital and that is technology dependent (Johnston, 2018).

They have a large presence on social media platforms,

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where people are presenting their social identities, styles, and personalities through visual content, as well as being influenced by other people's visual content (Djafarova & Bowes, 2021).

Green fashion is defined as apparel made from ecologically friendly materials and produced using eco-friendly methods to lower its carbon footprint. The eco-fashion market is still in its infancy. It needs a lot of time and work put into it all. Organic materials, such as cotton and jute cultivated without pesticides, and silk produced by worms fed on organic leaves may be wild or natural, are used to make eco-friendly clothing. In order to give the fabrics finishing, these goods were processed using little to no toxic chemicals and bleaches. Through this strategy, recycled and worn fabrics are also encouraged.

They either don't include any synthetic chemicals or toxic substances, or they only utilise them sparingly. The first store in Copenhagen, Denmark, to carry entirely eco-friendly apparel was called "Earth A Wear." This notion was the brainchild of Nick Paxevanos. The birth of his son served as his inspiration. "I was already concerned about the environment, but his arrival inspired me to get more involved." The scarcity of eco-friendly apparel pushed me in that direction. His goal was to open the first trendy organic clothes store for both adults and children. The main goals were to raise public awareness of environmentally friendly apparel. A new boutique or online retailer that only sells recycled or eco-friendly clothing increases the public's access to eco-fashion for purchase. People suddenly realise that eco-green fashion is not only elegant and stylish but also the best fashion statement someone could make in the modern world.

Being sustainable does not only mean adding more ethically-made pieces to your wardrobe, but also analysing and understanding what you already own. Sustainable fashion in its true sense calls for maximum utilization of existing belongings. Decluttering and reorganising your closet is the first step to help sift out what you need, what you no longer wear, what could undergo a possible revamp, etc. (Hazarika Mahima, 2021)

When someone buys an organic skirt, bamboo fibre blouse or pair of organic jeans, they fall in love with the clothes right away and develop a new enthusiasm for the idea of eco-friendly design. Consumers of today don't cut corners when it comes to health concerns. He proudly requests organic fabrics with natural dyes and finishings. He is willing to pay more for natural trendy things.

Consumers who are concerned about their health are many. A designer or manufacturer can make a good living and perhaps gain fame for their creativity and eco-friendly manufacturing practises by taking into account their market need. If the production requires more money, the government should provide funding for such strategies. Bank loans with reduced interest rates or subsidies help reduce their losses. There should be a global and national focus on going green.

## 2. ECO FASHION OR GREEN FASHION:

### Journey of green fashion:

The 1970s saw the emergence of green fashion, or eco-fashion. Its primary motivation was a desire for novelty in contrast to traditional fashion. At the time, hemp garments and natural dyes were used.

In **1990's** second time that eco-fashion evolved. The firms that popularised the eco-friendly movement were J.Crew and Patagonia.

Again in **2006**, environmental consciousness gained popularity. Levi's, a well-known global manufacturer, also created environmentally friendly clothing. American Apparel, Eillen Fisher, and Mc. Cartney are a few prominent names in the forefront of producing eco-friendly clothing. Many fashion firms employ only natural dyes for their collections. They leverage this characteristic of natural colouring to draw clients. It is also more environment- friendly to use natural fibres like cotton and wool rather of synthetic ones like nylon, polyester, acrylic, modacrylic, spandex, and lycra.

Natural fibres are not only environmentally sustainable, but they also have good porosity and rarely cause skin issues. Being porous natural fibres carry away surplus body heat and sweat unlike synthetic ones.

For the manufacture of organic silk, the worms are fed on chemical-free organic leaves, and the cocoons are either left to be punctured by the appropriate moths rather than being doused in chemicals or killed by high heat in an oven.

### Types of environment-friendly clothing

**Natural fashion:** includes jewellery manufactured from natural materials such shells and cans, accessories made by spinning yarn, using a loom, and needlework to create clothing.

**Organic Fashion:** Making clothing out of purely organically grown materials is known as "organic

fashion." For a fabric to be considered green, it must originate from a green farm or a location that has been recognised as a green manufacturing facility. Organically grown refers to plants that were sown without the use of herbicides or any other hazardous additions.

**Locally manufactured green fashion:** It includes locally made green clothing, jewellery, or accessories. This refers to apparel or accessories that weren't produced by factories that dumped rubbish or used sweatshop labour.

**Recycled fashion** uses recycled fibres from old textiles to create new clothing and accessories.

**Up cycled fashion:** Another form of environmentally friendly fashion is clothing that has been upcycled from older garments.

#### **Certain facts related to green fashion:**

Although many fashion experts think that green fashion is still in its infancy, fashion designers have recognised its significance. T-shirts are a common outfit choice for both young and senior people. If a T-shirt is composed of cotton that was grown conventionally, nearly 1/5 lb of pesticide is contained within it. Organic materials are those that are grown entirely naturally without the use of dangerous chemicals that harm the environment.

The following information relates to green fashion:

**Peace silk:** One of the newest and most well-liked green fashion products is peace silk. Given that the silk moth is permitted to emerge from its cocoon and complete its whole life cycle, this type of silk is also referred to as vegetarian silk. Additionally, this guarantees that silk quality meets industry standards.

**Bamboo:** Bamboo's porous nature absorbs sweat since it naturally has the capacity to breathe. It is very easily broken down. It produces fabric that is luxurious, robust, elastic, and comfy.

**Pina:** It is a fibre made from leaves of pineapple plant.

Additionally, it is blended with silk, polyester, or other synthetic fibres. Pina is made from a leaf. The leaf's fibre is extracted. The majority of leaf fibres are lengthy and a little stiff. Each pina fibre strand is manually scraped and knotted one by one to create a continuous filament that will be weaved into pina cloth.

**Corn:** The starch and sugars are extracted from corn, then processed to create a fibre known as nature work PLA. Currently, Cargill Dow Polymers is carrying out

this procedure, and the resultant fabric is known as Ingeo. The fabrics have characteristics of cotton, silk, and wool.

**Nettle:** Pest-resistant nettle is used to create nettle cloth. The nettle's fibres are hollow on the inside, allowing air to build up inside and act as a natural insulator. A permanent green dye can be made from the juice of the stems and leaves. One can make a yellow dye by boiling the roots of nettle plant.

**Milk silk:** Goats eggs are combined with genetic material from spiders, causing the female goats to produce milk with silk fibres. The resulting fibre is strong and biodegradable.

**Recycle Polyester from water bottles:** Melted recycled polyester polymer from recycled water bottles is used to create new fibre. It conserves raw materials, promoting a sustainable future.

**Soy silk:** Tofu waste materials are used to make soy silk. The liquid is spun into yarns after being extruded into fibres. The delicate fabric is frequently referred to as vegetable cashmere. It is a plant-based fibre made from soybean hulls. These hulls are by-products of the food industry as well; in fact, the soy fibres are created from the leftover soybean hulls. It can be grown organically and is naturally biodegradable. The soy crop can be grown with little or no pesticide use. It is one of the most popular alternatives to cashmere. Considering how delicate, soft, muted, and shiny soy fabric feels, it is also referred to as "soy silk."

**Timber Pulp:** Two fabrics made from wood pulp using a solvent-spinning process are Lyocell and Modal. The resulting fabric is excellent for delicate skin because it is incredibly smooth and supple. Additionally, it could have excellent wicking qualities that lead to porosity and keep moisture off the skin.

Various sources of green fashion accessories and clothing: There are several sources for eco-friendly apparel and accessories, including jute, cotton, hemp, silk, coir, and other organic natural fibres. Pesticides, insecticides, chemical fertilisers, and other chemicals like artificial colours, bleaches, and other chemical finishes are absent from them. Some of them are mentioned here:

**Jute:** Fashionable shoes, handbags, shirts, suit satchels, purses, and carry bags are made of jute.

**Hemp:** fashionable apparel, handbags, shoes, furniture, bed linens, etc.

**Wood pulp:** Clothing made by the solvent spinning process is extremely breathable, bendable, and healthy.

Jewellery made of bamboo, including earrings, armbands, strings, and purses.

**Paper jewellery:** There is a growing market for trendy paper jewellery that is embellished with dabaka, sequin work, kundan, and other metallic components.

**Shell jewellery:** Shahkhas, earrings, bangles, rings, clips, and brooches are examples of shell jewellery.

**Soy Silk:** Soy silk is a by-product of tofu, which is also referred to as "vegetable cashmere."

**Mud jewellery:** Mud jewellery done in a variety of hues is also a very good alternative to plastic jewellery that is not biodegradable.

### 3. CONCLUSION

Some well-known corporations have acknowledged the vitality of sustainable approach but still there are plenty of designers, developers, and production facilitators who don't adhere to eco- or green fashion lines. Undoubtedly, it needs a lot of work, vision, and financial risk, but the majority of the burden rests with the buyer. The market production will be determined by their demand. If they vehemently demand only eco-friendly products made entirely of natural raw materials and devoid of dangerous

chemicals, the outcome will be in his favour and manufacturing will change for the betterment and eco-friendly approach, dramatically. Since they are well-known figures in the public eye, fictional and real heroes like actors and actresses, athletes, and famous social workers can help in promoting green fashion. There Should be more researches and technological inventions to ensure sustainability in production. There must be strict guidelines raised by government legislations and regulatory bodies along with strict compliance regarding hazardous chemical free production. At last it can be concluded that if we consider sustainability, the best dress is the one which already exist in your wardrobe.

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# Designing Sustainable Eco-friendly Women's Clothes using 3D Fashion Design Software

Rajani Bala<sup>\*1</sup>, Ashish Hooda<sup>1</sup>

Department of Fashion Technology,  
BPS Mahila Vishwavidyalaya, Khanpur Kalan, Sonapat, Haryana

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## ABSTRACT

*The rise of eco-friendly women's clothing, often termed sustainable fashion, is gaining immense popularity. This movement places a strong emphasis on adopting ecologically responsible practices throughout the entire clothing production cycle, encompassing design, manufacturing, distribution, and disposal. Eco-friendly garments are typically crafted from sustainable and renewable materials such as organic cotton, bamboo, hemp, Tencel, and recycled textiles, mitigating the environmental impact of clothing production. One significant endeavor in this realm is the use of Software applicable for fashion design in 3d format to create environmentally sustainable women's clothing. This approach aligns perfectly with sustainability and innovation principles. 3D design software empowers designers to meticulously craft and visualize clothing designs with remarkable precision. It also promotes remote collaboration, reducing the need for in-person meetings and travel, thereby curbing carbon emissions. In essence, employing Software applicable for fashion design in 3d format for eco-friendly women's apparel represents a significant leap in waste reduction, operational efficiency, and the display of commitment to sustainability. By reducing the environmental footprint and fostering creativity, it contributes to the growth of a more environmentally aware and ecologically friendly fashion industry. This trend isn't just about clothing; it's a step towards a more sustainable and responsible future for fashion.*

*Keywords – Sustainable Fashion, Software applicable for fashion design in 3d format, Eco-Friendly, Simulation*

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## 1. INTRODUCTION

Consumers are presently more aware regarding environmental as well as social influences of their clothing purchases. Such fashion may lead to increase in demand of eco-friendly women's clothes. If you're looking to build a sustainable wardrobe, here are some key factors to consider: 1. Materials: Choose clothing made from sustainable and eco-friendly materials. Look for options like organic cotton, hemp, Tencel (Lyocell), bamboo, recycled polyester, and wool from responsibly raised animals. These materials are often generated with lower environmental impact compared to conventional alternatives (L. Eriksson, 2023). 2. Certifications: Check for certifications such as GOTS, OEKO-TEX Standard 100, and Fair Trade that ensure ethical and sustainable production practices (A. Hooda, 2023). 3. Local and Ethical Production: Support brands that prioritize local and ethical manufacturing. This reduces the carbon footprint associated with shipping and ensures fair payment along with secure working conditions for the labor force. 4. Secondhand and Vintage: Consider buying secondhand or vintage clothing. Thrifting is an eco-friendly way to extend the life of garments and reduce

the demand for new production (N. Särmäkari, 2023). 5. Minimalism: Embrace a minimalist approach to fashion by focusing on versatile, timeless pieces that can be mixed and matched. This reduces the need for constant new purchases (K. H. Choi, 2022).

## 2. LITERATURE REVIEW

L. Eriksson et al. (2023) reviewed the value and use of 3D models in the garment industry. This study seeks to consider research question, "What were the pros and cons of implementing 3D digital technology in the fashion industry on the design process of designers?" by an examination of fashion designers' first-hand accounts of using 3D design tools. (L. Eriksson, 2023)

A. Hooda et al. (2023) presented women's clothing 3D model utilized the 3D studio programme. Clothing, shoes, and accessories may all benefit from utilization of fashion design software, which was a kind of computer-aided visual design application that facilitates development of digital fashion drawings, garment designs, textiles, fashion illustration, artwork, and more. (A.Hooda, 2023)

X. Ren et al. (2023) conducted studies on how clothes might be dynamically shown in 3D simulation on a moving body. A practical solution was established to the research challenge by modeling and displaying clothing virtually (X. Ren, 2023).

N. Särämäkari et al. (2023) presented the Atacac and the Fabricant were two examples of digital 3D fashion designers. This article provides context for production of digital fashion industry by analysing the histories of two of its forerunners, Atacac and The Fabricant (N. Särämäkari, 2023)

K. H. Choi et al. (2022) expanded the capabilities of fashion design that is 3d and dynamic with the use of digital technologies and web-based resources. In order to assess the overall possibilities of 3d based dynamic garments and virtual simulation systems, this study conducted in-depth interviews of digital professionals (K. H. Choi, 2022)

H. Liu et al. (2022) supplied a virtual reality setting for designing clothes in three dimensions (5G). This study's major emphasis was on the use of 3D clothing design in a computer-generated 5G virtual reality context. This article takes a look at what virtual reality has to offer in context of 5G era of computing and advocates using VR to build 3D clothing (H. Liu, 2022)

G. Zhang et al. (2023) reviewed the act of retracted or withdraw a previously made statement or claim. This work is focused on implementation of 3D scanning technology in apparel design and development. The existence of these signs erodes our trust in article's integrity and as a result, they were unable to endorse its credibility (G. Zhang, 2023)

E. Papachristou et al. (2022) introduced the wearable antennas integrated into apparel with support of three dimensional virtual prototyping technology. From a technical perspective, antenna efficiency was always front and centre. This research describes the use of two dimensional pattern and three dimensional virtual prototyping technologies to create commercially viable clothes with automatic incorporation of wearable antennas, minimizing the risk of doing so at the expense of the garment's aesthetics or wearer comfort (E. Papachristou, 2022)

M. T. Hossain et al. (2022) presented the current trends and future contributions of three dimensional virtual clothing design automation in Bangladesh's fourth industrial revolution. Objective of such research was to

consider effect of three dimensional virtual garment designing software on the Bangladeshi textile industry (M. T. Hossain, 2022)

J. Zhang et al. (2022) provided the Meta universe in research related to fashion design with the support of three dimensional virtual simulation technologies. New life has been breathed into the fashion industry by a slew of designers that have emerged in the area of virtual fashion since the concepts of "virtual fashion" and "meta universe" became popular in 2018 and 2019 (J. Zhang, 2022)

S. H. Khajavi et al. (2021) focused on the sustainable futures for the garment industry using additive manufacturing. In this study, they examine the potential NBMs that might result from the use of AM technology and examine this sustainability problem from a lifecycle viewpoint. The use of AM to create finished goods was becoming more common (S. H. Khajavi, 2021)

H. McQuillan et al. (2020) provided 3D digital design in the zero-waste fashion industry. To investigate how the authors' design process evolved once they became familiar with 3D software—which was useful for integrated 2D/3D practices—an experimental design approach was used. (H. McQuillan, 2020)

### **3. ROLE OF 3D FASHION DESIGN SOFTWARE**

Three dimensional fashion design software is a powerful digital tool. It has been used in fashion industry in order to design, visualize, and prototype clothing. Designing of cloth has been made in three dimensions. This software allows fashion designers to translate their creative ideas into realistic 3D models. This enables them to experiment with fabrics, colors, and textures. Moreover such effort helps in refining their designs with precision. This is also supporting collaboration among designers, pattern designer as well as manufacturers.

Such softwares also provide a virtual environment for design development and product sampling. With its intuitive user interface and simulation capabilities, 3D fashion design software has revolutionized the way garments are designed. Such software are reducing need for physical prototypes as well as streamlining the design-to-production process. It helps in saving time and resources while promoting sustainability in fashion industry (G. Vignali, 2019) Fig 1: 3D Fashion Design Software

#### 4. ROLE OF DESIGNING SUSTAINABLE, ECO-FRIENDLY WOMEN'S CLOTHES

The role of sustainable, eco-friendly women's clothes designed using software that are used for fashion design is multifaceted and significant in today's fashion industry. Here are some key aspects of this role:

1. **Reducing Environmental Impact:** Sustainable fashion aims to minimize the environmental footprint of the clothing industry.
2. **Efficient Resource Management:** 3D design software enables designers to optimize utilization of materials by accurately calculating fabric requirements for each design (R. Kleinberger, 2018).
3. **Customization and Personalization:** 3D design tools can be utilized to develop customized and personalized clothing items. This reduces production of mass-produced, disposable fashion items and encourages consumers to invest in longer-lasting, tailored pieces (R. Sadoqat, 2017).
4. **Reducing Fashion Waste:** One of the biggest challenges in the fashion industry is post-consumer waste. Sustainable fashion, designed using 3D software, can focus on creating timeless pieces that have enduring appeal, reducing the turnover of clothing in a consumer's wardrobe.
5. **Reducing Water Usage:** Traditional dyeing and finishing processes in the fashion industry consume vast amounts of water. 3D design software can help in developing techniques that reduce requirement for water-intensive processes (O. Adelaja, 2016).
6. **Inspiring Change:** Sustainable, eco-friendly women's clothing designed with 3D software can serve as a model for the wider fashion industry (L. R. Varte, 2021)

[5] Challenges in building Sustainable eco-friendly Women's Clothes Sustainable eco-friendly women's clothing created using software that is used for fashion design, faces several challenges. Firstly, integrating eco-friendly materials and production processes into software that support 3d, can be complex, as it requires a deep understanding of sustainable textiles and supply

chains (Javaid, 2021). Secondly, ensuring that the virtual designs translate seamlessly into real-world, sustainable garments can be challenging, as the software may not always accurately represent the characteristics of eco-friendly materials (K. Morris, 2018). Thirdly, there is a need for widespread industry adoption and education on sustainable fashion practices, as many designers and brands still prioritize speed and cost over sustainability (A. Haleem, 2019).

#### 5. SCOPE OF WORK

The scope of building sustainable eco-friendly women's clothes using software that support 3D fashion design is promising and multifaceted. Here are some key aspects:

1. **Design Innovation:** Software that support 3d fashion design allows designers to consider innovative sustainable materials and textures, fostering creativity and pushing the boundaries of eco-friendly fashion.
2. **Reduced Waste:** By allowing fashion designer to develop virtual prototypes and assess designs before physical production, three dimensional software could significantly reduce the waste generated during the design and sampling phases of garment production.
3. **Sustainability Education:** The use of 3D fashion design software can serve as an educational tool to train future designers and fashion professionals in sustainable practices, creating a more environmentally conscious industry.
4. **Cost Efficiency:** While there may be an initial learning curve, using 3D software can ultimately reduce costs associated with physical prototyping, material waste, and the need for extensive physical samples.

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# Guddad – a Quilt Tradition of Pali

Dr. Akanksha Pareek<sup>1</sup>, Yashvi Ashish Rajyaguru<sup>2</sup>

Assistant Professor,

<sup>1</sup>National Institute of Fashion Technology, Jodhpur (Rajasthan) Bharat,

<sup>2</sup>Research Scholar, National Institute of Fashion Technology, Jodhpur (Rajasthan) Bharat  
akanksha.pareek@nift.ac.in

## ABSTRACT

*India's textile industry has a long history, and its roots may be found in the Indus Valley Civilization when people used hand-spun cotton to weave their clothing. Indian textiles of today honour the glorious past and meet the present world's demands. We may find various textiles, crafts, and skills throughout India. Any community, religion, or culture can be recognized by clothing and textiles with distinguished embellishments. In India, almost every state or region has its way of dyeing, printing, weaving, and embroidering the fabric, making it one of the world's most culturally rich and diverse countries. Indigenous people have used various colours, materials, motifs, and techniques to express multiple ideas ranging from culture, tradition, rituals, God, nature, and values to their emotions and life issues onto a piece of fabric. The Kalbelia community of Rajasthan has a traditional craft in which the gudari/guddad work or quilting is done on recycled fabric using vibrant coloured threads like acrylic wool yarns, silk, and mirrors. The nature of the study is exploratory. For the current study, through the snowball sampling technique, a family belonging to the Kalbeliya community currently lives in a small village called Nimaaj in the Pali district of Rajasthan (Bharat). The data was collected with the help of setting up a small interview with the married couple (husband Premnath & wife Radha) of the family. The questions dealt with materials, tools, the process of making the craft, colours, legacy, and tradition.*

**Keywords:** Kalbelia, Quilt, Guddad, Hand Embroidery, Patch

## 1. INTRODUCTION

In the past few decades, the Kalbelias, also known as snake charmers or the Sapera Community, used to play the *pungi*, an Indian folk music instrument, while going from one door to another. They would display the snakes that they kept in their bamboo hay baskets and receive donations of money and food in exchange. They captivated spectators with their distinctive traditional dance and singing, adorned in elaborate black outfits. The Kalbelia population is primarily itinerant and may be found in various regions of the Thar desert, spanning over India, Pakistan, and certain areas of Afghanistan. The individuals typically originate from the Bundi, Ajmer, Udaipur, and Pushkar districts of Rajasthan (Chakraborty, 2022). However, the community's cultural significance extends beyond their folk dances and songs. The Kalbelia tribe has gained international recognition for their exceptional song and dance traditions, leading to their inclusion in UNESCO's Intangible Cultural Heritage list in 2010. Additionally, they have a unique quilt-making tradition that is primarily practised within the boundaries of their *deras* (residence) (Aggarwal, 2022). A small group of predominantly female artists

from the Kalbelia community, a clan in Rajasthan that has been officially recognized as no longer belonging to a certain caste, exhibited their highly detailed and traditional embroidery and quilting methods. The traditional technique of quilt creation, known as Kalbelia, has been passed down through generations of women in the family. The knowledge is then transmitted to the female offspring of the family. This particular form of craftsmanship is generally referred to as "*gudari* work" or quilting, and it involves the use of repurposed fabric scraps.

## 2. METHODOLOGY

For the research, a family belonging to the Kalbeliya community who are practising this tradition. They are currently living in a small village called Nimaaj in the Pali district of Rajasthan. The data was collected with the help of setting up a small interview with the married couple (husband Premnath & wife Radha (Fig. 11)) of the family. The questions dealt with materials, tools, the process of making the craft, colours, legacy, and tradition.

### 3. RESULTS & DISCUSSION

The primary purpose of creating these quilts is to bestow them upon the daughters of the family as part of their dowry on the occasion of their weddings. When the groom's family visits, displaying these quilts at home is regarded as an indication of affluence and social standing, symbolizing that the women in the family have the expertise, proficiency, and aptitude in this art form. The results are analyzed and presented in the following categories-

#### 3.1 Tools & Materials

The sole implement needed for the quilt-making procedure is a needle (Figure 1). The quilt is crafted by the Kalbeliya community using recycled cloth sourced from their own homes, specifically for the purpose of filling the quilt. To create the top side of the quilt, where the embroidery is done, they get fabric pieces of different colours from the market. Embroidery and stitching threads are typically composed of wool. Acrylic wool yarns and silk, along with mirrors and vibrant designs, are utilized to create a visually striking effect.

#### 3.2 Stitches

The quilt is constructed with a double-running stitch. The decorative stitching on the surface is referred to as Kashida embroidery. The couching technique was employed to secure the thread onto the fabric's surface for embroidery, resulting in a raised or embossed appearance. This method is advantageous because the craftsperson skilfully performs the stitches on the 6-7 layers of fabric, making it challenging to pass the stitches through these layers.

#### 3.3 Process

The quilts are constructed by meticulously sewing together approximately 6 to 8 layers of cloth, with the embroidery being applied on the fabric's surface. This technique is commonly referred to as 'Doda-taka', wherein the needle is used to embroider various patterns with angular movements. Additionally, a limited number

of appliqué techniques are employed (सपेरों के कालबेलिया समुदाय की बूटेदार रजाई बनाने वाली कला को पुनर्जीवित करने का प्रयास, 2022).

The process of *guddad* or quilt-making commences by initially sewing together the layers of fabric. The primary layer of fabric is positioned on the top, with additional fabric inserted in between to provide padding, and finally, the bottom layer of fabric. The fabric edges are encased by overlaying another layer of cloth and sewing it in place. The recycled fabric utilized for stuffing should possess a thinness that allows the needle to penetrate it. They engage in appliqué, a technique where fabric is joined together. Following that, they employ the basic running stitch to connect two or three layers of fabric. The stitches are present on both the front and back of the quilt, whereas the embroidery is only visible on the top surface and does not go through the quilt. Their stitching technique is renowned for its brick repeat pattern. The surface is adorned with various designs created by the needle passing through the sewn thread. Embroidery is used to create various intricate and vibrant designs by stitching over these patterns. Embroidered designs can also incorporate mirrors. These quilts are retrieved for use during guest visits and are presented to the bride as a component of the dowry. The process of completing a single quilt might span from a few months to as long as one year. Pillow covers are produced along with the quilt to form a whole set.

#### 3.4 Motifs, Patterns and Colors

The quilt features motifs with descriptive names such as "*nariyal ful*" (coconut flowers), "*chiriya ke pankh*" (wings of a bird), "*bajubandh*" (armlet), "*bacche ki mangar*" (chain of youngsters holding hands), and so on. They imitate the patterns on snake bodies and mimic their movements. The motifs include *Ankadi Phool*, *Sagwan Jhar*, *Oont*, *Singola*, *Mudki Magar*, *Kodi*, *Kachbo*, *Kangara*, *Lat*, *Sankhadi*, and *faniya* (Pathak, 2022 & Samtani, 2022). Different geometrical and colourful patterns are made by embroidering over these stitches.







**Figure 1: Craft Details, a) Interview with the Artisan Shri Premnath Ji and Radha Ji, b) Front & Back side of Guddad (quilt), c) Doda-Taka, d)Close up view of stitches with needle used, e) A pillow case, f) Couching (embossed thread work).**

#### 4. CONCLUSION

The interview has yielded primary information and has also evaluated the socio-economic circumstances of the Kalbelia craft community while documenting the *Guddad* (Quilt) as a customary craft. The inclusion of talks, interviews, and informal interactions has provided a comprehensive foundation for the study, enabling the derivation of significant results. The investigation uncovered that individuals engaged in the aforementioned situation experience a lamentable state. By implementing suitable intervention and providing adequate support, it is possible to achieve a significant transformation in both the sector and the individuals involved. The procedure of *Guddad* (Quilt) creation is straightforward and does not necessitate the use of costly equipment. The use of outdated fabrics presents a challenge in promoting the goods, making it difficult to generate economic interest. Therefore, it is crucial to revitalize the sector from a societal perspective as well. The Kalbelia community has experienced numerous transformations, particularly in terms of its social and economic standing within society in the past. Art requires maximum support to enable the artist to experience contentment derived from their imagination, captivating designs crafted with a spectrum of colours, and exceptional craftsmanship.

#### ACKNOWLEDGEMENT & FUTURE SCOPE OF STUDY

We offer sincere gratitude to the artisan family, Shri Premnath Ji and Shrimati Radha Ji, for their invaluable contribution in providing profound insights and essential information about the craft, which greatly contributed to the success of this study. According to the current study and the cooperation of artists, there is a potential for documentation on other subjects pertaining to the craft and craftspeople and the scope of production of contemporary craft-based products that align with current fashion trends. This could open up opportunities for future research.

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TECHNICAL SESSION III

*THEME* -EMERGING ROLE OF DIGITAL TECHNOLOGIES AND AI IN  
FASHION & TEXTILES

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# Optimizing Supply Chains in the Fashion & Textile Industry through AI

**Neha Arora<sup>1</sup>, B C Anant<sup>2#</sup>, Dr. Kavita Chaudhary<sup>2</sup>**

*Assistant Professor, Amity School of Fashion Technology, AUUP, Noida  
Academic Associate, Great Lakes Institute of Management, Gurgaon  
Associate Professor, Department of Design, Banasthali Vidyapeeth, Rajasthan  
(#=Corresponding Author & Presenter: anant.b@greatlakes.edu.in)*

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## ABSTRACT

*The fashion & textile industry is constantly evolving, driven by shifting consumer preferences, shorter product lifecycles, and global supply chain complexities. To stay competitive and sustainable, companies in this sector are increasingly turning to artificial intelligence (AI) to optimize their supply chain operations. This research paper discusses the significance of AI in the fashion and textile industry's supply chain management, focusing on its potential to enhance efficiency, reduce costs, and promote sustainability, resulting transparency. The paper highlights several challenges faced by the F&T sector, like demand volatility, rapid trend changes, and the need for sustainability. These challenges have rendered traditional supply chain management methods obsolete, necessitating the adoption of AI-driven solutions. AI technologies, including machine learning, predictive analytics, and advanced algorithms, empower fashion and textile companies to forecast demand more accurately. AI helps analyze vast datasets and consider variables like historical sales, weather patterns, and social media trends, and generate precise demand forecasts. This enables brands to optimize inventory levels, reduce stock situations, and enhance customer satisfaction.*

*AI enhances supply chain transparency and traceability, vital for addressing sustainability concerns. It can track the environmental impact of materials, production processes, and transportation, aiding in the identification of areas for improvement and sustainable practices adoption. In automating routine supply chain tasks, such as order processing, inventory management, and logistics optimization, AI reduces operational costs and minimizes human errors increasing overall efficiency.*

*The research concludes with an explanation of the integration of AI in supply chain management of F&T industry. Adaption of the ever-changing market dynamics, improve sustainability practices, and optimize their operations, ultimately leading to increased profitability and competitiveness. This research paper provides valuable insights through qualitative & quantitative data, and consumer insights into the transformative power of AI in redefining supply chain management.*

**Keywords:** *Artificial Intelligence, Analytics, Automation, Data, Machine Learning, Optimization, Supply Chain Management.*

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## 1. AI AND THE FASHION INDUSTRY:

Artificial intelligence is a significant development in the tech-savvy industry and is very well capable of capitalizing on to the tasks that holds the capability of making humanly decisions and can perform great amount of task with a significant amount of speed and efficiency. The fashion & textile industry is a global powerhouse, contributing significantly to economies worldwide. Globally, the fashion industry is one of the biggest sectors, with a labor force of 3.45 billion and a value equivalent to 2% of the world's Gross Domestic Product. The global revenue of Fashion & Textile industry falls

between \$1.7 trillion and \$2.5 trillion. In India, one of the fastest-growing industries in the world, the fashion market is expected to grow at a compound annual growth rate (CAGR) of 11-12% to reach \$115-125 billion by 2025. Fashion & Textile industry also contributes as the 2<sup>nd</sup> largest global polluter, resulting in huge environmental consequences. It contributes significantly to global environmental pollution at every point of the supply chain (Abbate et al., 2023). From sourcing materials to production, processing, transport, and shipping, each step involves substantial energy use and emissions.

The fashion industry is one of the largest and most complex industries in the world, with a global supply chain that spans multiple countries and continents. This complexity makes it difficult to optimize the supply chain and ensure that products are delivered to customers on time and at a competitive price. Artificial intelligence (AI) as an emerging and a powerful tool for optimizing the fashion supply chain. AI can be used to improve demand forecasting, inventory management, transportation planning, and other key supply chain processes.

In response to these challenges, the fashion industry is undergoing a significant transformation with the industry 4.0 advent of Artificial Intelligence (AI). AI has been adopted by various fashion brands to optimize their operations and supply chain management, globally. Algorithms that are AI-powered are capable in predicting upcoming trends, understanding the customer preferences, offering personalized product recommendations, and most importantly, in optimizing the supply chain management systems through demand prediction (forecast) and automated inventory management system(s).

This paper deeply delves into these aspects, it also investigates how AI can be leveraged to optimize supply chain management in the textile industry, hence, contributing to a more sustainable and environmentally friendly fashion & textile industry. Supply chain is the concept that ensures a product reaching from the source of manufacturing to the end consumer(s), and for an industry that is as huge as the fashion & textile industry, there lies a lot of bottlenecks within, creating wastage to large quantities. F&T industry significantly contributes to global environmental pollution at every point of its supply chain. From sourcing of materials to the production, processing, transport, and shipping, (including the reverse logistics) each step involves substantial energy use and emissions.

## **2. THE CONCEPT OF OPTIMIZATION THROUGH AI, AND THE EXISTING CHALLENGES:**

Fast fashion, despite COVID-19, stands as a business model based on replicating high-end fashion designs for mass production, exacerbates the industry's environmental impact. These clothes are designed with a limited lifespan (PLC), leading to increased consumption and waste. The rapid turnover of trends, especially with the rise of smart and informed Gen-Z consumers, e-

commerce, the necessities of manufacturing processes have seen sharp swift, often involving cheap synthetic fabrics, and resulting in products not designed to last long! Adding to the carbon emissions, the fashion industry is a major consumer of fresh water and a significant source of water pollution. As per Sourcing and Supply Chains' 2021 report, garment production numbers doubled between 2000 and 2015, while the average number of times clothing consumption fell by 36%. This increase in production and decrease in usage is alarming and has led to an increase in water consumption and pollution, at large. Fast fashion encourages disposable consumption patterns. Low-quality clothes make it cheaper for consumers to buy new outfits frequently, this has resulted in mountains of discarded clothing being either burned or ending up in landfills.

## **3. THE IMPACT OF NEW AGE CONSUMERS AND E-COMMERCE ON THE FASHION INDUSTRY'S SUPPLY CHAIN:**

The new age consumers and the emergence of selling Fast Fashion through E-commerce has also had a profound impact on the fashion industry's supply chain. The rise of online shopping has led to an increase in demand for fast fashion items, generally, produced in large quantities and at a rapid speed to keep up with changing apparel lifecycle and trends. This has increased pressure on supply chains, that leads to operational inefficiencies and unexpected external disruptions.

Responding to these challenges, the fashion industry is exploring Artificial Intelligence and the transformation to optimize their operations and supply chain management. AI-powered algorithms can predict upcoming trends. This allows fashion brands to stay ahead of the curve (and their competitors), and prepare for future demands. AI can efficiently process massive amounts of data to understand customer preferences and develop consumer buying patterns, draw inferences. This helps in creating designs (products) that are more likely to resonate with the target audience and satisfy their needs.

AI is used by brands to offer experiential retailing through personalized product recommendations. This not only enhances the customer experience and helps fashion brands inventory management by promoting products that are overstocked. It optimizes supply chain management through demand prediction, that ensures

that the resources are allocated efficiently, preventing overproduction and waste (lean in nature). Automation of inventory using AI can help retailers manage their stock more efficiently, reducing the chances of stockouts or overstocking, which de-clutters the overall SCM. AI allows fashion companies to process, analyze, and depict a massive amount of data to identify faster than ever which products are being seen at the most interest or the highest purchase rate at any given time. This speeds up the supply chain process and allows manufacturers to know where to focus their resources, at the right time! AI is not just optimizing supply chains in the fashion and textile industry, but it's revolutionizing it by making it more efficient, sustainable, and responsive to market trends and consumer preferences. Chinese e-commerce giant, Alibaba has developed a concept called, "New Manufacturing" model that has reduced the need for garment/apparel merchants to hold inventory by 30%, it has also shortened the delivery time by 75%, and cut the water consumption by 50%. The level of efficiency achieved with an AI-enabled supply chain delivers over 65% effectiveness in lowering risks and lowering overall costs.

The basic framework cum process flow of AI-based supply chain optimization in the fashion industry involves several steps (*Disclaimer: This is a very basic process flow of AI based SCM in the Fashion Industry*):

**Collection of Data → Demand Prediction → Automated Inventory Management → Production-Planning → Order Fulfilment → Customer Experience Enhancement → Performance Analysis → Improvement(s).**

The process includes more or less of the same processes as mentioned above, AI uses the data accumulated from customers' search history, preferences, social media platforms, etc. to push specific suggestions, and understand what people buy, when they buy it, and where it should be placed in the store (offline & online). Demand Prediction is then analyzed through this data, AI predicts the upcoming trends and tailors the offerings accordingly for the brands, to offer to the customer. This helps in forecasting the demand for different ranges of products. To optimize supply chain management of fashion industry, by automating inventory management helps in keeping track of the stock levels and ensuring that the inventory is replenished as needed; *also mentioned above*. On the basis of the predicted demand and inventory levels, AI then assists the management team in planning the production of the visible variable in

fashion (the probable trend to be offered), this leads to a larger picture of sustainable order fulfilment in lesser packages, and more accuracy. Efficiency is also improved through consumer engagement; *leading to personalized last mile delivery and resolution of queries, issues through AI bots, ensuring further data collection to improve services at both the ends.*

**TABLE 1: AI Based SCM Elements**

Trend Identification:	Collection of Data
Demand Prediction:	Analysis, Demand, Predictions of Future Trends
Automated Inventory Management:	Prevents Inventory Out/Over Stock(s) at Large
Production Planning:	Reduces Wastage, Makes Systems Lean
Order Fulfillment:	Efficient Delivery (Sustainable in Nature)
Customer Experience Enhancement:	AI bot used to address queries, personalization
Continuous Learning and Improvement:	Addressing the issues, enhancing technology, optimization of SCM

**AI in FSCM: Consumers' Quantitative Perception (Challenges, Suggestions & Conclusion):**

This paper also analyzed the Consumer of the modern day from Delhi-NCR to understand their perception on the concept of AI based optimization of the SCM systems in the fashion industry. A total of 138 responses were collected based on 3 variables, (a) Understanding of AI incorporation in Fashion Supply Chain<sup>1</sup>, (b) Are consumer's willing to pay for a brand offering sustainable SCM<sup>2</sup>? (c) Significance of transparency & traceability in Fashion industry's SCM<sup>3</sup> to infer the understanding of these consumers about the designated concept of optimization of fashion supply chain. We found out the following concept that describes that there exists a sense of understanding and responsibility towards nature, and sustainability, and they seem to be ready to spend some amount towards a transparent Supply Chain. Let us now see what we have found from the answers of our respondents ranging between 18-40 years, from a Tier-1 demography. Basic quantitative analysis (descriptive) has been used. The data has a possibility to help fashion brands understand consumer psyche even better and optimize their supply chain

systems using AI and other new age technology. The variables; *termed as 1,2 & 3* depict the inferences based on the questions, and received responses.

FSCM here stands for Fashion Supply Chain Management.

**Table 2: Understanding Consumer’s Point of View on AI based Optimization of FSCM**

Sl. No.	Concept	Variable(s)	Response
1	Consumer Base	1,2,3	65.8% respondents are b/w 18-24 years of age
2	Purchase Decision Making (Digital)	1	38.4% buys few times a week, 12.3%, shops clothing once every week
3	Retail Selection- Factors	2,3	36.2%- Price Sensitive, 29.7%- Return Policy, 25.4%- Convenience, 8.7%- Shipping Speed
4	Consumer Responsiveness on SCM	2,3	40.6% (new age) consumers "Always" check Fashion Brand's SCM policies w/35.5% sometimes
5	Awareness on AI in FSCM	2	46.4% are "Somewhat aware," while 23..2% are "Fully Aware" of AI optimization in FSCM
6	Significance of Sustainability in Fashion	1,2,3	48.6% find it "Extremely Important," 43.5%- important, 6.5%- Somewhat Imp., and 1.4%- Not Imp.
7	Consumer Spending- Premium Price	2	38.4% are ready to pay premium price for AI driven sustainable system, w/42% unsure
8	Integration of AI in FSCM	3	54.3% says it is "Crucial," 3.6% believe AI is not at all required
9	Transparency & Traceability using AI in FSCM	3	29% believe "Very Transparent," 52.9%- Somewhat Transparent SCM, 15.2% are unaware of this
10	Brand Perception & Value	2	54.3% supports brands using AI based optimized FSCM

The revolution AI is bringing in FSCM in order to optimize the entire process flow, and reduce wastage is marvelous, however, that comes with a cost and several challenges like fear of loss of jobs, lack of real-time data analysis, high cost- investment in AI systems, expensive updates, extensive data driven IT infrastructure management, limited resources, lack of trust on predicted data, and many more! These challenges must be addressed by the Fashion Industry and brought on to the solution table. Consumer awareness and responsibility is also a big challenge, but with the emergence of AI based Supply Chain systems, lesser manual errors have become possible, and optimization as a concept has started being evident. This research has been an effort to understand the basics of AI based optimization principles from Industry and Consumer’s perspective. The future of F&T industry is bright, and with more and more technology being adapted, the pressure on maintaining sustainability goals for fashion brands, and industry at large shall be reduced. Developing economies that produce large amounts of clothing/ fashion products also need to start

incorporating Artificial Intelligence into their supply chain and overall production management systems to address the bottle necks and reduce them to size zero. Data safety must be prioritized in the Fashion Industry with the help of public-private partnership (with Governments and other stake holders). The data inferred from customers are promising, with an impressive quantity of consumers between 18-24 are finding themselves responsible for their purchases and with time, ready to adapt to the new age, cutting edge technology like AI. SCM is a huge area to explore, but this attempt as a paper ensures the pathway for F&T industry to implement AI in SCM and is brands can utilize the work performed to develop consumer buying strategies, with tailored channeling & messages.

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# Fashion in the Age of A.I.

Saloni Ashok Shukla

*Creative Technologist, Whistling Woods International – Mumbai*

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## ABSTRACT

*Artificial intelligence (AI) is rapidly transforming the fashion and textile industry, with a focus on preserving and recreating traditional art forms, creating new and complex discoveries, and improving the efficiency and accuracy of design and production processes. Preserving and Recreating Traditional Art Forms.*

*AI can be used to digitize and collate and restore historical textiles, or to create new designs based on traditional and cultural motifs. This can help to ensure that traditional art forms are preserved for future generations and that they continue to be a source of inspiration for designers. Using AI and Robotics the hope to recreate extinct and dying art forms and culture is something to look forward to.*

*For example, the Metropolitan Museum of Art in New York City has partnered with Google AI to launch a new online platform that provides free access to over 380,000 high-resolution images of the museum's collection, including a wide range of textiles from around the world. The platform also features AI-powered tools that allow users to explore and learn about the textiles in more detail.*

### *Creating New and Complex Discoveries*

*AI-powered design tools can help designers to create innovative new patterns and textures. AI can also be used to generate new materials with unique properties that can be used to create new types of clothing and textiles.*

*For example, the fashion brand Balmain has partnered with the AI company Material ConneXion to develop a new sustainable textile called "Biomimicry." Biomimicry is a textile made from algae and recycled polyester. The algae is grown in a bioreactor using sunlight and wastewater. The algae is then harvested and processed to create a fiber that is then blended with recycled polyester to create the Biomimicry textile. Biomimicry is a sustainable textile because it uses less water and energy to produce than traditional textiles. It is also biodegradable, so it does not contribute to landfill waste.*

*Improving the Efficiency and Accuracy of Design and Production Processes: AI can be used to automate tasks such as pattern making, grading, and cutting. This can help to reduce costs and improve the efficiency of the production process. AI can also be used to create personalized garments and accessories for individual consumers.*

*For example, the embroidery company Madeira has launched a new AI-powered embroidery machine called the "MLX." The MLX machine can create complex and intricate embroidery designs that would be difficult or impossible to create by hand. The machine uses AI to analyze the design and then automatically generates the necessary stitches. The MLX machine is also able to adjust the stitches on the fly to ensure that the design is perfectly recreated.*

*Methodology: This paper draws on a variety of sources, including quantitative and qualitative data, to explore the impact of AI on the fashion and textile industry. The paper also includes case studies from companies that are using AI in innovative ways.*

*Quantitative methods were used to collect data on the use of AI in the fashion and textile industry. This data was collected from a variety of sources, including industry reports, academic journals, and company websites. The data was then analyzed to identify trends and patterns in the use of AI.*

*Qualitative methods were also used to collect data on the impact of AI on the fashion and textile industry. This data was collected through interviews with fashion designers, manufacturers, and retailers. The interviews were used to gain insights into how AI is being used in different parts of the fashion and textile industry and the impact it is having on businesses and consumers. The case studies included in the paper provide further insights into how AI is being used in innovative ways in the fashion and textile industry. The case studies were selected based on their relevance to the research topic and their ability to provide a variety of perspectives on the use of AI in fashion.*

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### *Conclusion*

*AI is transforming the fashion and textile industry in many exciting ways. AI is being used to preserve and recreate traditional art forms, create new and complex discoveries, and improve the efficiency and accuracy of design and production processes. AI continues to develop, we can expect to see even more innovative and groundbreaking applications of AI in the fashion and textile industry.*

*Keywords: Artificial intelligence, Fashion, Design, Technology, Preservation.*

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## **1. INTRODUCTION**

Artificial intelligence (AI) is rapidly transforming the fashion and textile industry. AI-powered tools and technologies are being used to preserve and recreate traditional art forms, create new and complex discoveries, improve the efficiency and accuracy of design and production processes, and revolutionize the way we shop for and consume clothing.

### Preserving and Recreating Traditional Art Forms

One of the most exciting applications of AI in the fashion and textile industry is its use to preserve and recreate traditional art forms. AI can be used to digitize and collate historical textiles, or to create new designs based on traditional and cultural motifs. This can help to ensure that traditional art forms are preserved for future generations and that they continue to be a source of inspiration for designers.

For example, the Metropolitan Museum of Art in New York City has partnered with Google AI to launch a new online platform called The Met's Open Access that provides free access to over 380,000 high-resolution images of the museum's collection, including a wide range of textiles from around the world. The platform also features AI-powered tools that allow users to explore and learn about the textiles in more detail.

Another example is the work of the French AI company RE:3D, which is using AI to recreate extinct and dying art forms and cultures. RE:3D has created a digital archive of over 1 million 3D models of artifacts from around the world. This archive is being used to create new designs and products that are inspired by traditional art forms.

For example, RE:3D has partnered with the fashion brand Chloé to create a collection of jewelry inspired by ancient Egyptian artifacts. RE:3D used its AI technology to create 3D models of the artifacts, which were then used to create the jewelry.

### Creating New and Complex Discoveries

AI is also being used to create new and complex discoveries in the fashion and textile industry. AI-powered design tools can help designers to create innovative new patterns and textures. AI can also be used to generate new materials with unique properties that can be used to create new types of clothing and textiles.

For example, the fashion brand Balmain has partnered with the AI company Material ConneXion to develop a new sustainable textile called Biomimicry. Biomimicry is a textile made from algae and recycled polyester. The algae is grown in a bioreactor using sunlight and wastewater. The algae is then harvested and processed to create a fiber that is then blended with recycled polyester to create the Biomimicry textile. Biomimicry is a sustainable textile because it uses less water and energy to produce than traditional textiles. It is also biodegradable, so it does not contribute to landfill waste.

Another example is the work of the AI company Stitch Fix, which uses AI to generate personalized clothing recommendations for its customers. Stitch Fix uses AI to analyze data such as the customer's body type, style preferences, and budget to create a personalized selection of clothing. Stitch Fix's AI-powered recommendations have helped to improve customer satisfaction and increase sales.

In addition to generating personalized recommendations, AI is also being used to create new and innovative types of clothing. For example, the company Vollebak has created a jacket called the Solar Jacket that uses solar energy to generate heat. The Solar Jacket is lined with solar panels that convert sunlight into electricity, which is then used to power a heating element in the jacket.

## **2. IMPROVING THE EFFICIENCY AND ACCURACY OF DESIGN AND PRODUCTION PROCESSES**

AI is also being used to improve the efficiency and accuracy of design and production processes in the fashion and textile industry. AI can be used to automate tasks such as pattern making, grading, and cutting. This



can help to reduce costs and improve the speed and quality of production. AI can also be used to create personalized garments and accessories for individual consumers.

For example, the embroidery company Madeira has launched a new AI-powered embroidery machine called the MLX. The MLX machine can create complex and intricate embroidery designs that would be difficult or impossible to create by hand. The machine uses AI to analyze the design and then automatically generates the necessary stitches. The MLX machine is also able to adjust the stitches on the fly to ensure that the design is perfectly recreated.

Another example is the work of the AI company Teslasuit, which has developed an AI-powered body scanning technology that can be used to create personalized clothing. Teslasuit's body scanning technology can create a 3D model of the customer's body, which can then be used to create custom-made clothing that fits perfectly.

### **3. REVOLUTIONIZING THE WAY WE SHOP FOR AND CONSUME CLOTHING**

AI is also revolutionizing the way we shop for and consume clothing. AI-powered shopping tools can help consumers to find the right clothes for their needs and preferences. For example, the app StyleSage uses AI to recommend clothes to users based on their past purchases and style preferences. StyleSage also allows users to take photos of themselves and the app will suggest clothes that match their style.

Another example is the app MySizeID, which uses AI to help users find the right size clothes. MySizeID allows users to scan their bodies with their smartphones to create a 3D model of their bodies. This model is then used to recommend clothes that fit perfectly.

AI is also being used to develop new and innovative shopping experiences. For example, the company Amazon has developed a technology called Amazon Go that allows customers to shop without having to check out. Amazon Go stores use cameras and sensors to track what customers take off the shelves and add to their carts. When customers leave the store, they are automatically charged for the items they have taken.

AI is transforming the fashion and textile industry in many exciting ways. AI is being used to preserve and

recreate traditional art forms, create new and complex discoveries, improve the efficiency and accuracy of design and production processes, and revolutionize the way we shop for and consume clothing.

As AI continues to develop, we can expect to see even more innovative and groundbreaking applications of AI in the fashion and textile industry.

In addition to the applications of AI mentioned above, AI is also being used to improve the sustainability of the fashion and textile industry. For example, AI can be used to reduce waste in the production process and to develop new sustainable materials and processes.

AI is also being used to promote social responsibility in the fashion and textile industry. For example, AI can be used to track the supply chain and identify potential labor rights violations.

Overall, AI has the potential to make the fashion and textile industry more sustainable, socially responsible, and innovative.

### **4. CHALLENGES AND ETHICAL CONSIDERATIONS**

While AI has the potential to transform the fashion and textile industry in many positive ways, there are also some challenges and ethical considerations that need to be addressed.

One challenge is that AI algorithms can be biased. This means that if the data that is used to train an AI algorithm is biased, the algorithm will also be biased. For example, if an AI algorithm is trained on a dataset of fashion images that predominantly feature white models, the algorithm is likely to be biased in favor of white models.

This bias can lead to discrimination against certain groups of people. For example, if an AI algorithm is used to recommend clothes to consumers, it may be more likely to recommend clothes to white consumers than to black consumers.

Another challenge is that AI algorithms can be opaque. This means that it can be difficult to understand how an AI algorithm works and why it makes the decisions that it does. This lack of transparency can make it difficult to trust AI algorithms and to hold them accountable for their decisions.

Finally, there is the ethical consideration of job displacement. As AI becomes more sophisticated, it is likely to automate many of the tasks that are currently

performed by humans in the fashion and textile industry. This could lead to job displacement and unemployment.

It is important to be aware of these challenges and ethical considerations as we develop and deploy AI in the fashion and textile industry. We need to take steps to ensure that AI is used responsibly and ethically, and that it benefits everyone.

## 5. POSSIBLE SOLUTIONS

There are a number of possible solutions to the challenges and ethical considerations associated with the use of AI in the fashion and textile industry.

One solution is to develop and deploy AI algorithms that are transparent and accountable. This means that we need to be able to understand how AI algorithms work and why they make the decisions that they do. We also need to be able to hold AI algorithms accountable for their decisions.

Another solution is to ensure that AI algorithms are trained on unbiased data. This means that we need to be careful about the data that we use to train AI algorithms. We need to make sure that the data is representative of the population that the AI algorithm will be used to serve.

Finally, we need to develop policies and strategies to mitigate the negative impacts of job displacement. This could include providing retraining and job placement assistance to workers who are displaced by AI.

## CONCLUSION

AI has the potential to transform the fashion and textile industry in many positive ways. However, it is important to be aware of the challenges and ethical considerations associated with the use of AI. We need to take steps to ensure that AI is used responsibly and ethically, and that it benefits everyone and is fair through out the work chain.

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# Revolutionizing the Knitwear Industry: Digitalization and Sustainability through Seamless Garments and Innovative Machinery

Suman Lata Vats\*<sup>1</sup>, Ashish Hooda<sup>1</sup>

Department of Fashion Technology,

BPS Mahila Vishwavidyalaya, Khanpur Kalan, Sonapat, Haryana

\*sumanlatavats@gamil.com

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## ABSTRACT

*In the evolving landscape of the industrial realm, the knitting industry has witnessed the emergence of two prevailing trends: digitalization and sustainability. Digitalization, defined as the utilization of digital technologies to revolutionize business models and create fresh avenues for revenue and value generation, has risen as a potent means to attain sustainability on multiple fronts – encompassing environmental stewardship, economic viability, and human engagement. This transformation also extends to areas such as inventory management, supply chain transparency, product customization, reduction of wastage in labor and materials, and minimizing fabric loss through consistent production processes. In the context of the knitwear industry, sustainability is epitomized by the concept of seamless garments. The term "seamless" rigorously denotes garments that are devoid of any visible seams, prioritizing comfort and eco-friendliness. Simply, it can say Seamless garments are produced without the need for fabric laying, cutting, or sewing in the manufacturing process. One of the most groundbreaking solutions for achieving sustainability and environmental friendliness in the knitwear industry is the whole garment knitting machine developed by Shima Seiki in Japan. This remarkable machine employs intricate programming and advanced knitting techniques to facilitate the creation of seamless garments, accommodating intricate designs, diverse textures, and a wide range of materials within a single garment.*

**Keywords – Sustainable, Seamless Garment, Digitalization, Eco-Friendly, Whole Garment Knitting Technology.**

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## 1. INTRODUCTION

In today's contemporary world, one of the paramount concerns is sustainability. Within the textile and apparel industry, this matter has garnered significant attention from various stakeholders. Environmental sustainability, in essence, pertains to the capacity of a product or process to persist without causing disruptions to the delicate ecological equilibrium of our planet. Sustainable clothing items can be described as an integral component of the burgeoning design philosophy centered around sustainability. The goal of this philosophy is to establish a system that can be maintained indefinitely, both from an environmental and social standpoint (Allwood et al, 2015). A sustainable business model encompasses various other elements such as the product's durability, the utilization of natural resources during manufacturing, recycling practices, and the impact of production methods on the environment. (Allwood et al, 2015). The demand for clothing items is steadily rising, leading to a

continuous accumulation of vast quantities of discarded garments in landfills (Chakraborty, 2016). The primary aim of this paper is to investigate sustainable practices applicable to apparel manufacturing plants, with a specific focus on the knitting industry. Knitwear is a widely consumed product worldwide, significantly influencing people's lifestyles. A groundbreaking solution for enhancing sustainability and environmental friendliness in knitwear production is the whole garment knitting machine, developed by the renowned Japanese knitting machinery company, Shima Seiki. This technology revolutionizes garment manufacturing by eliminating the need for post-production sewing and minimizing material wastage, thus greatly improving sustainability and efficiency. The machine's advanced programming and knitting techniques allow for seamless construction, accommodating intricate designs, textures, and materials within a single garment. Additionally, the integration of SDS-ONE APEX programming further streamlines the production process by digitally

visualizing the garment's appearance, eliminating the need for pre-production sampling and approval.

## 2. LITERATURE REVIEW

### 2.1. Sustainable apparel products.

Sustainability can be described as the strategic planning of human and industrial systems with the goal of guaranteeing that the utilization of natural resources and natural processes does not result in a decline in the quality of life. This decline can manifest as either a reduction in future economic prospects or to adverse impact on social well-being, human health, and the environment (Rusinko, 2007). In order to attain sustainable development, designers must possess a consciousness regarding environmental consequences and integrate environmental considerations seamlessly into their design processes. Enhancing the sustainability of a product can be accomplished through multiple aspects, including the choice of fibers and textiles, manufacturing techniques, user behaviors, and strategies for reuse and recycling (Islam and Khan 2014). The initial step taken by designers and product developers to minimize a garment's environmental footprint often involves the selection of fibers and textiles. Opting for environmentally preferred fibers and textiles can bring about a substantial reduction in environmental impact and enhance the overall sustainability of an apparel product over its entire lifecycle, all without necessitating alterations to design practices or product development procedures (Rusinko, 2007).

### 2.2. Environmental Impact of Textiles Apparel Products.

The clothing industry gives rise to negative environmental and social consequences that manifest at various points throughout the lifecycle of apparel. The apparel industry encompasses an extensive and intricate production chain, encompassing numerous stages that span from resource extraction and production to fiber and yarn manufacturing, textile production, cutting, clothing assembly, packaging, logistics, distribution channels, consumer usage, recycling, and eventual disposal (Lewis and Chen, 2006). The primary environmental repercussions linked to the creation and utilization of clothing over its lifecycle encompass the release of wastewater from dyeing, finishing, and laundering operations, heightened pollution levels, the generation of solid waste, and substantial resource depletion stemming from the consumption of water, fossil fuels, and raw

materials (Goworek,2011). These challenges can be effectively addressed through the implementation of advanced clothing technologies. A prominent solution that addresses various environmental concerns within the textile industry, particularly in the knitting sector, is the progress in knitting technology, specifically, seamless garment technology.

## 3. SEAMLESS KNITTING TECHNIQUE

Knitting has played a significant role in shaping the evolution of fashion. Thanks to continuous research and development, knitting has emerged as a highly advanced technology, particularly in the pursuit of creating seamless garments. In contemporary times, machine knitting has made it possible to produce clothing items without seams (Ng, 2001). Machine knitting has enabled the creation of seamless sweaters through the utilization of both flat-bed knitting and tubular knitting machines. Shima Seiki disclosed a technique in Patent GB 2228750A for tubular knitting a seamless garment using both a traditional two-bed and a fourneedle bed V-bed flat machine. The primary aim of this patent is to manufacture a fashion-forward garment characterized by the seamless integration of sleeves and body, eliminating the need for any subsequent seaming processes. In pursuit of the objective of achieving a comprehensive apparel manufacturing technology that reduces post-knitting time and expenses while enhancing quality, Shima Seiki Manufacturing Limited has achieved success in producing lightweight, seamless, and comfortable clothing through its Whole Garment technology (Little, 1996). For instance, the SWG-V and SWG-X Whole Garment machines have the capability to knit a diverse array of one-piece sweaters, tops, and bottoms. These machines enable the creation of continuous designs that encompass the entire garment and completely reversible designs (Nakashima and Karasuno, 1996). Presently, the company provides a variety of advanced automated knitting machines SDS-ONE APEX capable of producing virtually every variety and design of seamless gloves and socks, in addition to fully-fashioned garments. Historical developments of seamless technique (Choi, 2005)

- 1589 - In England, William Lee devised the initial flat-bed frame for crafting hosiery.
- 1800 - Sinkers were added to flat knitting machines, allowing for stitch control and the production of single-jersey tubular items such as gloves, socks, and berets.

- 1863 - Issac W. Lamb introduced the first functional V-bed flat knitting machine, which featured latch needles.
- 1864 - William Cotton of Loughborough patented a rotary-driven machine employing a flat-bed to create fully fashioned garments.
- 1940 - In the United States, a patent for crafting shaped knitted skirts using the "flechage" technique was granted.
- 1955 - The Hosiery Trade Journal documented the automatic knitting of traditional berets with shaped sections.
- 1955 - At ITMA, Shima Seiki unveiled seamless entire-garment knitting.
- 1960 - Shima Seiki further explored tubular-type knitting for commercial glove production.
- 1960 - Courtaulds secured British patents related to the concept of producing garments by joining tube knitting.

#### **4. SHIMA SEIKI – WHOLE GARMENT KNITTING MACHINE**

WHOLEGARMENT represents a groundbreaking innovation in the world of knitwear, being the first seamless knitwear produced using SHIMA SEIKI's advanced WHOLEGARMENT flat knitting machine, specifically the MACH2XS model. The MACH2XS incorporates a spring-type movable sinker system, ensuring the creation of high-quality knitted fabrics with consistent tension and structure. Its 4-bed configuration system enhances design and pattern capabilities for the production. It's not just seam-free knitwear; it introduces an entirely new category that transforms the entire knit supply chain. Typically, traditional knitted garments consist of separate pieces—front and back panels and sleeves—stitched together post-production. In sharp contrast, SHIMA SEIKI's revolutionary WHOLEGARMENT knitwear is crafted in one continuous piece directly on the knitting machine. As a result, it eliminates the need for expensive and time-consuming post-production labor. This innovation creates a new kind of knitwear, known for its seam-free "second skin" fit and comfort, while also being eco-conscious by utilizing only the necessary amount of yarn for each item. The sustainability focus of WHOLEGARMENT extends to various aspects. It

conserves limited resources by minimizing yarn consumption, and efficient planning is achieved through high-resolution virtual samples, replacing traditional sampling that incurs significant time, cost, and material usage. The combination of virtual sampling and WHOLEGARMENT knitting optimizes inventory and minimizes waste. Additionally, Shima Seiki's knitting machine allows for 3D patterns, enabling the creation of flared skirts and dresses without seams, adjustable hem widths using techniques like flechage or short-row, and the design of bold and elegant drapes. It also facilitates changeovers in knit patterns, structures, textures, and materials, including the integration of special functional yarns in key areas for added value, such as moisture-absorbing and quick-dry materials in the underarms or soil-resistant yarns at the collar and cuffs

##### **4.1. Inverse Plaiting Technique.**

This method involves the use of two yarn feeders to create a single layer of fabric. One feeder is responsible for producing the fabric's base, typically a single jersey, while the other feeder handles the creation of intricate designs such as jacquard patterns and Intarsia.

##### **4.2. Inlay Technique.**

This innovative technique combines the soft stretch of knitted fabric with the refinement of woven material by weaving specialty yarn through the knitted fabric. WHOLEGARMENT knitting machines can be equipped with an inlay carrier option to facilitate efficient inlay knitting. In this technique, three yarn feeders are utilized. The intermediate feeder's role is to insert yarn between the two layers of fabric, making it particularly suitable for crafting items like puffer jackets.

##### **4.3. Applications.**

Beyond producing fully-fashioned garments, WHOLEGARMENT technology finds application in various domains:

- **Sports/Outdoors:** WHOLEGARMENT is employed for sportswear and outdoor gear.
- **Smart Garment Applications:** This includes the integration of conductive yarns, embedded electronics, IC tags, and communication antennas.
- **Safety Gloves:** WHOLEGARMENT is used to create safety gloves with properties such as cut resistance, heat resistance, electrical insulation, and chemical resistance.

- Industrial Applications: Special materials like carbon fiber, metal thread, and monofilament can be knitted using WHOLEGARMENT technology.
- Medical Applications: For instance, belly belts for pregnant women equipped with devices that monitor the infant's heartbeat.
- Home Furnishing: WHOLEGARMENT is employed in home furnishing items like rugs and pillow covers
- Infant Wear: Seam-free garments are ideal for infants and children, as they reduce the risk of skin irritation caused by seams.
- Accessories: Items like bags, caps, and neckties are crafted using WHOLEGARMENT technology.
- Automobile Applications: WHOLEGARMENT is used for creating automobile accessories like seat covers and mirror shields.

## 5. CONCLUSION

The integration of Entire seamless garment technology into the textile and apparel industry represents a significant step toward sustainability, efficiency, and innovation. It redefines the way we conceive and produce knitwear, offering a glimpse into a more sustainable and seam-free future for the world of fashion and beyond and move towards more sustainable and environmentally conscious future.

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# Interpretation of Origami Techniques on Garment Bodies with TR Cutting Method

Srividya P<sup>1</sup>, Shingo Sato<sup>2</sup>, Dr. Vibha Kalaiya<sup>3</sup>

<sup>1</sup>PhD Scholar, UID Karnavati University,

<sup>2</sup>Inventor o Transformational Reconstruction, Founder/CEO TR Cutting School

<sup>3</sup>Assistant Prof, School of Design, KU,

<sup>1</sup>pandurangaphd2022@karnavathiuniversity.edu.in, <sup>3</sup>vibha@karnavathiuniversity.edu.in

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## ABSTRACT

*This is a research paper at investigates an innovative approach to origami vortex design as a primary design element and keeps the pattern as one continuous pattern piece for cutting. Origami geometrical property of mountain and valley folds<sup>9</sup> on vortex design apparel. The foundation pattern blocks of garments like corsets, shorts and garments details such as pockets, sleeves and buttonholes are used for manipulating to incorporate origami. The unique technique of pattern making invented by Shingo Sato called the Transformational Reconstruction method (TR Cutting) is adapted to secure the folds of origami with seams and stitches, this method is more viable compared to the fabric folds with heat setting methods. In this process of developing product prototypes, environmental aspects of using sustainable denim fabric are used.*

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## 1. INTRODUCTION

This study is an exploratory method of both qualitative and quantitative research<sup>11</sup> to achieve Origami design. Fashion design is based on constant change with innovative ideas and significant demand for new concepts. The significant ancient clothing like chiton and togas had the formative method of folding, bending and angles of fabric to achieve the desired three-dimensional design aesthetics that were taught in fashion history.<sup>13</sup>

Origami fashion is one such approach to creative thinking that designers from Issey Miyake, Calvin Klein to Guess have all produced collection that incorporates origami looks.<sup>6 7 8</sup> ‘The process of creating complex patterns and the rich variety that may be obtained from a sequence of very simple operations are close to the aesthetic molecular basis of life’ says Peter, an American Origami artist and theorist, science writer, designer and architect.

Origami being original for paper art as a traditional form has been extensively used in the fashion industry for many years. The concept of origami-based designs is always defined by the laws that govern their geometrical properties of any scale<sup>10</sup> that has primarily two elements of mountain and valley folds which can be used in various methods to achieve the desired design perceptions, while pattern making for fashion also sway on similar principles to mould the two-dimensional

fabric into three-dimensional garments<sup>12</sup> which contours body accordingly with the manipulation of darts, style lines and sewing, the value of pattern cutting has been rediscovered as the new generation of creative minds favour pattern development over the design as the design arises from the process of pattern making for fashion.

To achieve this, a systematic method of documentation for incorporating origami into the interesting style of vortex pattern that leads to design movement to the Centre of the pattern, the design of Spiral Vortex pattern using transformational reconstruction technique (TR Cutting)

TR cutting method is an architectural approach for pattern development with geometrical application and keeping the ideology of pattern fit and form ineffective and remain same compared to that of fabric manipulated origami fabric. Using TR method of pattern development, origami folds which is sustainable for wash and wear compared to that of the fabric folding with heat press methods, as they fade away with multiple wears and wash especially in the case of fabrics that are composed of natural fibers. To apply origami as a freehand design applied on the garment patterns with TR Cutting method more versatile to apply and use than understanding the complications of pre folded origami fabric where there is a possibility of compromising on design limitation.<sup>2</sup>

**TABLE 1: Pattern-making tools and sewing supplies**

<b>Pattern making Tools</b>	<b>Sewing and pressing supplies</b>
<b>Muslin fabric</b>	Basic sewing machine setup
<b>Pattern papers</b>	Thread clipper
<b>Colored papers</b>	Awl
<b>Grid ruler</b>	Steam press setup
<b>French curve</b>	Tailors ham
<b>Multi colour pens</b>	Wooden clapper
<b>Masking tapes</b>	Cutting board/ table
<b>Silk pins and pincushion</b>	Interlining
<b>Fabric cutting shears</b>	Fasteners and trims
<b>Paper cutting scissors</b>	
<b>Paper cutting knife/blade</b>	
<b>Repurposed Denim fabric stack</b>	
<b>Foundation blocks of Corset, shorts, globe sleeve, welt pocket, buttonhole</b>	

TR cutting techniques can be applied to various degrees of garments from zero Degree garments like bras and body suits to fourth degree garments like jackets and coats, which give the endless possibilities of applying on whole garment or partial details in garments such as collars sleeves pockets plackets, lapels, cuffs, and even tiny elements of buttonholes.

TR cutting allows endless possibilities, one also needs to consider that there is a need in fashion industry to improve fashion surplus management and also supply and satisfy many consumers globally who are conscious of the environmental aspects and wish to have designs that are unique to wear while being eco-friendly, <sup>1</sup> hence these experimental prototypes are made using repurposed Denim fabric sourced from industrial waste/overstocks as a sustainable approach.

The ideas and brainstorming process has been executed in the resource center of Vidya Fashion Academy, Bengaluru which represents TR Cutting School India in association with Shingo Sato CEO of TR cutting School, inventor of the technique, with his guidance and support for the possibility and exploration and experimentation with the process of using various pattern making and sewing tools.

The primary core tools needed are listed in the table below;

With these tools, a systematic stepwise methodology is adapted as stated below.

- 1 Foundation block was traced on paper, seam allowances were added and a pattern was cut.
- 2 Darts were kept closed and style lines were drawn from the outermost edges of the pattern similar to iris folds design line forming spiral vortex towards the center of the contoured block. (It was more convenient to use different colour marking lines to have the clear understanding of the layers.) The pattern style lines had no limitation as they are to the individual need.
- 3 Style line doesn't go beyond the dart head point and was kept in same shape to maintain the contour control of the pattern.
- 4 By Trueing, the style lines were numbered and the direction of the pattern with the arrow mark.
- 5 Inserting of a coloured paper; cut in the shape of triangle width of minimum 7cms at the pattern end and a minimum of 5cms longer to overcome the angle of folds.
- 6 The triangle were kept as a valley fold and the garment Pattern edge as a mountain fold, the excess paper transcending the main pattern block was trimmed.
- 7 The same method of inserting triangles was continued until the end of the style lines
- 8 Darts were kept unchanged and the space was filled with a colour paper that will function as the origami fold.
- 9 Using silk pins/ steel headlines, the pattern was secured on the fabric and cut along while no seams were added for this design.
- 10 Steam pressing the cut fabric along with the paper pattern supported the crease lines of the design.
- 11 Stitching was done from the innermost style line, securing all raw edges with a seam while folding on; then continued to sew the style lines.
- 12 Darts were stitched as darts, to provide the required fullness to the contour of the body.
- 13 Pressed along the origami pattern before finishing the garment.



14 The further steps were as per the Style of a particular apparel design.

Note: This project was implemented with the repurposed Denim fabric, it was washed and pressed as a preparatory process.

### Observations



In the process of creating and trials it was observed that after sewing the outermost style line of the origami design stretches and falls apart on the three-dimensional body, so it was advised to keep 0.75cm to 1cm depth of fold for origami and sewn to the remaining fullness.

In a conversation with San Shingo Sato that happened in one of the 100 workshops that he conducts in a year. He reveals that 'though this technique of vortex origami has been known to many TR masters, they are only demonstrated through live sessions or with pre-recorded videos around the world'. He also observes that this technique has neither been printed nor documented in a text format. Additionally Valentina Kozhevina Ukrainian TR Master also insists that 'videos require no language and is a considerably easier way to document while demonstrating, also perceiving and learning as opposed to writing.'

## 2. CONCLUSION

Fashion designing is continuous innovation and designers require to scrutinize and attempt new techniques and technologies. Origami has been a popular design element for many designers through the decades. Unlike paper fold, fabric has poor memory to hold the crease and can be easily undone, reinforcing a seam to

hold the shape will give better control over the design. Therefore, TR method is an architectural approach that helps the origami vortex pattern manipulation become easier compared to the heat press method origami specially for denim fabric; hence, providing more liberty to the designer to place the folds as their ingenuity desire. Apparels like corsets and shorts are contoured zero-degree and first-degree garments and achieving the origami vortex was challenging. Pertaining garment details with a controlled pattern gives leeway for the exploration of this TR technique of origami. The approach of using sustainability in this investigation is an additional resolution towards the environmental aspects.

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# Analyzing the Impact of Blend Ratio and Weave Structure on Cotton-Bamboo Handloom Fabrics

Sushma Kumari\*, Harinder Pal, Sagarika Pal

Dept. of Fashion Technology, Bhagat Phool Singh Mahila Vishwavidyalaya, Khanpur Kalan, Sonapat, Haryana  
sushmakumarikit@gmail.com

## ABSTRACT

*This article explores the sustainability impact of different cotton and bamboo yarn blends woven on handlooms. Cotton, while a natural fiber, poses environmental challenges due to chemicals, pesticides, and high water usage. In contrast, bamboo, a renewable resource with exceptional properties, offers an eco-friendly alternative in textiles. In this research study experiments were conducted to develop plain and twill weaves, combining 100% cotton, 50-50 bamboo-cotton blends, and 100% bamboo yarns with a 2/20 count. All fabrics used 2/20 count cotton yarn for the warp. Handloom technology was chosen for its sustainability benefits over modern looms. The analysis reveals that weave structure and yarn blend ratios significantly affect fabric properties. Bamboo fiber enhances physical, mechanical, and comfort attributes, contributing to environmental sustainability. When compared to 100% cotton fabric, bamboo-cotton blends exhibit longer fiber/fabric, lower density, higher moisture regain, increased strength, pilling resistance, abrasion resistance, and greater fabric flexibility. Overall, the use of bamboo fiber in enhancing fabric comfort, mechanical and physical properties cannot be ignored, apart from adding environmental sustainability. This study advocates for bamboo fiber adoption in the handloom sector, appealing to environmentally conscious consumers and businesses, promoting the shift from synthetic textiles to sustainable options. In an era where sustainability is paramount, bamboo offers a compelling solution for greener textile production.*

**Keywords:** bamboo, handloom, cotton, environmental sustainability.

## 1. INTRODUCTION

The textile industry is increasingly focusing on sustainability, with increasing demand for textiles and awareness of environmental and ethical implications (Kiekens, 2022 and Ozek, 2017). This research explores the use of bamboo as an alternative to cotton in handloom technology, highlighting its potential for eco-conscious production (Waite, 2010 and Balaji, 2014). Bamboo, a renewable resource, has minimal environmental impact (Ogunwusi) and can outperform 100% cotton fabrics in various aspects, including fiber length and tearing strength. The study highlights the importance of handloom technology as a sustainable option in textile manufacturing, promoting a shift towards environmentally conscious practices. The research aims to inspire consumers, businesses, and the industry to embrace sustainable alternatives and transition from synthetic textiles to environmentally responsible choices, reimagining the future of fabric production.

Researchers are exploring the use of bamboo-blend bamboo blended fibers in various fields. A Literature review revealed that bamboo/cotton blended fabrics have

superior thermal properties, better wicking properties, and lower thermal resistance compared to pure cotton (Chidambaram P. and Govindan R.). Various literature reviews have shown many mechanical properties with increasing bamboo content. Ajay Rathod et. al. found that 100% bamboo fabrics had higher breaking strength and greater elongation compared to blended yarn fabrics. Büyükakinci reported that higher crystalline size of bamboo fiber and higher dry tenacity of bamboo fiber may possibly increase abrasion resistant. Manju & Pal evaluated that, handloom denim fabrics made from bamboo and cotton yarn showed better elongation, tearing strength, and flexibility, but slightly lower crease recovery compared to cotton-based fabrics. Khan et. al., expressed that, plain weave structure resist pill formation due to least integral yarn expose in plain weave as compared to twill weave structure. Avinash examined that bamboo fabric offers better protection against ultraviolet radiation than cotton fabric, making it suitable for UV- protective garments. Rathod and Kolhatkar revealed that twill weave structure attributes higher strength due to higher float length. Shivraj kulkarni et. al. reported that, blending bamboo with cotton is cost-

effective and increases the utility of bamboo in textile applications. Vinitha paulose et al. studies have also examined the anti- bacterial properties of bamboo and bamboo/cotton handloom fabrics treated with herbal extracts, suggesting they can be used for eco-friendly and anti-bacterial textiles.

## 2. MATERIALS AND METHODS

Six woven fabric samples with varied specification were manufactured using bamboo and cotton yarn on a handloom machine at the Weaver Service Centre in

Panipat, Haryana, during the month of February 2023.

A single warp beam was constructed using 100% cotton yarn with a 2/20 count. Three different yarns were used in the weft direction: 100% cotton yarn, a 50:50 combination of bamboo and cotton yarn, and 100% bamboo yarn. Three of the samples were woven in a plain weave pattern and three were made in a twill weave pattern. Various characteristics were evaluated in accordance with standards in order to study the physical, mechanical and comfort properties of the samples. The following are the fabric specifications:

**TABLE 1: Specification of plain and twill weave samples**

Sample ID	Weave structure	Warp yarns	Weft yarns	Count of yarns	EPI	PPI	GSM
S1	Plain	100% C	100% C	2/20's	46	32	200
S2	Plain	100% C	50/50 (B/C)	2/20's	46	35	210
S3	Plain	100% C	100%B	2/20's	46	36	216
S4	Twill	100% C	100% C	2/20's	46	46	237
S5	Twill	100% C	50/50 (B/C)	2/20's	46	48	248
S6	Twill	100% C	100%B	2/20's	46	49	256

## 3. RESULT & DISCUSSION

The testing of handloom fabric samples was conducted under a  $65 \pm 2\%$  RH atmosphere and  $27 \pm 20^{\circ}\text{C}$  temperature to ensure reliability of results. The efforts were made to keep the construction parameters same for all the samples except weave structure and blend ratio. Since the samples were developed on handloom. Hence, due to manual control there was variation in the thread density in weft direction. Due to change in the thick density and blend ratio, variation in GSM is observed as shown in table 1. Though, there is not much variation in

GSM for plain weave samples. However, significant GSM was observed in twill weave samples as compared to plain weave samples. The reason is attributed to higher thread density for twill weave samples.

**Mechanical properties:** The tensile strength of samples tested on an Asian Tensile Testing Machine complied with ASTM D5304-95. There was no significant difference in warp way between plain and twill weave fabrics as shown in table 2, but a significant difference in weft way may be due to increased bamboo fiber content used in the weft direction.

**TABLE 2**

S.ID	Weave structure	Tensile strength (Kgf)		Tearing strength (Kgf)		Abrasion resistant (no. of cycles)	Pilling resistant Ratings	Drape coefficient	Air Permeability ( $\text{m}^3/\text{m}^2/\text{min}$ )	WVP ( $\text{g}/\text{m}^2/24\text{h}$ )
		Warp wise	Weft wise	Warp wise	Weft wise					
S1	Plain	53.25	39.05	4.3	5.1	10,400	3	0.59	218.79	851.935
S2	Plain	48.6	42.85	4.9	5.6	11,200	4	0.56	137.11	866.075
S3	Plain	43.45	53.75	5	5.7	12,000	4	0.54	140.36	887.285
S4	Twill	56.1	55.7	6.1	6.2	12,000	2	0.5	145.27	788.305
S5	Twill	55.45	57.45	6.2	6.6	20,700	2	0.46	129.12	837.795
S6	Twill	44.55	86.85	6.7	7.1	26,300	3	0.44	138.52	859.005

Tearing strength was measured on an Elmendorf tear strength tester as per the ASTM D1424 standard. Tearing strength in plain and twill fabric samples increased with increasing bamboo content in the weft direction, possibly due to the higher strength of bamboo yarns. Twill weave samples also showed higher tearing strength due to fabric float structure and increasing PPI. The Martindale Abrasion Tester machine measured abrasion resistance for all samples. Twill weaves fabrics, revealing higher resistance than plain weave fabrics. This is due to the maximum number of PPI in twill weave and floating yarns, as well as diagonal patterns on the fabric surface. The trend increased with increasing bamboo content in the filling yarn, possibly due to the higher dry tenacity of bamboo yarn (2.33 cN/dtex) than cotton (1.9–3.1 cN/dtex) and may also be due to the higher crystal size of bamboo fibers. The pilling resistance of all samples was measured on Martindale abrasion & pilling tester, based on ASTM D4970-02 standards. Results showed plain fabric is more resistant to pill formation than twill weaves, possibly due to less interlacement and the increased bamboo content in the weft direction. This may be due to least integral yarn expose in plain weave as comparison to twill due to less interlacement. Increase of Bamboo content in weft direction giving more resistant to pilling.

**Comfort Properties:** Plain weave samples exhibit higher drape coefficient in comparison to twill weave samples, due to more flexibility of twill weave or less stiffer as compared to plain weave fabric. Another major observation regarding drape coefficient indicates that it decreases with increase in bamboo content in weft yarn imparting more flexibility than cotton yarn. Air permeability in woven fabric is influenced by pore size and weaves structure. Plain weave fabrics, with their shorter float length and compact structure, have lower air permeability compared to twill weave fabrics. This may be due to increased thread density in weft yarns, which hinders air flow. Water vapor permeability (WVP) in woven fabrics is influenced by pore size and weaves structure. The result has shown in table 2 have revealed WVP is more in case of plain weave fabric, the reason may be attributed due to higher interlacement, and shorter float length, resulting in bigger pore size as compared to twill weave and lower thread density in weft direction. WVP increases with increasing bamboo content in both plain and twill weave samples, possibly due to higher moisture absorption or regain in bamboo

fibers compared to cotton fibers, which do not hinder moisture transfer in hydrophilic systems.

## CONCLUSION

The study highlights the potential of bamboo-cotton blended fabrics woven on handloom technology to improve sustainability in the textile industry. Bamboo, a renewable resource, is a promising alternative to traditional cotton due to its minimal environmental impact. Bamboo-cotton blends showed superior tensile and tear strength, particularly in the weft direction. Twill weave fabrics showed higher abrasion resistance, while plain weave fabrics showed better pilling resistance. Plain weave samples displayed higher drape coefficients, while increasing bamboo content in weft yarn improved resistance. Bamboo-cotton blends also showed higher water vapor permeability, suggesting improved comfort. The study advocates adopting bamboo fibers as sustainability option as well as handloom sector.

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POSTER PRESENTATION

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# Sarees – The Indian Moon

**Anjali Bhardwaj**

*Research Scholar, Department of Home Science, Banasthali Vidyapith, Rajasthan, 304022*

*anjali**bhardwaj**855@gmail.com*

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## **ABSTRACT**

The saree, a quintessential Indian garment, is a profound symbol of culture, history, and artistic expression. Its centuries-old legacy as an integral part of the Indian subcontinent's cultural heritage signifies grace, elegance, and identity. With its versatility, diverse draping styles, and the extensive range of textiles employed in its construction, the saree is a captivating subject for exploration. This research paper embarks on a comprehensive examination of the saree's multifaceted dimensions, encompassing its historical evolution, regional variations, the profound significance embedded within its intricate designs, and its contemporary relevance in the global fashion arena. Through a meticulous analysis of craftsmanship, cultural relevance, and the influence of modern trends on this traditional attire, this study endeavors to illuminate the timeless charm of the saree and its enduring presence in both traditional and contemporary contexts. By unraveling the intricate details and cultural importance of the saree, we not only foster a deeper appreciation for its aesthetic beauty but also contribute to the broader discourse on the preservation and celebration of cultural heritage within the ever-evolving realm of fashion and design.

**Keywords:** *Saree, Traditional Indian attire, Textiles, Fashion, Culture*



# Textile Eco Printing for Sustainable Fashion

**Dr. Babita Bhandari<sup>1</sup> and Dr. Pallavi Bawari<sup>2</sup>**

<sup>1</sup>National Institute of Fashion Technology, Kangra, <sup>2</sup>Amity University, Noida

Email: babita.bhandari@nift.ac.in

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## ABSTRACT

The textile industry contributes 10 percent to global greenhouse gas emissions amounting to approximately 1.2 billion tons of GHGs. Moreover, the textile dyeing and printing industry uses a lot of harmful chemicals and releases hazardous effluents into the water streams.

However, as manufacturers are becoming more conscious of their actions, efforts are being made to lessen their negative environmental impact. Recently there has been an increase in the use of eco-friendly chemicals and processes in the industry, one such technique being explored these days is eco-printing. Eco-printing is the process of generating imprints of plants' parts using heat, moisture, and pressure. This process is facilitated by using natural or synthetic mordants for fast colours. In order to create beautiful Eco prints one must have the knowledge of right plant material, fabric, and its process. Hence in this paper an account of different plant materials suitable for eco printing, fabric used, and different processes have been illustrated. Moreover, different brands exploring eco printing technique, their product lines, materials used, and different value-addition techniques have been demonstrated.

**Keywords:** *Eco printing, mordants, brands, environmental impact.*

# Mindful Fashion: The Potential of Spirituality in Challenging Consumerism

**Radhika Pal<sup>1</sup> and Souvik Mondal<sup>2</sup>**

*<sup>1</sup>M. Des 4th semester, Amity School of Fashion Technology, Amity University Rajasthan, India*

*<sup>2</sup>Asst. Professor, Amity School of Fashion Technology, Amity University Rajasthan, India  
radhikapal067@gmail.com<sup>1</sup>, smandal@jpr.amity.edu<sup>2</sup>*

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## ABSTRACT

In an era dominated by rampant consumerism and fast fashion, the fashion industry has come under scrutiny for its environmental and ethical implications. Within this context, the concept of "mindful fashion" has emerged as a transformative paradigm, seeking to challenge the prevailing consumerist ethos and foster a more sustainable and ethical approach to clothing consumption. This literature review explores the profound relationship between spirituality and mindful fashion, shedding light on the possibilities it holds for a more conscious and compassionate approach to clothing consumption. The review examines the work of scholars, authors, and thought leaders who have delved into the intricate interplay of spirituality, consumerism, and fashion. It delves into the ecological and ethical dimensions of clothing consumption, prompts a reevaluation of the fashion industry's role in perpetuating consumerism, and offers insights into the potential of spirituality in reshaping consumer behavior and attitudes. The review also highlights case studies showcasing the real-world impact of spirituality-driven mindful fashion initiatives. Ultimately, this literature review provides a comprehensive understanding of how spirituality can serve as a catalyst for change in the fashion industry, inspiring consumers to seek meaning and purpose in their wardrobe choices. It invites readers to reconsider their relationship with clothing, reflect on the ethical and ecological consequences of their choices, and explore how spirituality can be a catalyst for transformation in the fashion landscape.

**Keywords:** Mindful fashion, Spirituality, Consumerism, Fashion industry, Sustainable clothing, Ethical consumption, Environmental impact, Conscious choices, Transformative paradigm, Case studies.

# Digital Evolution – The impact of Transforming the Fashion Industry through E-commerce in Global Market

Sweta Moga<sup>1</sup>, and Dinkar Kumawat<sup>2</sup>

<sup>1</sup>M. Des 4th semester, Amity School of Fashion Technology, Amity University Rajasthan,

<sup>2</sup>Asst. Professor, Amity School of Fashion Technology, Amity University Rajasthan, India

<sup>1</sup>moga.sweta15@gmail.com, <sup>2</sup>dkumawat@japr.amity.edu

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## ABSTRACT

The widespread influence of e-commerce and the incorporation of digital technology have greatly altered the fashion business in recent years. Traditional company models have been altered by this "digital evolution," which has also changed customer expectations and behavior. The paradigm change brought about by the digital development is explored in this article review, with an emphasis on the revolutionary potential of e-commerce. The main goal of this analysis is to thoroughly examine the many facets of the digital evolution in the fashion sector, with a focus on the function of e-commerce. This review reveals how e-commerce has affected consumer behavior, marketing tactics, supply chain dynamics, and the general landscape of the fashion industry through a thorough examination of the available literature and pertinent research. By delving into the intricacies of this transformation, it offers insights into how e-commerce has reshaped the industry and the implications these changes hold for the future. The structure of this paper review is organized into several sections. It begins with an overview of the digital evolution in fashion, highlighting key technological advancements that have driven this transformation. The subsequent sections delve into the concept of ecommerce in fashion, exploring its role in reshaping the business model and consumer experience. The review also examines digital marketing and brand engagement, consumer experience and personalization, and the redefinition of supply chain dynamics and logistical processes within the fashion industry. Furthermore, it addresses the challenges and potential pitfalls associated with digital evolution while envisioning future trends that will shape the industry's trajectory.

**Keywords:** Fashion industry, Digital evolution, E-commerce, Consumer behaviors, Marketing strategies, Supply chain dynamics, Business transformation, Online storefronts, Brand engagement, Personalization.

# The Possibilities of Reuse, Reduce and Recycling in Future Fashion Textile Trend

**Kesar Sinha<sup>1</sup>, Baljinder Kaur<sup>2</sup>, Dr. Sambaditya Raj<sup>3</sup>**

<sup>1,2</sup>*M. Des I Sem, Amity University Rajasthan, Amity School of Fashion Technology,*

<sup>3</sup>*Dy. Director, Amity School of Fashion Technology, Amity University Rajasthan, India*

<sup>1</sup>*baljinderkaurr77@gmail.com, <sup>2</sup>kesarsinha1212@gmail.com, <sup>3</sup>sraj@jpr.amity.edu*

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## ABSTRACT

The "Waste to Wealth" study, which was published in July 2022, gives an overview of India's potential and difficulties in relation to the flow of textile waste as well as the different nuances of the nation's emerging circular economy. We are grateful for the superb on-the-ground collaboration with Sattva Consulting and Saahas Zero Waste, who provided us with this comprehensive overview of the diverse, complicated, and dynamic Indian market. India generates more than 7,793 tonnes of textile waste yearly, or 8.5% of global production. Only around 59% of this waste makes it back into the global supply chains for high-end textile products due to challenges with quality and visibility. A little amount of warp that cannot be weaved, around a few inches, is wasted during the weaving process and left at the front and rear of the loom. The amount of thrums in the initial crack may be determined based on how economical the loom was warped. Through study, it has been discovered that thrums are employed in a variety of applications, including 'charity crafting', 'hit & miss' mug rugs, rya pile rugs, tying up tomato plants, florists' line of work, filling small toys for children, hand spinners, etc. It was also discovered that thrums are collected by robins and sparrows in addition to being utilised by people. This study advocates using thrums to make custom decorations for clothing and accessories, introducing a novel method for reusing thrums. We can create luxuriant improvements thanks to the wide variety of thrums, with silk thrums particularly well suited to the creation of bespoke jewellery and exquisite trimmings for haute couture. This project seeks to revolutionise fashion by working towards a paradigm of zero waste while adopting a completely trendy mentality, in line with the concepts of sustainability and circularity.

**Keywords:** *Thrums, circular economy, Doodad, Sustainable, textile recycling process, waste clothing, recycle fashion.*

# The Evolution of Clothing in Rapture for Present and Future Fashion Sustainability

**Kumari Parul Tomar**

*M. Des 3rd Sem, Amity University Rajasthan, Amity School of Fashion Technology.  
Tomarparul09@gmail.com*

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## ABSTRACT

This essay explores the dynamic evolution of Indian dress across time, highlighting its enduring ties to culture, tradition, and symbolism. The study sets out on a historical trip, starting with the mysterious Indus Valley Civilization and ending with the current fusion of styles. It emphasizes the crucial significance that textiles have had in forming Indian society and safeguarding its extensive cultural legacy. The inquiry uncovers the transformation of clothing impacted by location, religion, and social dynamics. It derives conclusions from historical documents, art, archaeology, and iconography. In order to provide a thorough understanding of Indian apparel as a reflection of the country's pulse and cultural ethos, the research tries to disclose the narratives underlying clothing choices. In light of the quickening pace of world change, it emphasizes the continuing importance of clothes. The study is broken into numerous sections, beginning with a look into Indus Valley Civilization clothing, which, despite the lack of textile artefacts that have been preserved, provides an intriguing look into early design. It examines the many fashions that have developed throughout time, highlighting the geographic and cultural variety that has led to India's numerous clothing traditions, including the renowned sari, traditional turbans, and men's dhotis. The research's analysis of the evolution of damaged and disrupted clothing designs, which developed from their roots in the punk and hippie movements of the 1970s to become a mainstream fashion trend, brings the study to a close. The development of this trend is studied in relation to other historical fashion trends, highlighting how fashion changes over time. Overall, by tracking the development of this link and considering its wider ramifications as a cultural and social phenomena, this research illuminates the significant connection between clothing and Indian culture.

**Keywords:** *sustainable fashion, rapture fashion, culture, civilization, eco- conservation.*

# The Impact of Color and Psychology in Traditional Costume to Modern Fashion in India

**Harshita Batra<sup>1</sup>, Dr. Sambaditya Raj<sup>2</sup>**

<sup>1</sup>M. Des 3rd Sem, Amity University Rajasthan, Amity School of Fashion Technology,

<sup>2</sup>Dy. Director, Amity School of Fashion Technology, Amity University Rajasthan, India

<sup>1</sup>batraharshita4@gmail.com, <sup>2</sup>sraj@jpr.amity.edu

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## ABSTRACT

This study investigates the intricate relationship between color psychology and fashion preferences, aiming to understand the emotional and cultural influences that shape individuals' perceptions of color in their clothing choices. Through a comprehensive online survey administered to 73 participants, the research explored the diverse attitudes and behaviors related to color selection in fashion. Key findings revealed a strong association between color and emotional states, with a significant proportion of participants attributing specific emotional responses to wearing bright or bold colors. The survey also highlighted the widespread recognition of cultural variations in color perception, emphasizing the need for cultural sensitivity and inclusivity in the fashion industry. Participants demonstrated a heightened inclination toward following fashion color trends, with a substantial percentage emphasizing the importance of color in conveying messages and emotions through their clothing choices. Moreover, the research uncovered the significant role of color in influencing consumer behavior, as evidenced by participants' experiences of regret or returns based on dissatisfaction with selected clothing colors. These insights underscore the complex interplay between individual preferences, emotional connections, and cultural contexts in the realm of fashion and color psychology, presenting valuable implications for fashion retailers, designers, and researchers seeking to create more meaningful and inclusive experiences within the fashion industry.

**Keywords:** *Color Psychology, Cultural Influences, Consumer Behavior, Consumer Psychology, Moods, Fashion preferences, Emotional responses, Color perception, Trend analysis, Clothing choices.*

# A Future Possibilities of Sustainable Approach in Textile Dyeing with Indigo Plant and Weeds Plants

**Pragya Paliwal<sup>1</sup>, Prof. (Dr.) Sambaditya Raj<sup>2</sup>**

*<sup>1</sup>M.Des I sem, Amity University Rajasthan, Amity School of Fashion Technology,*

*<sup>2</sup>Dy. Director, Amity School of Fashion Technology, Amity University Rajasthan, India  
bheriritu32@gmail.com<sup>1</sup>, ppaliwal1985@gmail.com<sup>2</sup>, sraj@jpr.amity.edu<sup>3</sup>*

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## ABSTRACT

Adopting a sustainable strategy is now imperative given the rising demand for textiles in order to stop the overuse of natural resources. When dyers extract colours from plants with culinary and medicinal uses like turmeric, saffron, safflower, annatto, etc., natural dyeing as a practise becomes unsustainable. In order to address this issue, an effort has been made in this study work to extract the dye from an invasive plant and onion peels. Statistical software was used to optimise the dyeing conditions after the powdered, dried leaves were extracted in an aqueous solution. The local dyers and artisans might use the derived dyeing recipe.

INDIGO is probably the oldest natural dyes used by the ancient dyers. It was extracted from the plant *Indigofera tinctoria* and the source of dyes were leaves of the plants. Indigo is virtually insoluble in water and belongs to the class of Vat dye. Hence it required reduction by a natural infusion and fermentation done with the help of WOAD, which is a plant very similar to *Indigofera* and know as *Isatis tinctoria*. This plant is cultivated in France, Germany and Britain. It has the main active substance know as INDIGOTIN which was the same compound found in INDIGO. But the main feature of the plant that differs from *Indigofera* is that it contains the micro-organism required to set up fermentation and successive reduction of itself.

**Keywords:** Sustainable practices, textile dyeing, weeds, Indigo, traditional Practices

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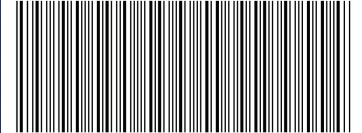
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