TANTU 2026

Annual Journal of Alumni Association

Indian Textile and Apparel Industry Under Present Geo Political Conditions



COLLEGE OF TEXTILE TECHNOLOGY

SERAMPORE & BERHAMPORE (NORTH INDIA CHAPTER)

www.tantutextile.com

TANTU

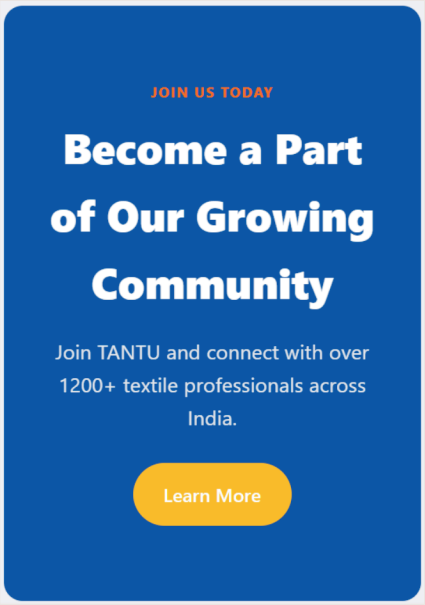
TANTU, What's That?

A decade back the alumni from Textile colleges of Calcutta University, based in north India constituted a forum named “TANTU”..... The thread!! During British Rule in India, two institutions were established on the banks of Ganga in West Bengal to make a history of learning new way of textiles (Textile Technology). Since then these two institutions at Serampore and Berhampore (CTTB & CTTS), cultured the textiles and apparel being the alma mater of innumerable successful technologists. The students have etched their marks not only in Indian industry and research-based projects but also in the international arena of textiles.

Our Aim & Vision

To promote the brotherhood, exchange through and serve the textile industry across globe. This forum has been interacting with success in various ways focusing on relevant issues of “Textile & clothing industry” and disseminating the information among all.

The forum is a platform for eminent professionals occupying high profile jobs in various segments of industries including MNCs, Export Houses, Trading agencies, R&D Organizations, Retails and brands, Academic Institutions like IIT, NIFT etc



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Editorial

The textile and apparel industry has long been central to India's socio-economic fabric. It is the country's second-largest employer after agriculture, directly engaging more than 45 million people, and contributes about 7% of industrial output and roughly 2.5% of GDP. With its market size expected to reach US$350 billion by 2030, the sector remains a cornerstone of national growth, supporting livelihoods from farm to fashion.

The industry depends heavily on exports, which links its bottom line directly to global conditions. Political disturbances in several regions, shifting alliances and changing trade policies can quickly affect orders, input costs, logistics and buyer sentiment. Geo-political awareness has therefore become essential to business strategy.

India has responded by widening its network of preferential trade agreements, with Australia, New Zealand, Mauritius, the UAE, Oman and the EFTA bloc, and more recently the United Kingdom and the European Union. A free trade agreement with the United States is under negotiation. These economies are important destinations for Indian textiles and apparel, and better market access offers a chance to diversify buyers and move up the value chain, provided compliance, quality and delivery reliability are assured. The Government has also introduced various schemes to strengthen the industry, including measures to attract foreign direct investment.

This Annual Journal reflects the breadth of these concerns. It examines the international trade of the industry, with attention to the role of cotton textiles, and the influence of geo-political conditions on the sector. Other articles address technological transformation, including generative AI in fashion design education, and digital transformation, AI, predictive planning and Industry 4.0 in apparel manufacturing. The journal also covers the taxonomy and design of textile products, a data-driven analysis of the MSME capability gap in on-time delivery and quality compliance in Tier 2-4 Indian retail, and whether AI can replace human expertise in apparel quality assurance. Together, these articles offer readers a balanced view of the challenges and opportunities ahead.

Against this backdrop, TANTU, the alumni association of the two oldest textile institutes in West Bengal, is organising a seminar on this theme today, 22 November 2026, at IIT Delhi. It brings together representatives of industry associations such as CITI, CII and export promotion councils, government agencies, and textile and apparel enterprises. Through candid exchange, the seminar seeks to chalk out practical future steps for the overall improvement of the industry, and TANTU hopes the deliberations will contribute to a resilient, globally competitive sector that continues to serve the nation's economy and the millions who depend on it.

Prasanta Sarkar

Editor, Tantu Textile Alumni Association

Message from the President

The world is going through some positive as well as negative situations, which is influencing textile and apparel businesses throughout the world and India is no exception. The textile and apparel industry is going through various changes as per the prevailing conditions of the market. TANTU, the Alumni Association of Government College of Engineering and Textile Technology, Serampore and Berhampore, North India, is arranging the seminar namely "**Indian Textile and Apparel Industry in present geopolitical conditions**" on 22nd November 2026, to share and exchange the experience of various textile and apparel companies. Sharing and exchanging the steps taken by them will benefit other companies and the benefits will reach to all the stakeholders and make Indian textile and apparel industry stronger.

The FTAs signed with European Union, United Kingdom, New Zealand, Japan, and different countries from Africa and Asia has opened up the opportunity for Indian T&A industry to diversify its export market which may help in increasing the export as well as derisking from dependence on one or few countries. Presently, major export of T&A industry of India is in USA and European Union. Any change of policies such as imposition of extra tariffs or restriction of import affect us badly, which can be reduced by diversifying into more number of countries.

When we may receive opportunity of exporting our products to countries with minimum or no tariff, they will also get the same opportunity. Countries in Asia such as Bangladesh, Sri Lanka, Vietnam are also very strong in T&A especially in Apparel Sector, which may also affect our domestic T&A market. We need to be prepared to face that situation also. Hence, it is very important that industry adapt continuously with existing conditions.

I wish the seminar a success and hope the outcome of this seminar will be useful for industry, policy makers and exporters.

Dr. Arindam Basu

President, TANTU

International Trade of Indian Textile and Apparel Industry and Role of Cotton Textiles

Dr. Arindam Basu | Director General, NITRA (Retd), Ex Director CSTRI and SITRA, Director, Nattex Sols Private Limited

Introduction

Textile and Apparel Industry plays a very important role in Indian economy, society and in providing jobs to a large number of people. With population of around 1.5 billion it is very important to provide jobs to large number of people including those who are not highly qualified. Unfortunately, India is highly dependent on import of crude oil, which cannot be avoided, hence export is very important for India for balancing the trade. The topmost export commodities from India are Mineral and Petroleum products, Electrical Machinery and equipment, nuclear reactors & boilers, Natural and cultured pearls, precious stones and jewellery (including diamond), Textile and apparel, Pharmaceuticals etc.

India's top trading partners (FY 2025-26) are:

Country	Trade Volume
China	US$ 150.10 bn
USA	US$ 140.80 bn
UAE	US$ 101.25 bn
Russia	US$ 59.86 bn
Saudi Arabia	US$ 41.07 bn
Singapore	US$ 36.10 bn
Hong Kong	US$ 32.41 bn
Germany	US$ 31.03 bn
Iraq	US$ 27.52 bn
Japan	US$ 27.48 bn

In today's world no country can live on its own, every country is dependent on others for one or more items including industrial raw materials, chemicals, fuel, food stuff and many other things. In beginning of 2000s world agreed to have equal rights for each country in trade, by removing quota system, under the name of World Trade Organization (WTO). But gradually each country started dealing with preferred countries under different agreements such as Free trade agreements (FTAs), Comprehensive Economic Cooperation/ Partnership agreements (CECAs/ CEPAs) and Preferential Trade Agreements (PTAs).

Major free trades and comprehensive Agreements

India maintains key comprehensive and free trade agreements with partners such as Mauritius, the UAE, Australia and the EFTA nations (Iceland, Norway, Lichenstein, Switzerland), alongside regional and bilateral pacts with Malaysia, ASEAN, Japan, South Korea, Singapore, Malaysia and Sri Lanka, as well as South Asian Free Trade Area (SAFTA). Also, agreements have been concluded and signed with UK, Oman, New Zealand and the European Union (EU).

Preferential Trade Agreements and Bilateral Treaties

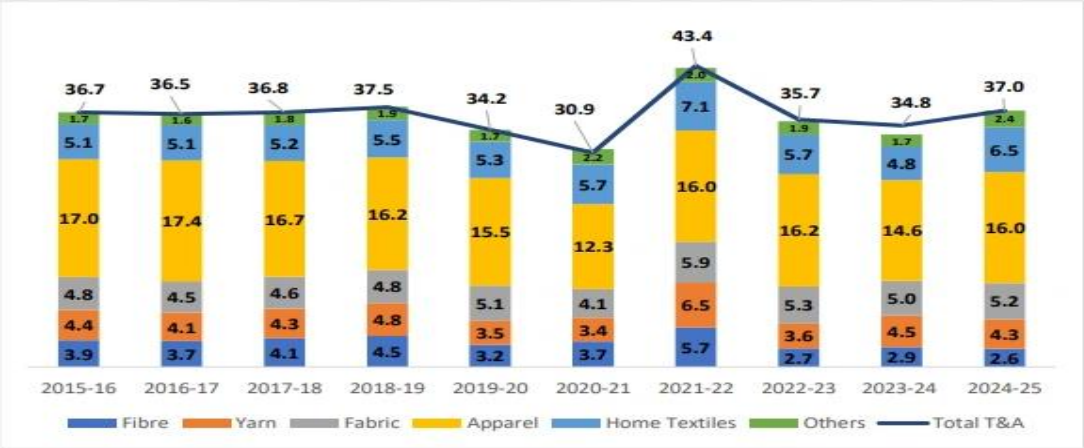
Key preferential frameworks include the Asia Pacific Trade Agreements (APTA), the Global System of Trade Preferences (GSTP) and agreements with Mercosur, Chile & Afghanistan. India also holds dedicated trade and transit treaties with neighbors Nepal and Bhutan alongside a framework agreement with the USA.

Major agreements under discussion

Discussions and negotiations are ongoing for pacts with partners including Bangladesh, Canada, Israel, Peru and South African Customs Union (SACU), the Eurasian Economic Union (EAEU) and Gulf Cooperation Council (GCC). The discussion about FTA with USA is nearly complete and will be notified any time this year.

Textile and Apparel Exports

The textile and apparel industry including handicrafts in India is the sixth largest exporter in the world with an estimated value of US 35 billion. The Indian export of the various textile products over the years are shown in Fig 1.



Source: DGCI&S & CITI Analysis

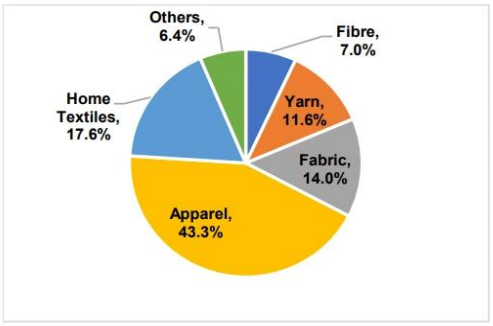
Fig.1 Export of Indian Textiles over the years

It can be seen from **Fig. 1** that the textile and apparel exports have almost been stagnant during the last 10 years. During 2024-25, India's textile and apparel export stood at about US$ 37.0 billion but almost similar to 2015-16. India's exports of apparels have reduced from US$ 17 bn in 2015-16 to US$ 16 bn in 2024-25.

It can be seen from **Fig.2** that the contribution readymade garments are around 44% amongst all textile products. Cotton textiles and natural fibre contribute 29%, Man-made fibre and Synthetic fibres 15% and handicrafts and carpets contribute 6.17%.

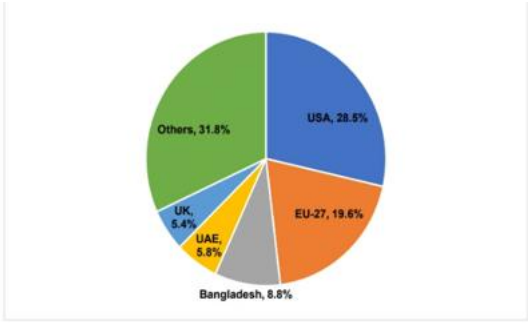
It can be seen from **Fig.3** that the export of Indian textile and apparel products to different countries vary. The USA is the biggest customers of Indian T&A products, European Union (EU27) are the second highest buyer consisting of around 29%. Our future is in the region of UAE and

Middle East countries as there our export is growing at the rate of 22%. Table 1 shows the export of Indian T&A products to different countries in the world. Till 2024 the highest exports were in the USA, EU and Bangladesh.



Source: DGCI&S & CITI Analysis

Fig.2 Break-up of Indian Textile and Apparel Exports



Source: ITC Trade Map & CITI Analysis

Fig.3 The top export destinations for textiles and apparels

Table -1: India's export of T&A products over the years

Country	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR
USA	7.43	7.54	7.79	8.12	8.45	7.51	10.82	10.84	9.30	10.47	3.87%
EU-27	6.86	7.03	7.36	7.34	6.87	5.49	7.05	7.62	6.69	7.18	0.52%
Bangladesh	2.08	1.92	2.26	2.50	2.06	2.08	4.27	3.49	2.64	3.24	5.04%
UAE	4.52	4.37	4.11	2.47	2.44	2.07	2.67	2.09	1.98	2.14	-7.96%
UK	2.41	2.23	2.24	2.19	2.15	1.60	1.96	2.01	1.87	1.98	-2.13%
Others	13.85	12.34	13.48	14.48	13.51	10.86	14.70	12.26	11.75	11.69	-1.86%
World	37.15	35.42	37.23	37.11	35.49	29.61	41.47	38.31	34.23	36.71	-0.13%

Source: ITC Trade Map & CITI Analysis

Global Scenario of fibre production, consumption and value

Global fibre consumption is dominated by man-made fibre and synthetic materials, with natural fibres making up roughly 20% to 27% of the total market share. While natural fibre accounted for over 50% of global fibre consumption in 1990, man-made fibres and synthetic fibres 9led by polyester) have surged to represent over 70% and 75% of total use. Cotton remains the leading natural fibres world-wide, accounting for 20% of the global fibre demand and standing as the second-most used fibre overall (after polyester). Beyond cotton, global natural fibre volumes include major agricultural fibres such as Jute (approx. 3.3 mn tons). Wool (clean approx. 1.2 Mn tons), coir (approx. 900,000 tons) plus flax, hemp, abaca, sisal, ramie and silk.

The Asia Pacific region leads in the natural fibre production and consumption (holding over 50% market share), driven heavily by countries like China and India, followed by Europe and North. Fig. 4 & 5 show the production and share of different

fibres in global market and Fig. 6 shows the value of fibre products in the global market. Fig. 6 shows that the value of cotton product market is still nearly 50% i.e. cotton products adds more value. China is the highest producer of cotton fibres amounting to around 7.5 Mn tonnes and India is the second highest producer of cotton amounting to around 5 Mn tonnes.

The global fibre production reached approximately 132 Mn tonnes, with man-made and synthetic fibres making up roughly 72- 75% of the total fibre output and is projected to scale up towards 169 Mn tonnes by 2030. Polyester is the leading man-made fibre accounting for about 59% of the global fibre production. China is the largest synthetic and man-made fibre producer accounting for 73% of the global output, whereas, India is the distant second largest producer of synthetic and man-made fibres producing around 8% of the global production.

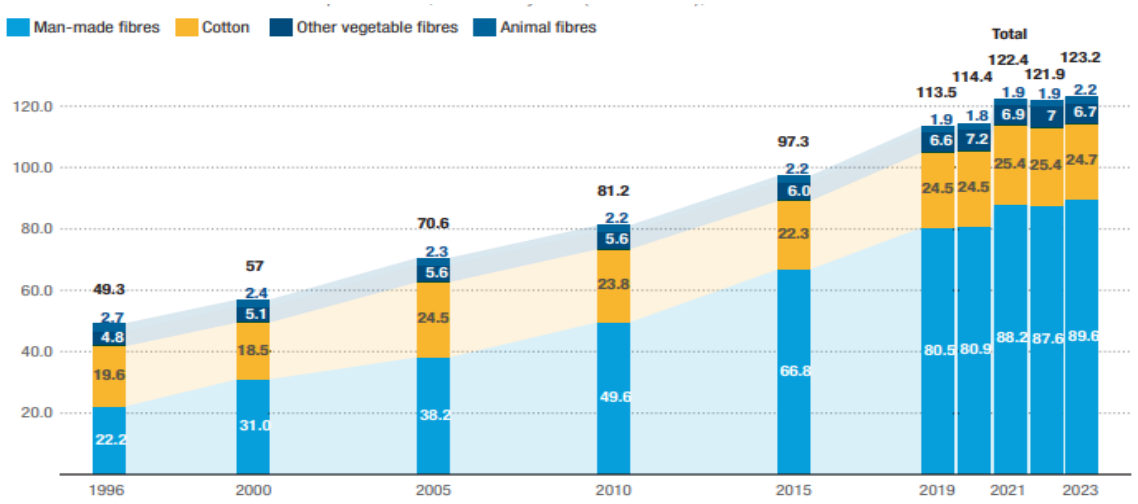


Fig. 4 Global production of different fibres over the years

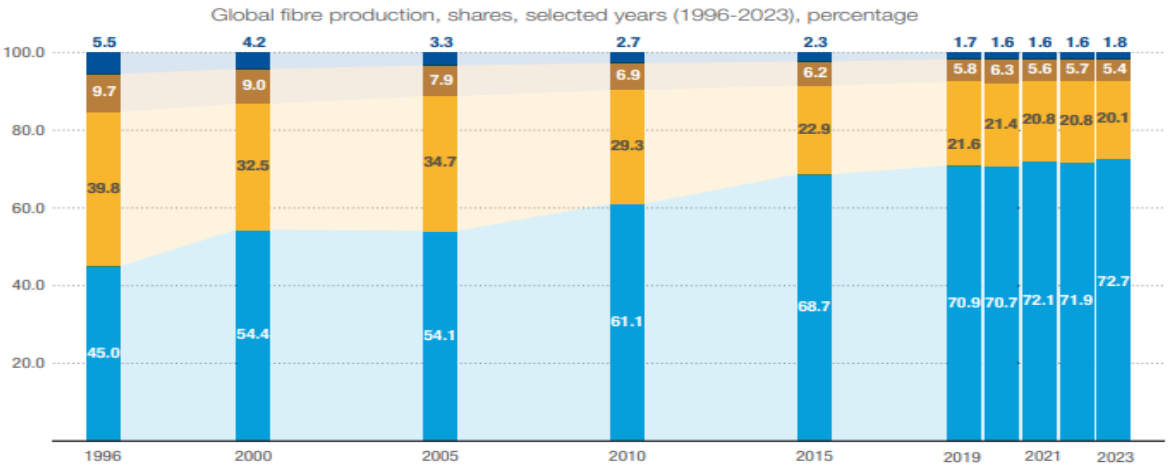


Fig.5 Global fibre production (proportion) over the years

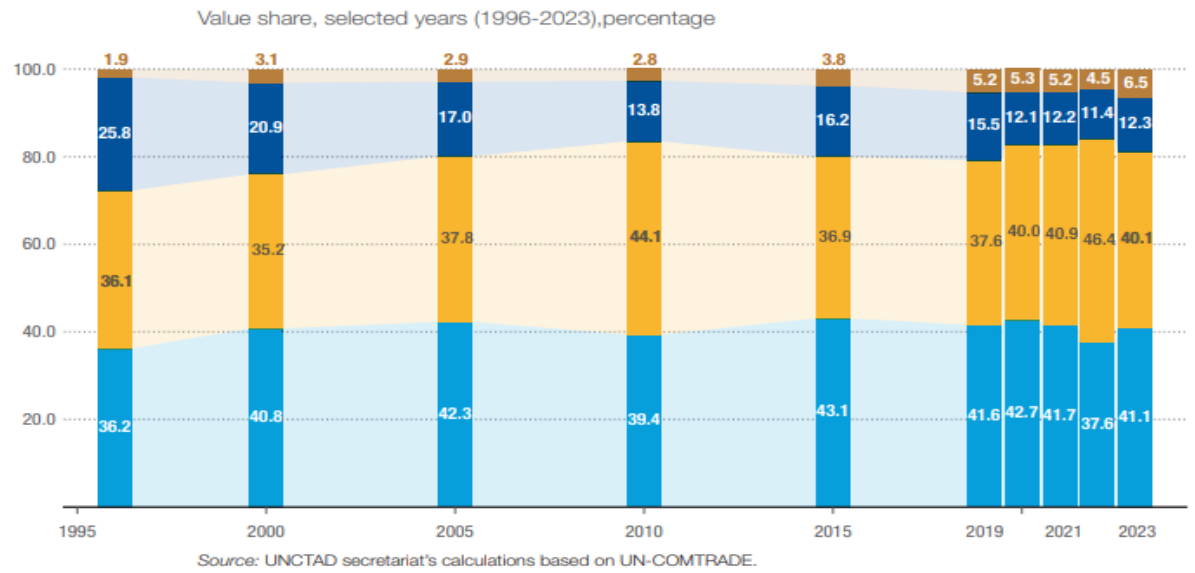


Fig. 6 Value share of different fibre products over the years

The figures 4,5 and 6 reveal that trade in fibres followed a different pattern compared production, with cotton trade consistently aligning with trends in man-made fibres. The absolute value of cotton trade rose from US$ 8 billion in 1996 to US$ 21.6 billion in 2022. During the same period its share in global trade grew from 36.1% to 46.4% in 2022.

Production and trade data raved a stronger inclination for natural fibres to be traded internationally compared to man-made fibres. In 2023, the trade to production ratio for cotton, other vegetable fibres and animal fibres stood at 0.26, 0.32 and 0.26 respectively. In contrast the ratio for man-made fibre was notably lower at 0.075. Back in 1996, these ratios were 0.22, 0.17, 0.48 and 0.18 respectively. This indicates that the propensity to trade was lower for cotton and other vegetable fibres but higher for animal fibres and man-made fibres at that time. These evolutions suggest that while vegetable fibres are increasingly being traded and processed across multiple countries and regions, the processing of animal fibres and particularly man-made fibres has become more concentrated in countries that produce the raw materials. Also, it shows that the demand of cotton and other vegetable fibres have spread around the countries who don't produce these fibres. One of the reasons for the same is the awareness of the eco-friendliness including carbon footprints of these fibres as compared to animal and man-made fibres.

Importance of cotton textile in India

India remains a center pillar of the global market in cotton production, accounting for 23% of total worldwide production and supports roughly six million farmers and over 45 million jobs across the value chain. Fig. 7 shows the country wise cotton consumption in their textile units over the years. It can be seen that it is predicted during 2035 also India will remain a major cotton using country despite huge competitions from man-made and synthetic fibres. Though in some opinion one of the major important ways to increase the export figure by more usages of synthetic fibres and their blends with cotton. In the field of synthetic textile export, the developed countries play a major role and

due to availability of cotton in the country, India find it easier to dominate in the cotton and cotton blended products.

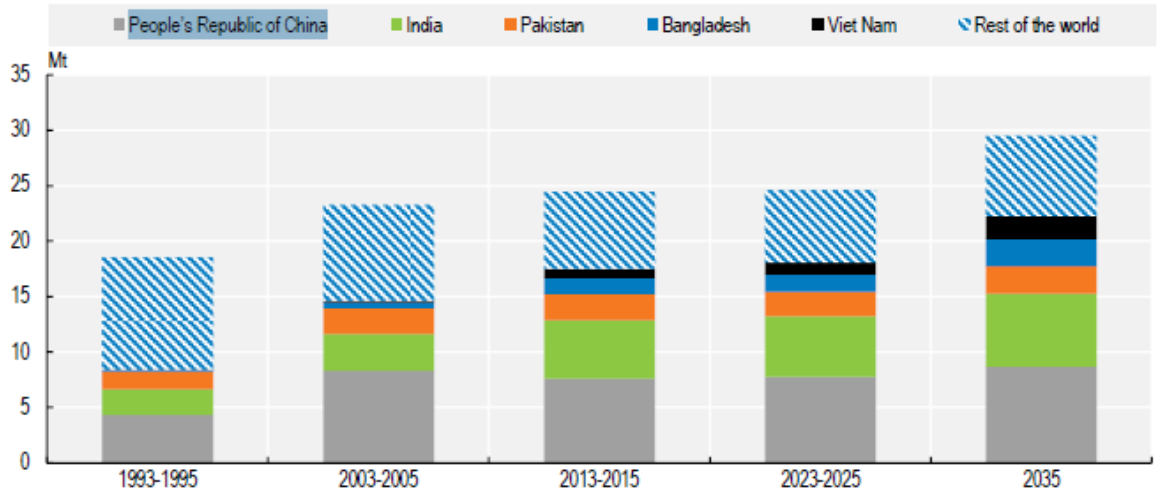
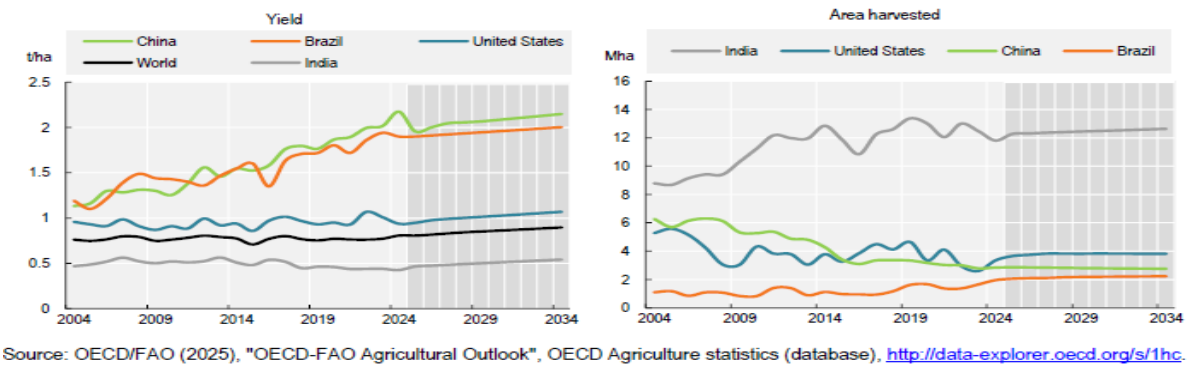


Fig.7 Cotton consumption of textile units in major textile production countries

In India a large area is covered under the production of cotton fibre. Due to urbanization and continuous increase in demand of food, it is very unlikely that there will be increase in area in cotton production, rather there may be a small reduction in cotton harvesting area. The only way to cater future demand by increasing the yield per area. Fig. 8 shows the yield of cotton ad areas under cotton in major cotton growing countries over the years.



Source: OECD/FAO (2025), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://data-explorer.oecd.org/s/1hc.

Fig.8 Yield and areas under cotton cultivation in major cotton growing countries

The above figure shows that in India cotton yield is much lower as compared to other countries, which has a good scope of improvement. The yield of cotton in Brazil, Australia, USA, China are much higher as compared to India. The world average yield is more than 600 kg of lint per hectare, whereas the yield in India is around 450 kgs/hectare. The yield in India had reached at the level of 550 kg/hectare due to introduction of BT cotton, few years back

but it has come down to the level of 450 kg/hectare which is alarming.

The major factors for this low and decreasing yield are:

- Small land holding of Indian farmers, who grow cotton, which makes it difficult in mechanization.
- Too many varieties of cotton seeds are available in Indian market and each year many research institutes and agricultural universities introduce new varieties of cotton, without withdrawing the older one. An estimate tells that in India more than 500 varieties of seeds are available commercially. This creates a unique problem of mix up of different cottons in the ginning factories and mills receive cottons with wide variations, high trash content and highly fluctuating price.
- Mechanical harvesting can reduce the variation of cotton length in a particular field due to picking of bolls in one go, instead of 1st pick, 2nd pick and 3rd pick, which is practiced now.
- The bollworms have grown resistance to old BT cotton; hence, it is important to develop newer version of BT cottons in India itself, which is generally not encouraged in India.
- Some trials are in progress to introduce newer agriculture practices such as High-Density cotton planting, high yield cotton varieties, restriction of only few varieties in an area based on agro-climatic condition etc.

As per OECD- FAO report global raw cotton consumption is projected to grow between 1.2% -1.6% annually over the coming decade, backed by rising urban populations and household incomes and fueled by rising import demand in Asia. The production of cotton is expected to grow largely as a result of by yield improvements, reaching 30 million tonnes 9Mt) by 2035. China remains the world's largest cotton processor and importer, while countries like India, Vietnam (growing at 2.7% annually) and Bangladesh (2.1% growth annually) are rapidly expanding their spinning and textile capacities due to competitive labor cost.

Rise of circularity and recycling

The industry is moving past traditional fast-fashion models towards fibre-to-fibre recycling loops, mechanical/chemical recycling and bio-based alternatives to combat the world-wide problem of microplastics. A study shows that a comparative results of emission amounts from raw materials purchased for production in 2023 are as follows:

Cotton - 61.58 kg CO2eq/m2

Polyester – 7879.05 kg CO2eq/m2

Wool - 732.46 kg CO2eq/m2

Viscose – 4178.43 kgCO2eq/m2

Beside fresh raw cottons, recycled cottons are extensively used in textile industry to mitigate the problems of high carbon footprint, that actually increases the volume of final products without the increase in production of raw cotton. It has been shown by various studies that the carbon footprint of recycled cotton is much less than raw cotton production.

Conclusions

The global political condition may not be much encouraging but thanks to various agreements signed by Government of India with UK, EU(27), Australia, New Zealand, various Asian and African countries we are seeing a positive results in India's export of textiles and apparels. India is blessed with a large amount of cotton production (second highest) and that helps us in export of cotton products throughout the world. As there is a limitation in the area of

production of cotton, the future export market will depend on cotton and its blends with man-made/synthetic textiles. The latest data shows that the trade of man-made fibre fabrics are increasing in very fast rate in the world. India has very good possibility of continuing a good export of cotton textile products and export of blended and man-made fibre textiles can only help us in improving the export level at faster rate.

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Dr. Arindam Basu, a Ph.D. from University of Leeds, England, has a long experience of leading national level research institutes and researcher for many years. He worked as Director General of Northern India Textile Research Association (NITRA), Ghaziabad, Director of Central silk Technological Research Institute (CSTRI), Bangalore and Director of South India Textile Research Association (SITRA), Coimbatore over 23 years. He was Chairman of Textile division council of Bureau of Indian Standard, and chairman of Bureau of Energy Efficiency Textile Industries division. He is presently the co-founder of a company named Nattex Sols Private Limited.

He has published around 25 books, including 3 published by the Textile Institute, U.K. He has published around 175 research papers in International and National Journals of repute, including Textile Research Journal, Journal of the Textile Institute, Melliand Textilberichte, Journal of Industrial Textile, Indian Journal of Fibre and Textile Research, etc. He has twelve patents to his credit as an inventor.

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MEMORY

Geopolitics and The Indian Textile and Apparel Industry

By Shatarupa Majumdar | Management Trainee, Welspun Living Limited

Abstract

Geopolitics can be understood as the study of how geography influences political power, state behaviour and relations between countries. In this view, geography is not only a background for politics, but it also decides who gets access to resources, trade routes and markets. India is among the top textile exporters in the world, one of the largest producers of cotton and yarn, and one of the very few countries that can manage the full journey from fibre to finished fashion within its own borders. Due to this position, any major change at the global level, whether it is a quota system, a trade war or a shipping crisis, has a direct effect on Indian mills, exporters, workers and buyers.

This article looks at the Indian textile and apparel industry from historical, economic, political, technological, social and environmental angles. It follows India's path from the period of the Multi-Fibre Arrangement, through the rise of China, to the present period of Red Sea disruption, tariff uncertainty and structural change. It also examines what is helping India and what is holding it back, and argues that India's future will depend on how far it can turn a geopolitical opening into real strength in technology, logistics and policy.

Keywords: Geopolitics, Indian Textile, MFA, WTO, China Plus One, Red Sea Crisis, Tariffs, FTAs, Sustainability, MSME

1. Introduction

What is Geopolitics?

Geopolitics looks at how the geography of the Earth shapes political power, the behaviour of states and relations between nations. In this sense, geography is not only a silent background to politics. It decides who can reach resources, trade routes, markets and strategic advantage (WTO, 1994).

How is Geopolitics related to the realm of textiles

The textile business does not stay inside one country. It works through a wide network that crosses borders. For example, raw cotton from one country can be processed in India and sold in another country. For India, this network matters even more because India both makes and uses textile goods on a very large scale. Because it depends so much on global links, the Indian textile industry reacts quickly to any geopolitical change. A small change in trade policy, a new tariff, a border dispute, a sanction, political unrest, or a blocked shipping lane does not stay local. It spreads through the whole Indian chain and changes raw material prices, delivery time, production cost, export strength, and finally the situation of Indian workers and buyers.

For this reason, for the Indian textile and apparel industry, geopolitics is not only an outside factor. It is a part of how the industry works.

2. India's Position in the Global Textile Map

India has a position that only China can match. It can manage the full chain inside one country, from fibre to yarn to fabric to processing to garmenting. After China, India produces the most cotton in the world. It is also a major player in man-made fibre, home textiles and technical textiles. The sector provides work to more than 45 million people directly and indirectly, and makes a large contribution to India's exports and GDP (Ministry of Textiles, 2024-25). More than 80 percent of this industry is made up of MSMEs. This makes it flexible, but also easy to hurt. Having the full chain is India's biggest geopolitical strength. While other countries need to depend on China for yarn and fabric, India can make most things at home. Yet this strength is not fully used, because India is still behind in synthetic fast-fashion, worker productivity and logistics.

In my view, India's strength is not only its size, but its completeness. The problem is that completeness has not yet become competitiveness.

3. Historical Context: India in the MFA era (1974-1994)

The most important turning point in this story is the Multi-Fibre Arrangement (MFA), its end, and the rapid growth of China as a manufacturing power. For India, the MFA was both a shield and a limit. This section looks at that period in more detail.

The MFA Era: Managed Protectionism

In 1974, a system was introduced under GATT to control textile trade through quotas (GATT, 1974). Under this system, developing countries could only send a fixed amount of textile and apparel goods to rich markets like the USA and the European Union. The idea behind this was to protect garment factories and jobs in developed nations, which were worried that low-cost labour in developing countries would shut down their own units.

For India, this meant that even with large labour force and raw material base, it could not export beyond its fixed quota. Indian exporters had an assured market, but they could not grow past the limit. This protected small Indian exporters from open competition, but it also stopped India from becoming a global leader. Since no single country could export beyond its quota, global brands had to split their orders among many small countries. They bought at the same time from Bangladesh, Sri Lanka, India and several African nations. This helped small Indian clusters like Tirupur to enter the global market, even though they were small. For Indian exporters, the MFA period felt comfortable but limiting. They had assured quota, so they had little reason to improve technology, because quota, not quality, decided sales. In the author's assessment, this is why India entered the post-MFA period with weak technology but strong raw material base.

4. The Great Transition (1995-2004) and the China Shock for India

In the Uruguay Round of 1994, countries agreed on a plan to slowly remove the MFA system over ten years, ending by 1 January 2005 (WTO, 1994). In the middle of this phase-out, China became a member of WTO in December 2001, which changed the rules for India. After joining, China got the benefit of the quota relaxations that had already happened. Western brands saw that a large workforce, supported by strong state-backed infrastructure, was about to become free from quota limits. Brands began to plan a

large shift of production to China, and India started losing orders that it had earlier got through quota. For brands like Nike, H&M, and Zara, China's entry was a major opportunity. They could now get large volume, steady quality and low price from one country, instead of handling 20 small Indian suppliers. For Indian textile workers, this felt like a threat. They saw orders moving to China and worried about job loss. For them, liberalisation brought more competition, not more security.

5. The 2005 Post-MFA Shockwave: How India Survived

When the MFA ended on 1 January 2005, the global textile picture changed within a short time.

China's textile exports rose sharply. Its system, which brought together raw materials, local machinery, integrated supply chains and low labour cost, allowed it to offer prices that few others could match. Many smaller countries that had depended on protected quotas saw their exports fall as production moved to China. India managed to survive for three reasons: very low labour cost, local availability of cotton, and a large home market that gave support even when exports fell. In South Asia, India and Bangladesh were the two countries that were able to protect their share.

The rise in Chinese exports was so large that the US and EU used safeguard clauses from China's WTO entry agreement to put a temporary cap on growth of Chinese garments till 2008. This gave India a short time to adjust, but India did not use that time fully to upgrade technology and scale.

6. Evolution of Geopolitical Shocks (2018-present) and Impact on India

The post-MFA system made China the main textile factory of the world. However, recent shocks have started to work in India's favour.

The US placed wide tariffs on Chinese imports. This reduced the margin on Chinese apparel. By 2025, US imports of Chinese garments had fallen to very low levels. For India, this opened a chance. Buyers who had earlier bought from China started to look at India as an alternative. In 2021, the US brought in the **Uyghur Forced Labor Prevention Act**, which stopped products linked to Xinjiang, the region that grows most of China's cotton (US CBP, 2021). This cut the flow of Chinese cotton and forced brands to ask for clear proof of where their cotton came from. India gained because Indian cotton was seen as traceable and compliant. Buyers started to prefer Indian cotton over Chinese cotton. Western brands also started to reduce dependence on one country.

This approach is known as China Plus One. Under this approach, brands continue to buy from China but also develop a second source country like India. As a result, garment assembly moved to Vietnam, Bangladesh and India. India became a strong candidate because of its stability and full value chain. Even today, China still controls most of the global supply of synthetic and man-made fibres, yarns and advanced fabrics. Even when a garment is labelled Made in Vietnam or Made in Bangladesh, the factory often depends on raw material coming from China. For India, this is both a warning and a lesson. If India does not build its own MMF capacity, it will stay dependent on

China for synthetic yarn, even if it stitches the final garment.

7. The High-risk Era: Red Sea Crisis and Its Cost for Indian Exporters

The global textile industry has now entered a period of high risk, shaped by political fragmentation, changing tariffs and serious problems in shipping and logistics. For India, this period is very costly. Earlier, the industry followed a simple rule: make where labour is cheapest.

That rule has now changed. Brands now want speed, safety and certainty, not only low price. A chokepoint is a narrow sea route through which a large share of world trade must pass. The Red Sea and the Suez Canal are such routes. For India, they are the main way to Europe. When they are disturbed, Indian exporters feel the effect first. Most ships going to Europe are now avoiding the Red Sea and taking the longer route around Africa's Cape of Good Hope. This is a very long detour for Indian ships going to Europe.

The longer African route adds 10 to 21 days to Asia-to-Europe travel. For Indian fast-fashion exporters in Tiruppur and Surat, this is a serious issue. If a design takes 21 extra days, it may already be out of fashion. Rerouting adds up to 1 million dollars in fuel cost for one trip. War risk insurance has also become costly, blocking working capital. For Indian MSME exporters who work on thin margins, this is a question of survival.

In India and Bangladesh, the logistics problem has directly reduced profit margins, created container shortage, and pushed freight rates up sharply. Indian exporters get orders, but they cannot ship on time or have to pay very high freight.

8. The New Global Tariff Wars and India's FTA Strategy

Tariff changes have created deep uncertainty in sourcing. For India, tariffs are now the biggest deciding factor. Global brands are moving orders quickly to whichever country has lower tariffs at that moment. India has been directly affected by this volatility. After facing 50 percent tariffs that threatened its core apparel base, India reached a breakthrough agreement with the US. This brought textile tariffs down from 50 percent to an 18 percent benchmark, with nearly half of Indian goods getting zero-duty entry. This shows how one trade agreement can protect the whole Indian apparel industry. Sanctions, such as a 25 percent US surcharge on entities dealing with certain Middle Eastern nations, have created heavy traceability needs.

Indian makers now must use costly software to show where yarn and cotton came from. If any step involves a banned country, the whole product can be rejected. At the same time, deals like the pending agreement between the EU and Indonesia aim to cut garment import duty from 10 percent to 0 percent, which is pulling buyers towards Southeast Asia. India has answered with its own FTAs. Under the India-UK agreement, almost all Indian textile products can now enter UK without import duty, and the India-EFTA partnership also gives Indian mills a strong edge (Government of India, CETA and TEPA). For India, FTAs have now become a geopolitical tool to stay competitive.

9. Structural Realignment: From Lowest Cost to Fastest and Safest

Faced with logistics crisis and tariff wars, the textile sector is changing its basic thinking.

1: Shift in Sourcing Model

Traditional Model: Focused strictly on lowest labour and production costs

2026 Model: Prioritizes sourcing speed, proximity, and delivery certainty Western buyers are no longer asking only about price. Their main question now is: can you deliver in four weeks? This is pushing nearshoring to Turkey, Eastern Europe and North Africa for the EU market. For India, this is a threat, because India is farther from Europe than Turkey.

India must compete on speed through better ports, faster customs and digital supply chains. Inside India, a clear split has appeared. While raw textile output has gone up, ready-made apparel making is still under pressure. In simple terms, India is making more yarn and fabric, but its garment factories are struggling. The reasons are rising raw material cost and uncertain global demand. This shows that the Indian chain is not growing together.

10. Geopolitical Advantages for India

India today has a historic geopolitical opening. The following **five points** explain why global buyers are now looking at India more seriously than before.

China Plus One Sourcing Shift: Global brands are moving away from China due to tariffs, rising Chinese costs, and the Xinjiang cotton issue. India is now seen as a stable, vertically integrated option with fibre-to-fashion in one country. Unlike Vietnam or Bangladesh, which depend on China for raw material, India can offer the full chain at home. This lowers risk for buyers.

Competitor Instability in South Asia: Political volatility, labour unrest, and factory shutdowns in Bangladesh and Pakistan have pushed buyers to send high-volume orders to India's more secure hubs. For a buyer, on-time delivery matters more than a small price saving. India's political stability has now become a commercial advantage.

Expansion of Free Trade Agreements: India-UK CETA and India-EFTA partnership have removed high tariffs and given Indian mills a strong edge. For many years, India lost orders because of high duties in Europe. Now, with zero-duty access, Indian products are finally competing on equal terms.

Geopolitical Tariffs on Alternate Hubs: High US tariffs on other hubs and problems in Mexican apparel trade have made Indian cotton products more cost-competitive for Western retailers. When competitors become costly due to tariffs, India becomes attractive without changing its own production cost.

Alignment with Sustainability Mandates: Through Kasturi Cotton and recycling plans, India is entering the growing market for verified organic, sustainable and traceable textiles. This matches EU and US sustainability rules. In the author's view, sustainability is no longer only a marketing term for India. It is now a geopolitical entry ticket to Western markets.

11. Geopolitical Disadvantages for India

Even with these openings, India faces **five serious** structural problems that limit its ability to use the geopolitical window fully.

Soaring Logistics and Freight Costs: Tensions in the Middle East and Red Sea disruption have pushed freight and insurance up sharply. This lowers margins of Indian exporters and makes delivery slower. For MSMEs, this is not only a cost issue, but also a cash-flow crisis.

Volatile Crude Oil and Energy Costs: Global conflicts push crude oil prices up. Because polyester and nylon come from petrochemicals like PTA and MEG, India's MMF sector faces margin pressure and struggles against subsidised Chinese synthetic yarn. India is still a cotton-dominant country, while the world is moving to synthetics. This mismatch is India's biggest weakness.

Regional Supply-Chain Disruptions: Land-route trade bans and stoppages involving Bangladesh have broken important links, blocking Indian spinners from sending cotton yarn to cross-border clients. India sends yarn to Bangladesh, Bangladesh makes garments. When routes are blocked, both suffer. This shows that India cannot ignore regional geopolitics even if global FTAs look favourable.

Western Tariff Fragility and Policy Delays: Delays in finalising a full trade deal with the US keep Indian mills exposed to sudden tariff changes from their largest buyer. The author's analysis is that India has got short-term relief, but long-term stability is still missing.

Structural Rigidity Under Pressure: India's industry is over 80 percent MSMEs. It struggles to take large, sudden orders due to low labour productivity, rigid state labour rules, and heavy dependence on natural cotton instead of synthetic fast-fashion fibres. In simple terms, when a large order shifts to India, India is often not ready to take it at scale.

Overall Assessment: Geopolitics is giving India the order, but India's internal structure is deciding whether India can actually deliver that order. Opportunity without capacity will go to Vietnam or Indonesia.

12. Multi-viewpoint Discussion: Indian Stakeholders, Different Realities

Viewpoint of Indian Exporters and Manufacturers: For them, geopolitics is a survival problem. A tariff change or freight hike can wipe out their entire profit. They need government support, cheap credit, and stable policy.

Viewpoint of Global Brands Buying from India: For brands, India is a risk management solution. They want multiple suppliers, fast delivery, and full traceability. They are ready to pay slightly higher price if India is safe and reliable.

Viewpoint of Indian Workers: For workers, geopolitics decides jobs. When orders shift from Bangladesh to India, Indian workers gain jobs. When factories automate, workers face job loss due to technology. The challenge is to create jobs without stopping automation.

Viewpoint of Indian Government: For the government, textiles are not just business. They are employment, foreign exchange, and political power. India uses FTAs as a geopolitical tool. Schemes like PM MITRA parks, PLI for MMF and technical textiles, and Kasturi Cotton are geopolitical strategies to make India competitive.

Viewpoint of Environment and Sustainability: Geopolitics is pushing longer shipping routes and more synthetic fibre use, which increases pollution. But it is also pushing traceability, organic cotton, and recycling. India must balance geopolitical resilience with environmental responsibility.

Viewpoint of Technology and Engineering: For technocrats, geopolitics creates a new engineering demand: smart factories, digital traceability software, automated spinning and weaving, AI-based supply chain prediction, and technical textiles. The Indian engineer of the future must understand both machines and markets.

13. Conclusion And Future Outlook for India

The Indian textile industry has moved from a stable, low-cost, quota-protected model to a high-risk, fragmented, and resilient model. First, the MFA controlled India's trade. Then, China dominated trade and India had to survive. Now, Red Sea disruptions, tariff wars, and supply bans are reshaping trade again, and India has a historic window of opportunity. Brands no longer ask only: where is it cheapest? They ask: where is it fastest, safest, and most certain? India can answer this question because it has stability, complete value chain, FTAs, and sustainable cotton.

But India will fail if it does not solve its internal weaknesses: logistics cost, MMF capacity, labour productivity, MSME fragmentation, and infrastructure. The future belongs to Indian companies that can combine technology, speed, traceability, sustainability, and geopolitical adaptability.

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Shatarupa Majumdar is an avid learner and aspiring professional in the realm of textile technology. She is committed to contributing innovative solutions and pushing the boundaries of this ever-evolving industry. With a profound interest in the intricate world of textiles, she is dedicated to exploring the diverse facets of this field, aiming to combine technological advancements with creativity

Application of Generative AI in the Fashion Design Classroom

By Priyabrata Mondal | Assistant Professor, Amity University Kolkata

Introduction

A fashion student begins with a theme, a sketch and a question about the person who will wear the design. Generative artificial intelligence adds another way to explore those decisions. A written description or uploaded drawing becomes the starting point for visual alternatives. Yet a convincing image does not explain why a silhouette suits its user, whether a textile will behave as shown, or whose cultural knowledge informed the surface design. Those questions remain part of the students' work.

This article develops ideas from the AI-Augmented Fashion Design Education Framework, or AI-AFDEF, presented by Mondal, Raha and Jana (2027). Their chapter describes exploratory classroom activities at Amity University Kolkata, primarily involving second-year Fashion Design and Fashion Communication students. Activities include mood boards, motif development, sketch-based visualisation and portfolio work. Here, the emphasis shifts from presenting the chapter to explaining its educational choices for students, teachers and the university community. The examples proposed below are places for student work, not a new dataset.

The central question is practical, how should a fashion course teach students to direct, question and revise AI-generated material? The answer requires more than access to software. It requires research habits, fashion vocabulary, visible decision-making and responsibility for the final presentation. Recent studies provide reasons for experimentation, alongside evidence against treating faster image production as automatic improvement in learning.

What does the research tell us?

Fashion education research now includes structured prompting, studio implementation and comparisons between conventional and AI-supported workflows. Lee and Suh (2024) developed a prompt guide within a technology-integrated teaching model and worked with 30 third- and fourth-year fashion students. The paper reports overall satisfaction of 4 out of 5 and a prompt-guide rating of 4.7. These numbers describe responses within that programme. They do not establish equivalent gains in independent design skill, production competence or long-term creativity.

Other studies extend the discussion beyond satisfaction. Jung and Suh (2024) examine soft skills in AI-supported textile design, while their later pedagogical case study describes prompt-based AI literacy practices (Jung & Suh, 2026). Balasubramanian (2026) discusses integrating generative AI into a fashion curriculum through a structured digital collection project. Together, these publications support examining the relationship between teaching design, student interaction and reflection, rather than attributing an educational outcome to a tool alone.

The findings are not uniformly positive. Jang (2026) compared matched textile-design tasks completed by 34 undergraduates using conventional vector

tools and AI-supported workflows. The study reported lower workload and greater procedural efficiency, alongside weaker personal-style expression and lower ratings on several creative and experiential outcomes. Its lesson for educators is specific: easier production and stronger creative ownership are separate outcomes. Both deserve attention when an AI-generated image appears successful.

Prompt literacy starts with design knowledge

Prompt literacy means expressing an intention, interpreting the response and deciding what to change. It is broader than memorising a formula for attractive images. Foundational AI-literacy research includes understanding, evaluation and ethical engagement, alongside practical interaction with AI systems (Long & Magerko, 2020; Ng et al., 2021). Laupichler et al. (2022) also identify the need for stronger assessment of AI literacy in higher and adult education. For fashion students, this means judging the design and the process used to produce it.

A prompt such as "make a sustainable dress" leaves almost every design decision unspecified. A useful brief identifies the garment, user, occasion, silhouette, material intention, colour direction and constraints. Students also need to explain which details arise from research and which remain speculative. Describing a fabric as recycled does not verify its composition. Describing a garment as inclusive does not demonstrate fit across different bodies.

Knoth et al. (2024) studied prompting among 45 university students in non-fashion tasks. Prompt quality was associated with output quality, but relationships with broader AI-literacy dimensions were mixed. The study supports attention to prompting behaviour without proving a universal recipe. In a fashion course, prompts should therefore be taught through domain-specific decisions and critique. Longer wording is useful only when it communicates something relevant.

Reading AI AFDEF as a teaching framework

The chapter's AI-AFDEF combines five connected concerns: creative augmentation, technical amplification, data-empowered research and sustainability, curricular embedding and pedagogy, and ethical and human-centred practice. These are broad educational priorities. The chapter also presents a more practical sequence for ideation and prompt development: investigate inspiration, define a concept, construct prompts, generate alternatives, refine the design and assemble documented outputs. The framework and the workflow serve related but different purposes.

For magazine readers, the practical value lies in making those connections visible. Research supplies the concept. Prompting translates selected decisions into instructions. Generated images offer material for review. Student editing and technical development determine what survives. Portfolio documentation explains the relationship between the original intention and the submitted result. Ethics belongs within every step, including the choice of reference material and the decision to publish an image.

AI-AFDEF should be discussed alongside other approaches rather than presented as the only structured model. Hatef Jalil and Abdullah (2026) report a four-hour design-thinking workshop with 30 undergraduates. Manchiraju (2026) proposes a fashion-specific AI-literacy

framework that still requires empirical validation. These comparisons position AI-AFDEF as a classroom-oriented contribution within an expanding conversation. Its effectiveness across institutions and tasks remains a question for further evaluation.

Start with research before generation

An assignment should begin with sources students understand. Research might include personal observation, drawings, textile samples, documented craft references or a clearly defined user need. Students should identify where each source came from and explain why it matters. Asking an AI system for background information is not a substitute for checking the information against dependable sources. The first assessable outcome is therefore a defensible design direction, before any generated image appears.

Students then translate research into choices. A theme becomes a colour relationship, a construction question, a repeated form or a surface treatment. They should distinguish observations from interpretations. For example, a photograph documents a visible arrangement of motifs. The claim that the arrangement carries a particular cultural meaning requires an appropriate source or consultation. This distinction prevents a visual reference from being treated as evidence for every story attached to it.

Structured interaction also offers an alternative to unrestricted prompt writing. Khleborodova and Kim (2026) investigate an attribute-based system that organises fashion variables before translating them into prompts. The implication for teaching is useful: a vocabulary sheet or brief template provides support while students learn to articulate intention. It should support their reasoning, not replace research or prescribe the same aesthetic for everyone.

Botanical Motifs in Two Colour Stories

This project explores botanical surface design through two colour stories: vivid red and pink florals on black, and pastel floral-and-arch motifs on a light ground. Hand-rendered designs documented in Bushra Haider's assignment provide the visual starting point for Gemini-assisted garment concepts. The direction emphasises motif scale, placement and colour contrast across dresses and separates. The outputs are visual concepts, not tested garments. Bushra Haider, a student of, B.Des. Fashion Design, Amity University Kolkata used AI tools Google Gemini, ChatGPT for her work, under the guidance of a faculty Assistant Professor Priyabrata Mondal. Concept note and board layout are editorial interpretations of the submitted work.

From sketch to a controlled prompt

A sketch records decisions before generation. Its proportions, line relationships and surface placements create a basis for evaluating what an image tool preserves or changes. The chapter includes sketch-to-visual work using Gemini and Newarc AI. Such work is most informative when the original drawing and generated version appear together. A polished visual alone leaves the reader unable to identify the student's contribution or the system's alterations.

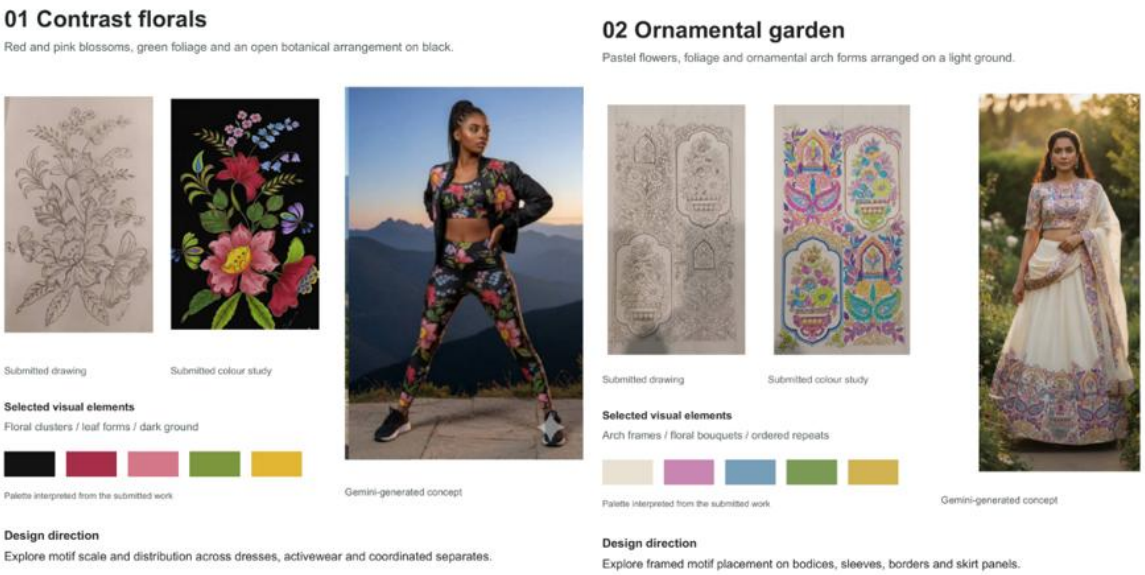

Figure-1: Botanical motifs in two colour stories. A retrospective concept assembled from Bushra Haider's submitted drawings, coloured designs and Gemini-generated garment visualisations

The following is a proposed teaching prompt, not a quotation from a student: "Develop a front-view concept visual from my attached jacket sketch. Preserve the asymmetric closure, hip length and sleeve proportions. Use a muted blue palette and show the intended woven surface. Keep the background plain. Do not add logos, jewellery or extra panels. This image is for concept discussion, not a construction specification." Each instruction refers to a design choice students should be able to explain.

The generated response then becomes an object of inspection. Has the closure moved? Has the tool added seams or removed a pocket? Does the apparent textile contradict the stated intention? Choi et al. (2023) emphasise fashion-domain knowledge when developing AI-supported design systems, while Zhang and Liu (2024) identify continuing designer involvement in Midjourney-based concept development. Both help explain why visual generation still requires informed human review.

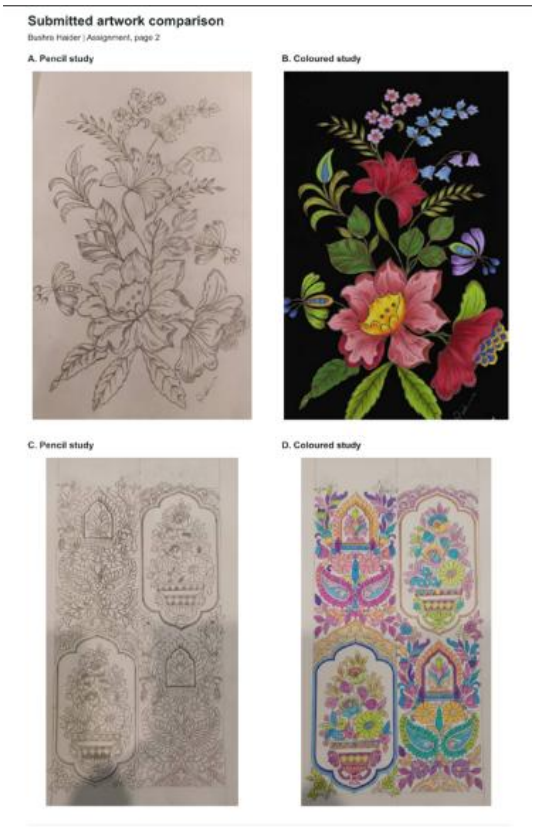

Figure 2. Pencil and coloured versions of botanical motif studies presented. The comparison shows line, colour and compositional details.



Figure 3. AI-assisted visualization of a floral-print dress developed from Bushra Haider's submitted artwork. The original garment visual was generated using Google Gemini and subsequently refined through Codex to improve lighting and clarity. Fine print and background details



Figure 4. Floral-and-arch motifs translated into a Gemini-assisted garment concept.

Iteration should show a reason for change

Generating more images is not the same as developing a concept. A useful iteration records a problem, the change intended to address it and an evaluation of the response. If motif placement obscures a garment opening, the next instruction should address placement. If the silhouette no longer serves the intended user, students should revisit the brief rather than add more styling language. Each revision needs a design reason.

A short process record helps. Students retain an initial prompt, a revised prompt, selected outputs and notes explaining their choices. They should also keep an unsuccessful example when it reveals a

meaningful limitation. The goal is not to reward a fixed number of generations. It is to show whether students recognise a problem and respond with a purposeful intervention. Manual redrawing or abandoning an AI direction are equally legitimate decisions.

This approach also addresses fixation. Wadinambiarachchi et al. (2024) examine the relationship between image generation, design fixation and divergent thinking. Research outside fashion adds another caution: Doshi and Hauser (2024) found that AI assistance improved evaluations of individual short stories while making the collection of stories more similar. That writing experiment does not measure fashion creativity. It does justify asking whether a class is producing varied ideas or converging on familiar generated appearance.



Figure 5. Retrospective portfolio selection assembled from Gemini-assisted garment concepts. The images explore different applications of the documented motifs.

Keep human authorship visible

Creative authorship includes choosing references, drawing, setting constraints, rejecting alternatives and transforming a result. It is not established by placing a student's name beneath an image. The portfolio should make these decisions legible. An annotated comparison helps readers see where the student intervened and where the system supplied visual material. If the student mainly selected an output, the description should say so without implying extensive manual development.

Särmäkari and Vänskä (2022) examine fashion designers working with generative algorithms, providing an earlier perspective on changing creative practice. Meron and Tekmen Araci (2023), working in design-course development rather than student fashion production, also describe the need for human prompting and editing when

using ChatGPT. These contexts differ, but both discourage a simple account in which the system independently resolves the creative task.

Students should be able to answer three questions during critique: What did you intend? What did the tool change? What did you decide to retain? A short oral discussion complements the portfolio record. It reveals reasoning a final image does not contain. Human authorship becomes an assessable process of decision-making rather than an unsupported claim about originality or an attempt to hide assistance.

Cultural references require context

The chapter includes work drawing on Madhubani painting and Sambalpuri and ikat references. A magazine presentation should preserve the distinction between a researched cultural source, an individual interpretation and a generated variation. Naming a tradition in a prompt does not verify the resulting image's accuracy. Nor does combining recognisable features establish an authentic representation. Students need to explain the particular source they studied and the changes they introduced.

Boutier (2026) argues for embedding cultural rights and critical reflection within technical AI education. This is a conceptual argument, not an empirical audit of every image model. It nevertheless raises a relevant classroom question: whose knowledge is represented when a tool produces an image described as culturally inspired? Students should seek guidance from suitable sources and, where appropriate, practitioners, rather than treat a community's visual language as anonymous decoration.

The caption matters. "Student interpretation informed by documented Madhubani references" is more precise than claiming an AI-generated design is an authentic traditional work. Credits should distinguish the student, source creator and AI system. Restricted, sacred or community-sensitive material requires particular care. A strong presentation acknowledges uncertainty and omitted context instead of using cultural terminology to give a generated image authority it has not earned.

Responsible images and responsible information

Fashion images communicate assumptions about bodies, gender, age, occupation and place. Naik and Nushi (2023) and Bianchi et al. (2023) investigate social and demographic biases in text-to-image generation. Their work supports inspecting model outputs rather than assuming neutral representation. In a classroom critique, students should ask who appears, who is missing and whether the image reproduces a stereotype. More varied prompts alone do not establish that a system is fair.

Information also needs checking. Walters and Wilder (2023) documented fabricated references and bibliographic errors in outputs from the ChatGPT versions they tested. Those results are not an error rate for every current tool. They show why an apparently complete reference is insufficient evidence. Students should locate the source, confirm its bibliographic details and read the relevant material before using it to support a claim.

Privacy and consent belong in the same workflow. Do not upload identifiable classmates, unpublished work or sensitive material without appropriate permission and an understanding of the service's conditions. Consent to submit a classroom

assignment does not automatically cover university-magazine publication. Chan's (2023) policy framework links pedagogical practice with governance and operational support. For a department, this means clear rules for tools, data handling, publication and responsibility, rather than leaving every student to negotiate them alone.

Sustainability needs evidence beyond an image

A generated garment labelled "zero waste" is not a verified zero-waste pattern. A realistic visual does not establish fabric composition, durability, repairability or resource savings. Those claims require evidence suited to the question. Pattern efficiency needs pattern and layout information. A material claim needs a documented specification. An environmental comparison needs a stated boundary and data on the activities being compared. Visual plausibility is a different kind of evidence.

Students should therefore use AI-assisted images to explore intentions without presenting them as environmental results. An upcycling concept might show possible placements for reclaimed panels, followed by measurements and a physical or technically modelled trial. A portfolio should label untested assumptions. If no fabric consumption was recorded, it should not report waste reduction. If no construction test occurred, it should not claim production feasibility.

AI use also has an environmental cost. Luccioni et al. (2024) compare energy use and emissions across machine-learning tasks, including image generation. Their study supports considering computational demand, not assigning a universal footprint to every student image. A responsible studio records generation activity and avoids unnecessary repetition. Any future claim of net savings should consider both digital activity and physical resources, using a transparent comparison rather than assuming digital work is inherently sustainable.

Assess the process without inventing results

For undergraduate work, five criteria offer an accessible structure: design research and documentation, prompt construction and refinement, concept-output ideation, human creative authorship, and cultural, sustainable and ethical responsibility. These reflect the chapter's simplified rubric. As a proposed classroom arrangement, each criterion receives up to 20 marks, giving a total of 100. Teachers should establish descriptors and explain evidence requirements before assessment begins. The arrangement is a teaching proposal, not a validated measurement instrument.

Marks should follow an actual review of retained work. An attractive image does not justify a high score for prompt refinement if the prompts are unavailable. Missing documentation should be recorded as missing evidence, rather than treated automatically as proof of weak ability. Retrospective assessment needs an explicit date, an identified assessor, the scoring procedure and the material available for each judgment. Without those records, numerical precision creates a misleading impression of certainty.

This magazine article reports no new numerical assessment of student work. The proposed figure sequences instead show readers what useful process evidence looks like. Future evaluation should include independently assessed work and an appropriate comparison. An unaided follow-up task would address a particularly important question: what has the student learned to do after the AI

assistance is removed? Such a task would distinguish a successful assisted presentation from retained knowledge and independent design judgment.

Support students and teachers together

AI integration depends on teaching conditions. An and Park (2026) interviewed 10 fashion-design instructors about student challenges and instructional support. Browning-Samoni and Eike (2026) compare mentor-supported and individual learning contexts, with outcomes centred on student perceptions. These studies help direct attention towards scaffolding, collaboration and feedback. They do not support treating a software subscription as a complete educational intervention.

A larger study by Zhang (2026) analysed survey data from 500 fashion-design students across 18 Chinese universities. It identified associations among teacher support, AI use and reported design-learning constructs. The scale of the sample is informative, but structural equation modelling of survey relationships does not by itself establish causality. The practical implication is to investigate support carefully, without presenting an association as proof that a particular teaching action caused learning gains.

Departments should also address access. Paid features, device limits and language confidence influence participation. Provide shared access where possible, an alternative route through the assignment and assessment criteria that reward reasoning rather than premium image quality. Chan and Hu (2023) document student concerns about accuracy, privacy and ethical use in higher education. Listening to these concerns helps teachers plan a course students understand and trust.

Teachers need time to test a brief before assigning it. A short trial reveals whether the selected tool preserves sketches, records revisions or exports readable images. The assignment should name the permitted assistance and explain what students must complete themselves. Students should know whether AI-generated text belongs in a concept statement, whether external images are permitted and which process records to submit. Consistent instructions reduce uncertainty during critique and help teachers judge comparable evidence across different projects.

What a student portfolio should communicate

A useful magazine spread presents a design story readers are able to inspect. It identifies the brief, shows the student's starting material, explains the AI interaction and records the final human decisions. Images should be large enough for meaningful comparison. Captions should name the tool and describe the work accurately. Use "AI-assisted concept visual" when the image has not been developed into a tested garment or technical digital prototype.

The educational purpose is not to produce the largest number of images. It is to develop designers who understand their sources, communicate intentions, evaluate alternatives and defend decisions. AI-AFDEF offers one way to organise that work. Its value should be examined through documented practice and careful evaluation. A successful student presentation makes both the possibilities and the unresolved questions visible, leaving the reader with a clear account of human judgment throughout the design process.

Adaptation acknowledgement

This article discussed the AI-AFDEF concepts presented by Mondal, Raha and Jana in their book chapter. It presents a new discussion rather than a new empirical study. Student images are added with appropriate credits and permissions.

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Shri. Priyabrata Mondal, Assistant Professor and Program Leader at Amity University Kolkata, brings extensive expertise to the realm of fashion technology. With a master's degree in Fashion Technology from NIFT, New Delhi, and a Bachelor of Technology in Apparel Production and Textiles, Mr. Mondal's academic foundation is robust. His five years of industry experience with renowned organizations like Woodland and Shahi Export, coupled with his academic tenure, enrich his perspective. Currently pursuing a PhD from Anna University, Chennai, Tamil Nadu, Mr. Mondal's research focuses on implementing AI in the garment industry to enhance efficiency and sustainability.

His interests span Artificial Intelligence in Fashion, Machine Learning, PMTS implementation, and ergonomics. His dedication to merging technology with fashion underscores his commitment to innovation. His work not only contributes to academic discourse but also addresses practical industry challenges. As an influential figure in academia, Mr. Mondal is shaping the future of fashion technology through research and education

WITH BEST COMPLIMENTS

TANTU Annual Seminar 2026

From a Well-Wisher

The Future of Apparel Manufacturing: Integrating Digital Transformation, AI, Predictive Planning and Industry 4.0

By Bhaskar Bairagi | Operations Manager, Welspun Lean Six Sigma Black Belt Certified

Abstract

Garment manufacturers face more demanding customers, shorter lead times, volatile demand, rising operating costs, and intensifying competition. The management systems on which many factories still rely (manual reporting, spreadsheets, historical assumptions, and individual experience) were not built for these conditions. This article examines how the technologies associated with Industry 4.0, namely connected systems, real-time data, automation, artificial intelligence (AI), machine learning, and predictive analytics, are changing the planning and management of apparel production. It describes the scope of digital transformation across the manufacturing value chain, the limitations of conventional planning, the role of enterprise resource planning (ERP) as an information backbone, and the contribution of factory-floor technologies and AI to a move from reactive to predictive management. It illustrates predictive reasoning with a worked example, considers the principal challenges and risks, and proposes a phased route to adoption. The article argues that future competitiveness will depend not only on how efficiently factories make garments but on how intelligently they plan, monitor, anticipate, and manage their operations.

Keywords: apparel manufacturing; Industry 4.0; digital transformation; artificial intelligence; machine learning; predictive planning; enterprise resource planning

1. Introduction

The global apparel industry is entering a new phase of technological change. Customers expect more, and expect it sooner. Demand is harder to forecast. Operating costs continue to rise, and competition between producers has become both wider and sharper. Together these pressures are obliging manufacturers to question the systems by which they manage production.

For many years, garment factories have relied on manual reports, spreadsheet-based plans, assumptions drawn from past performance, and decisions guided by experience. These practices have sustained manufacturing operations and should not be dismissed. They are, however, frequently too slow, too imprecise, and too opaque to manage a production environment of today's complexity, in which a factory may be running dozens of styles across many lines simultaneously.

Industry 4.0 offers a different foundation. It brings connected systems, data captured as events occur, automation, artificial intelligence (AI), machine learning, and predictive analytics into the operation of the factory. For apparel manufacturers, the significance of this shift lies in what it makes possible rather than in the equipment itself: an environment in which information moves freely between departments, problems are detected early, and decisions are supported by dependable data.

Digital transformation in this sense is far more than the substitution of computer screens for paper reports. It concerns the

creation of an intelligent manufacturing environment. The future of the industry will be determined not simply by how efficiently factories produce garments, but by how intelligently they plan, observe, anticipate, and manage what they do.

The article is conceptual rather than empirical. It draws together established ideas from operations management, industrial engineering, and information systems and applies them to the circumstances of garment manufacturing; it does not report original survey or experimental data. The numerical illustrations are constructed for explanatory purposes and are not taken from any particular factory. The discussion is directed chiefly at cut-make-trim manufacturers, although much of it applies equally to vertically integrated producers, and it concentrates on planning and management rather than on the technology of individual machines.

2. Digital Transformation across the Apparel Value Chain

2.1 Definition and Scope

Digital transformation denotes the deliberate integration of digital technologies into manufacturing processes in order to improve productivity, visibility, decision-making, and operational performance. In garment manufacturing its reach is broad. It can extend to planning and control, industrial engineering, materials and inventory, production monitoring, quality management, machine maintenance, supply chain coordination, and the tracking of shipments.

The common aim is to connect these activities through integrated digital systems, so that each draws on, and contributes to, a shared body of information rather than a private set of records.

2.2 The Flow of Information

The value of integration is easiest to see by following a single order. When an order is confirmed, its details should pass without re-entry through merchandising, sourcing, material planning, scheduling, production, quality, and shipment management. At each stage the people responsible see the same order, in its current state, and add their own information to it.

The benefits are threefold. Manual transfer of data, with its attendant delay and error, is reduced. The accuracy of information improves because it is entered once and used many times. And management acquires a common picture of operations, in which departments argue less about whose figures are correct and more about what to do.

3. The Limits of Conventional Production Planning

A large number of factories continue to plan by manual methods, and five weaknesses are commonly encountered.

Dependence on spreadsheets. Schedules, capacity calculations, and material trackers are frequently held in separate spreadsheet files, each maintained by a different person. The result is a risk of out-of-date information, conflicting figures, and arithmetical or formula errors that go undetected.

Late visibility of output. Daily production reports may not be available until the working day has ended. Management then learns of a shortfall after the time in which it might have been recovered has already been spent.

Imprecise forecasting. Conventional planning often rests on historical averages and takes little account of changes in styles, skills, materials, or conditions on the

floor. An average describes the past; it says little about the order now in progress.

Divergent versions of the truth. Departments keep their own reports and may work from different versions of the same schedule, so that coordination depends on personal contact rather than on shared records.

Reactive management. Problems are dealt with after they have occurred instead of being foreseen and prevented. The cost of a problem tends to rise the longer it goes unnoticed, so late responses are also expensive ones.

Integrated, real-time information systems offer a means of overcoming each of these limitations.

4. ERP as the Information Backbone

Enterprise resource planning (ERP) systems link the functions of a business through a single, centrally maintained platform. In a garment factory such a platform can bring together order management, the procurement of fabric and trims, inventory control, production planning, costing, finance, and shipment management.

The practical effect can be seen when a customer order is entered. Every function that touches the order can then consult the same record. The production planner sees the confirmed quantity and delivery date and can check the status of materials before committing capacity. Procurement sees the requirements it must satisfy. Costing sees the quantities and prices that determine margin, and the shipment team sees the dates to which it must work. Changes made in one place, such as a revised delivery date, are visible everywhere at once.

The relevance of ERP to garment manufacturing is clearest in material planning. Each style is defined by a bill of materials (BOM), which lists every fabric, trim, and packing item together with its consumption per garment. When an order is confirmed, the system multiplies the order quantity by the consumption of each item, adds an allowance for wastage, and compares the result with stock and with purchases already placed, so that only the shortfall remains to be bought.

A simple example illustrates the logic. Take an order of 30,000 garments in which each garment consumes 1.4 metres of main fabric. The net requirement is 30,000 × 1.4 = 42,000 metres. Applying a wastage allowance of 5 per cent for cutting loss and defects, the gross requirement becomes 42,000 × 1.05 = 44,100 metres. If 6,000 metres are already in stock and 10,000 metres are on order with the supplier, the quantity still to be purchased is 44,100 − 6,000 − 10,000 = 28,100 metres. Carried out by hand for dozens of styles and hundreds of trim items, such calculations are laborious and prone to error. Within an integrated system they are produced consistently and revised automatically whenever a quantity or a consumption figure change.

Integration also allows material availability to govern the schedule. A system that holds the expected arrival date of each material can show the planner the earliest date on which cutting may begin, so that production is not released against materials that have not arrived. It can link the order to a time-and-action calendar and warn when a milestone, such as fabric approval, is overdue. And it can feed the actual cost of materials and labour into costing, so that margin is known while an order is in progress rather than after it has shipped.

An ERP system is nonetheless a foundation, not a complete solution. It records transactions reliably, but it does not by itself capture what is occurring minute by minute on the production floor, and it does not predict. Its quality also depends on that of the data entered into it. These limits explain why ERP is usually extended with floor-level data capture and analytical tools, as described in the following sections.

5. Industry 4.0 Technologies on the Factory Floor

Industry 4.0 is commonly characterised as the connection of physical production with digital information. Several technologies are of particular relevance to garment manufacturing.

Sensors and connected devices. Input terminals, scanners, counters, and sensors fitted to machines can record output, machine status, and utilisation as they happen. Such devices replace retrospective manual reporting with continuous measurement, and they supply the raw material from which every later analysis is made.

Connectivity and cloud platforms. Networks and shared platforms allow data from many sources to be brought together and accessed by planners, engineers, and managers, including those at other sites or in the offices of buyers.

Automation. Automated equipment, from programmable sewing units to automated cutting and material handling, reduces variability and dependence on manual dexterity for certain operations. It also generates data of its own.

Simulation and digital twins. A digital model of a line or factory, fed with current data, allows planners to test the consequences of a decision, such as changing a sequence or adding a line, before committing resources to it.

None of these technologies is an end in itself. Their value lies in the quality of the decisions they support.

6. Artificial Intelligence and Machine Learning in Planning

Artificial intelligence and machine learning allow patterns to be extracted from large bodies of data and applied to new situations. In garment manufacturing, several applications are of particular interest.

Forecasting. Learning from past orders, models can estimate demand and also the time that particular styles are likely to take, taking into account factors such as fabric, construction, and the line to which they are assigned. This addresses the weakness of averages noted above.

Scheduling support. Optimisation methods can search the very large set of possible schedules for combinations that meet delivery dates while balancing loads and limiting changeovers. They can re-plan when conditions change, which no manual method can do quickly.

Delay-risk detection. By comparing the progress of live orders with patterns seen in earlier ones, systems can flag orders likely to be late while there is still time to intervene.

Quality prediction. Defect and inspection data can reveal which styles, operations, or conditions tend to give rise to faults, allowing preventive action rather than inspection alone.

Predictive maintenance. Machine data can indicate when equipment is likely to fail, so that maintenance is scheduled before a breakdown stops a line.

It is important to describe the role of these tools accurately. They support, and do not replace, the judgement of planners and engineers. A model is only as sound as the data on which it learns, and it cannot appreciate commercial context, such as the strategic importance of a customer. The most effective arrangement is one in which the system proposes and the experienced professional decides.

7. From Reactive to Predictive Planning

The progression of analytical capability can be described in four steps. Descriptive analysis reports what has happened. Diagnostic analysis explains why. Predictive analysis estimates what is likely to happen next. Prescriptive analysis recommends what should be done about it. Most factories operating manually remain at the first step, and often at a late and incomplete version of it.

The value of prediction can be shown with a simple illustration. Suppose an order of 30,000 garments is planned over 40 working days, which requires 750 garments a day. After 10 days, 6,000 garments have been completed, an average of 600 a day, whereas the plan called for 7,500. If the present rate continues, the remaining 24,000 garments will take a further 40 days, so the order will finish on day 50, ten days late. To recover and finish on day 40, the line would have to produce 24,000 ÷ 30 = 800 garments a day for the remaining 30 days, which is one-third above the current rate and above the original plan.

Position at day 10	Daily output	Projected completion
Original plan	750	Day 40
Current rate continued	600	Day 50
Required to recover	800	Day 40

A planner working from a daily report compiled by hand might reach this conclusion late, if at all, and might attribute the gap to a bad day. A system that projects the position every day would raise the alert as soon as the trend became clear, while recovery remained feasible: additional operators, a rebalanced line, overtime, or an early conversation with the buyer. A predictive system adds the learned patterns of earlier orders to this arithmetic, for example by indicating that styles of this kind typically improve their efficiency over the first fortnight, and so refines the estimate. The principle, however, is that early warning widens the choice of remedies and reduces their cost.

8. Challenges and Risks

The promise of these technologies should be set against the difficulties of realising it.

Data quality. Predictions and optimisations are only as reliable as their inputs. Inaccurate standard times, inconsistent master data, and incomplete records will produce confident but wrong results.

Integration with existing systems. Factories often hold a mixture of older and newer applications that do not communicate. Connecting them can be technically demanding and costly.

Skills. Effective use requires people who understand both garment manufacturing and data. Such combinations are scarce, and existing staff will need training.

Cost and scale. Investment may be difficult for smaller manufacturers. Phased adoption, and the selection of modest tools that address real problems, are generally more prudent than ambitious programmes.

Change management. Planners and supervisors may distrust systems whose reasoning they cannot see, or fear that they will be displaced. Early involvement, training, and transparent explanation of how recommendations are produced are essential.

Security and resilience. Connected factories are exposed to cyber-security threats, and dependence on networked systems makes continuity planning for failure important.

Responsible use of data. Where systems monitor individual performance, care is needed to ensure that data are used fairly, that workers understand how they are used, and that applicable privacy and labour standards are respected.

9. A Phased Route to Adoption

Because the difficulties above are best met incrementally, manufacturers are advised to proceed in stages, each building upon the last.

At each stage, benefits should be demonstrated on a pilot area before wider rollout, and results reviewed by planners, engineers, and managers together. Moving to a later stage before an earlier one is secure usually produces disappointment, since advanced tools magnify the weaknesses of the foundations beneath them.

Table-1: Phased route to AI adoption

Stage	Focus	Intended outcome
1. Foundations	Accurate standards, clean master data, a single integrated ERP environment	A reliable common record of orders, materials, and capacity
2. Visibility	Real-time capture of output, efficiency, attendance, and work in progress	Planners see the factory as it is, not as it was
3. Prediction	Analytics and models for forecasting, delay risk, and quality	Problems are anticipated while remedies remain inexpensive
4. Optimisation	Scheduling and recommendation tools, tested through simulation	Decisions are supported by evidence and routinely improved

10. Limitations and Directions for Further Research

The argument of this article should be read with its limitations in mind. It is conceptual, and the numerical illustrations are constructed rather than observed, so they show how the reasoning works without demonstrating the size of the benefits in practice. Technologies in this field are changing quickly, and particular tools mentioned here may be superseded. Factories also differ greatly in size, product mix, customer base, and national setting, and what is feasible for a large exporter with extensive data may be unrealistic for a small subcontractor.

These limitations suggest several directions for further research:

- empirical studies measuring the effect of integrated and predictive planning on on-time delivery, efficiency, work in progress, and cost in garment factories;
- comparative research on adoption and outcomes in small and medium-sized enterprises as against large manufacturers;
- study of the human dimension, including how planners come to trust, question, or override automated recommendations, and how their skills and roles change;
- examination of the ethical and legal questions raised by data collection about workers, including transparency, fairness, and privacy;
- investigation of how factory-level data can be shared with buyers and suppliers to improve visibility across the wider supply chain; and
- analysis of costs and returns at each stage of adoption, so that investment decisions can rest on evidence rather than on enthusiasm.

11. Conclusion

The apparel industry is moving from a model that relies on manual reporting, historical assumptions, and individual experience towards one in which connected systems, real-time data, and artificial intelligence support management at every level. This is not a matter of buying technology but of changing how decisions are made: from reacting to problems after they appear to anticipating them while there is still time to act.

Integrated systems such as ERP supply the common record; floor-level technologies supply the evidence of what is happening; analytics and machine learning supply foresight; and experienced professionals supply the judgement that gives all of these their direction. The difficulties are real, and they are best met by careful, phased progress founded on good data and the confidence of the people who will use the systems. Manufacturers that proceed in this way will be better prepared for the demands of the coming decade, and the future of the industry will belong to those who combine efficient production with intelligent planning.

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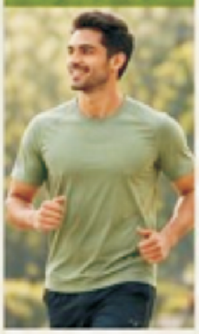

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- Moisturizing
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- Antioxidant
- Antimicrobial

GYM WEAR



- Anti-Aging
- Antioxidant
- Antimicrobial

ACTIVE WEAR



- Antioxidant
- Antimicrobial

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Textile Products: Taxonomy & Design

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Introduction

Textile is intimately associated with us since the dawn of civilization. Over centuries we have developed so many varieties of textiles. Initially the material was probably used for protecting us from rain, intense heat, cold, dust, wind and to protect one's dignity. As civilization evolved many more varieties appeared based on human need. Technical application such as straining cloth, ropes and strings of various sizes, sleeping mats appeared. Human ingenuity kept on developing textiles to satisfy various requirements. Development of textiles has gone hand in hand with the development of agriculture and shelter.

To many, textile is considered to be a humble product that we use in our daily life and its failure is not of many consequences. However, with the advent of new technology in different engineering areas, rising cost of energy necessitated a search for alternative light weight, strong, heat resistant, bio compatible material. The new age fibres fulfilled this need and a spurt of new products started appearing in the market opening new business opportunities. The increase in population, affluency, and a change of taste of the younger population also fueled demand for smart new functional clothing material with enhanced aesthetics. The world of textile product becomes enormous.

Textile product classification

1 Broad classification

There are three broad categories:

- Apparel: Trouser, shirt, and all dress material
- Home Textile: Towel, bed sheet, carpets, curtain etc. and
- Technical/ industrial/ function focused fibrous products: Industrial, medical, protective clothing, build-tech, agro-tech & geotextile, smart textile etc.

These three types have distinguishing feature in terms of volume, value / unit, and design complexity. The level of these factors varies depending upon the extent of specialty which is a direct function of the level of design performance.

Table-1: Products and their distinguishing features

Product	Volume	Value	Design complexity
Apparel	High	Low	Low, dependent on experience, and intuition or duplication. However, functionalities are being added to these products now. Ex: Anti-bacterial clothing, flame retardant clothing, functional athletic socks

Home textile	Medium	Low	Low, dependent on experience, and intuition or duplication. However, functionalities are being added to these products now. Ex: antistatic, stain resistance carpet, fire retardant upholstery.
Technical	Low	High	High, duplication is difficult, needs application of scientific and engineering principles

2 Different variants of textile products

The products can have following seven variants.

Market pull products:

These products are developed when market opportunity comes. The examples are: when there is any big event such as Olympic game, world championship, change of uniform of police, paramilitary or military. The generic development process is followed. Market pull products are associated with low risk and mostly imitation of existing ones with minor modification.

Technology push product:

With the advent of new technology opportunity comes that can be exploited to make significant improvement in performance. These are innovation driven due to scientific breakthrough or advancement in technology. They do not originate from consumer request. Gore-tex membrane is an example. Many products can be made out of it. Technology push products evolve from the development in basic material or technology. The generic product development process can be used with minor modification. Technology push is opposite of market pull.

Process intensive products:

Such products are process intensive in nature. The production process places constraints on the properties of the product and product design cannot be separated from process design. Capability of the process places constraints on the product design. The examples of such products are, high-performance stretch denim, multifunctional active wear, surgical gowns, fire retardant uniform etc. These product lines present unique operational challenges.

Table-1: Technology push vs Market pull products

	Technology Push Product	Market Pull Product
Risk	High	Low
Cost	High	Low
Return	High	Low
Time	High	Low
Effect on company	High	Low

Customized products:

High risk products are those where uncertainties with respect to technology or market could exists. These are developed when asked by some customer. Customer usually specifies, material, physical dimension, colour, stitching details etc. Request for new products may come from big organization such as, defence, railways, airlines, hospital chain, buying house (Marks and Spencer, Ford GAP, NIKE etc.).

High risk products:

The risk associated with these products are performance risk, market risk, budget and schedule. For mitigating technical risk

related to performance, working models are build and tested. Design reviews are done at each stage. For consumer acceptance risk of a new product, sample production is done and tested by taking customer feedback.

Quick build products:

Due to rapid prototyping possibility today, design-build – test cycles have shortened. It is achieved by three methods

- late-stage customization (garment dyeing and printing),
- Low complexity high velocity garment design (oversized tees, lounge wear, leggings, sport bras, underwear)
- Agile localized micro supply chains by locating cutting sewing facilities right next to primary consumer markets.

Sweater, socks, shirts, are completely sewn together using undyed cotton yarn and kept in storage. As soon as retail sales data shows demand for specific shade of any particular colour or print, design, the factory dye or print the design in these pre-sewn garments and as a result cuts down 6 moth fabric to retail cycle. Manufacturer intentionally defer customization to the absolute last possible moment of supply chain.

Complex textile products:

These are highly engineered products that integrate multiple disciplines such as, electronics, biochemistry, mechanical engineering, aero-space engineering, geotechnical engineering depending upon the nature of product. The product may have multilayered structure, smart materials, embedded electronic components.

Some examples are:

- **Smart textiles:** incorporate embedded microelectronics, biosensors, conductive graphene fibers, and posture-monitoring systems.
- **Functional performance** fabrics that utilize far-infrared yarns, nano-coatings, self-cleaning photocatalytic fiber treatments, and flame-retardant or antimicrobial barriers
- **Medical textiles:** artificial ligaments, vascular grafts, and specialized protective gear
- **Geotextiles & geo membrane** etc.

The different variants and distinct features with examples are summarized in Table 2.

Table 2: Variants of Textile Product

Product type	Description	Distinct features	Examples
Market pull product	The team begins with a market opportunity and selects appropriate technologies to meet customer needs	Planning, concept development, system level and detail design, testing and refinement and production ramp –up phases	Sports goods, furniture,
Technology push products	The team begins with new technology (e.g. Basic material or basic process technologies) then	Planning phase involves matching new technology and its characteristics with application and market opportunity.	Gore tex rain wear, Chromic fabric, fitness garment for biometric data, nano technology enabled fabrics,

	finds an appropriate market	The technology should give clear advantages in meeting customer need.	
Platform product	The new product is built around a pre-existing technology platform. Attempt is made to incorporate them into several products	Concept development assumes a proven existing technology platform such nonwoven line, leather processing facility, garment manufacturing facility	Mountaineering jackets for different temperatures and environmental condition, shoes for different terrain, and industry, military textiles consisting of Gore-Tex membrane
Process intensive products	Characteristics of the product are highly constrained by the production process.	Either the existing production process must be specified from the start, or both product and process are to be developed together from the start	High-performance stretch denim, Muti-functional outdoor active wear, Surgical gowns
Customized product	New products are slight variation of existing products. Developed in response to specific order by a customer.	Similarity of projects allows for a streamlined and highly structured development process.	Garments ordered by buying house, Govt department,
High risk products	Technical performance or market uncertainties creates high risk	Risks are identified early. Concept testing using renderings or user interface prototypes is done early in the process. and tracked throughout the process.	New finishing treatment, new blend, Life threating technical products
Complex design system	System must be decomposed into several subsystems and many components	Subsystems and components are developed by many teams working in parallel followed by system integration and validation	Active thermoregulation apparel, 3D woven composites for aerospace and automobiles, ballistic body technical textile,

Challenges in the development of fashion apparel

The challenges are listed below.

- For the fashion apparel product development, the timeframe is relatively short as compared to the development time frame for other products. Normally, 3 to 9 months is available to develop one fashion apparel product line.
- Fashion changes quickly and the development process must respond quickly to the changes of fashion seasons. It requires coordination with fashion trends, (colours, silhouettes, and yarns) otherwise the product will be out-off date by the time it appears in the market. Late entry to the market, may require cutting down on prices

which will cause the company's financial loss.

- The value of some fashion apparel products rapidly decreases over time. The price has to be drastically reduced as the product is off the season. The leftover fashion apparels, for not being delivered to the market on time, or were not purchased, cannot be sold during the next season at full price.
- It is more common for apparel manufacturing companies to be threatened by cheaper imported products. Domestic manufacturers must have a plan to survive and compete with low-cost imported goods.

These challenges can be met only when marketing, design, and production teams work in coordination throughout the product development process

Challenges in the development of technical textile products

- **High Research and Investment Costs:** Creating high-performance tensile structures, or functional surfaces requires extensive, long-term laboratory testing, prototype iterations, and capital.
- **Specialized Raw Material Requirements:** Technical textiles demand high-grade synthetic and specialty fibres (such as aramids like Nomex, carbon fibres, glass fibres, or specialized polyester yarns) that must meet strict parameters for stretchability, thermal stability, and shrinkage.
- **Machinery and Infrastructure Deficits:** Most advanced manufacturing and processing machinery for technical textiles is not locally produced in many developing markets, leading to heavy import dependence.
- **Standardization and Quality Gaps:** A shortage of universal standard benchmarks leads to inconsistent product quality making institutional and defence buyers hesitant to rely on local procurement.
- **Smart and Nanotech Integration Hurdles:** Integrating IoT sensors, conductive materials, 3D/4D printing, and energy-harvesting components introduces severe scaling, power-durability, and washing-resistance challenges.
- **End-User Awareness and Skill Gaps:** A shortage of specialized engineers and skilled technicians hampers production scaling.
- **Sustainability and End-of-Life Compliance:** Balancing high durability with circularity is difficult, especially given the strict environmental norms governing chemical waste, microplastics, and the recycling of multi-material technical composites.

Conclusion

Textile products are evolving over the centuries. From a humble beginning of use as apparel and household use, it has now reached a stage where tailor made products are developed for use in technically demanding areas. The consumption of textile for traditional use is huge and growing as the population and economy too are growing. Most of the trade in textile is happening in apparel and home textile sectors. Technical products made from high-performance fibres are finding applications in many fields. Advance countries are focussing more on the

development of technical products as profit margins are high. There is a need for us to focus on the design and manufacturing and evaluation of technical textile products.

About the author:



Dr. R. Chattopadhyay, a graduate of Calcutta University did his M. Tech and Ph. D. from IIT Delhi. His academic journey started from IIT Delhi in 1984 and continued till 2025 when he retired as Emeritus Professor from the Department of Textile and Fibre Engineering. He had been the Head of the department and also held many administrative positions in IIT Delhi. Presently he is Adjunct Professor in NIT Jalandhar, Punjab and attached to many research and government organizations and academic institutes of the country. He is a fellow of Intuition of Engineers India and regular reviewer of research papers published in national and international journals. His video courses on yarn manufacture and product design run by NPTEL Govt. of India, are well received by the student community of the country. His latest edited book “Textile Calculation” is a part of The Textile institute Book series UK. He may be contacted:

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Indian Textile and Apparel Industry under the Present Geopolitical Condition

By Rajarshi Sinha | Global Sourcing Manager at Target

Abstract:

India's textile and apparel (T&A) sector is a roughly US$194 billion industry that directly employs about 45 million people. Between August 2025 and July 2026, the additional US duty on Indian goods fell from 50% to 18% and then to 10%; the West Asia conflict disrupted shipping through the Strait of Hormuz and the Red Sea; and India secured preferential UK market access and concluded a landmark agreement with the EU.

Evaluating the sector across 14 parameters, from tariffs and sourcing realignment to raw-material security, sustainability and MSME resilience, this note argues that India's opportunity lies less in replacing China as the low-cost supplier than in becoming a trusted, multi-fiber, compliance-ready sourcing platform.

1. Introduction

Textiles is India's one of the oldest traded goods and most politically sensitive industries. Textile and apparel sector contributes roughly 2% of GDP, about 8.6% of merchandise exports in 2024-25 and around 4.1% of global T&A trade, making India the world's sixth-largest exporter. Textile and apparel (T&A) sector are governed by rural workers, predominantly women. T&A, which supports 45 million direct jobs and over 100 million indirect livelihoods, transmits geopolitical shocks into employment faster than almost any other manufacturing activity because its apparel segment is labor-intensive, price-sensitive and concentrated in a few destination markets.



Fig.1: India's Textile and Apparel Exports Assessment (Source: Author's qualitative assessment synthesizing Sections 2–15 of this note)

Nowadays, trade policy is being weaponized for non-trade objectives, from energy sanctions to forced-labor enforcement; maritime chokepoints have become theatres of conflict; and US and European buyers are shifting sourcing away from China. This note examines how these forces are reshaping the Indian industry and the strategic responses they require.

2. Geopolitical Headwinds and Trade Barriers

US tariffs, which peaked at an additional 50% in 2025, cut US apparel imports from India by 26% in early 2026; US–China rivalry is redirecting buyers, though India has captured little of the shift while rivals such as Vietnam gained ground. Further the West Asia conflict has disrupted the Strait of Hormuz and the Bab-el-Mandeb, roughly doubling Asia–US freight rates and squeezing exporters' margins; and lastly Europe's sustainability rules act as a non-tariff barrier for producers unable to document compliance. All these cumulatively have stalled export growth to just 1.8% in FY'26.

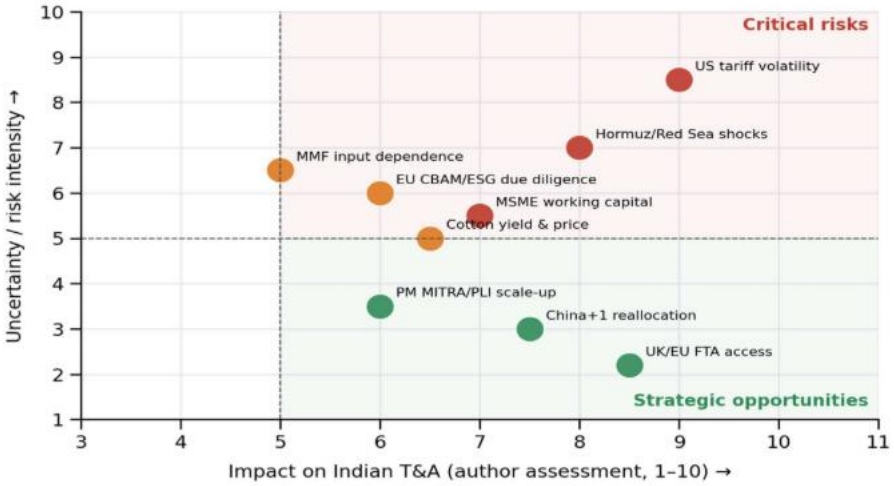

Fig.2: India's Geopolitical Risk Opportunity Matrix (Source: Author's assessment based on developments cited in this note. Bubble position is qualitative)

3. India's Export Performance

Indian T&A exports, including handicrafts, reached US$36.7 billion in FY'26, having grown at a CAGR of about 4.5% since FY'20. Of this, the US and the EU together account for nearly 49%, while the remaining 51% is spread across the rest of the world. India is competing on fiber-to-fashion depth, it is the largest cotton grower by area, the second-largest producer of cotton and silk and the largest jute producer. Bangladesh competes on scale in basics and denims, Vietnam is on MMF, speed and FTA coverage, and China on complete ecosystems.

To close the gap, India must address fragmented garmenting and intend ways to improve apparel productivity by investing in 3D sampling and CAD, automated cutting, digital printing, recycled polyester and shop-floor analytics, which is even lower than Sri Lanka, and also, it must be less dependent on cotton-heavy mixes at a time when MMF made up about 57% of US apparel imports in 2025.

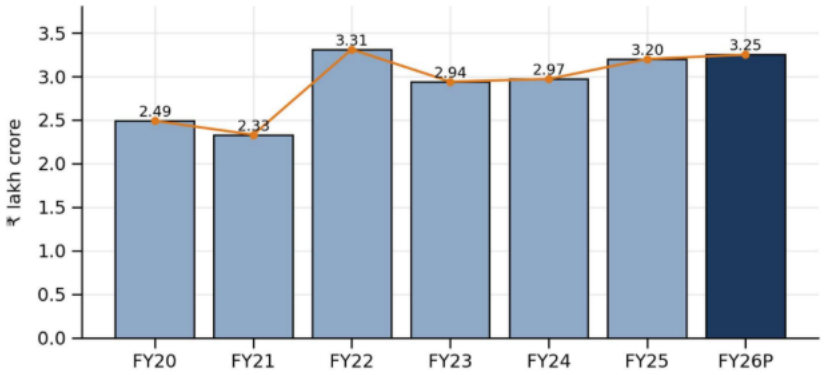

Fig.3: India's T&A exports CAGR (Source: Ministry of Textiles, Lok Sabha reply, Aug'26)

4. Global Sourcing Realignment

The shift away from China is real but uneven. China's share of US apparel imports fell from 21% to 14% between January and October 2025, and Vietnam emerged as the largest supplier to the US, while India held its share without capturing much of the shift. In early 2026, US apparel imports from China fell 43% and from India 26%, while Cambodia and Indonesia grew. Retailers such as Walmart, Gap, H&M, Inditex, Primark, TJX and Uniqlo are nonetheless deepening their India exposure, tariff advantage single-handedly cannot automatically translate into orders; buyers reward reliability, speed, product breadth and compliance, not just the duty differential.



Fig. 4 US Apparel Imports by Origin (Jan'26 to May'26) (Source: Dhaka Tribune)

5. Raw-Material and Input Security

Raw-material constraints weigh directly on India's export competitiveness: cotton is its strategic asset and its weak point, and input security extends well beyond it:

- Yield gap: India holds about 36% of world cotton area but yields only around 448 kg/ha in 2025-26, well below world averages, and roughly 62% of the crop is rain-fed, which leaves exporters' input supply and costs exposed to weather.
- Shifting fiber mix: Natural-fiber output declined to about 3% CAGR from 2019-20 to 2024-25, while filament yarn output grew at about 23% CAGR. With MMF at about 57% of US apparel imports in 2025, a cotton-heavy base limits India's share of the fastest-growing demand.

- Policy response: The government suspended cotton import duty from 1 June to 31 October 2026 and approved a cotton productivity programme for 2026-27 to 2030-31 to ease input costs for exporters.
- Upstream dependence on China: Petrochemical feedstocks for polyester and nylon, specialty fibers, dyes, trims and machinery are largely sourced from China. Additionally, rules-of-origin compliance under new FTAs now depends on input localization, which determines how fully exporters can use UK and EU preferences.

6. Logistics and Energy Security

West Asia conflict has turned logistics into a geopolitical variable, raising the cost and time of moving Indian goods to market for exporters that compete on lead time and thin margins:

- Energy exposure: About 40% of India's crude imports and a large share of its LNG and LPG pass through the Strait of Hormuz. Brent peaked near US$115 per barrel in May 2026, and CareEdge Ratings warns a dual Hormuz–Red Sea closure could push it to US$130–135, raising energy and input costs for producers.
- Freight and transit costs: Diversion around the Cape of Good Hope adds two to three weeks to Europe-bound transits, Asia–US spot freight has roughly doubled, and carriers have introduced emergency and war-risk surcharges on Gulf cargo, squeezing exporters' margins. Port congestion: Congestion at JNPA and Mundra pushed dwell times to about seven days at peak, further stretching delivery lead times.
- Export impact: Port throughput growth dedicated freight corridors, PM Gati Shakti and the new Vizhinjam transshipment hub improve resilience but cannot remove chokepoint exposure.

7. Sustainability and Compliance

Sustainability compliance has become a condition of market access, so exporters who fail to document traceability from fiber to finished garment can face a non-tariff barrier in EU and US markets:

- Regulatory pressure: EU rules on due diligence, eco-design, extended producer responsibility and carbon border adjustment, together with US forced-labor enforcement, set the compliance bar for exports into both markets.
- India's strengths: Clusters such as Tirupur have zero-liquid-discharge processing and renewable energy, India leads in organic cotton, and the Tex-Eco initiative promotes circularity, giving compliant exporters a credible edge with these buyers.
- Gaps: MSMEs lack certifications such as GOTS, OEKO-TEX and Higg modules, and water stress in processing hubs is a material risk, limiting these units' access to compliance sensitive buyers.
- Export impact: Digital product passport (DPPs) and verified traceability are likely to become baseline buyer requirements within this decade, so exporters without them may risk losing orders.

8. Supply-Chain Resilience

Resilience means building optionality, which is increasingly decisive for winning and holding export orders in a disrupted environment:

- Logistics optionality: multi-port routing through JNPA, Mundra, Chennai, Tuticorin and the new Vizhinjam hub reduces exposure to single-gateway disruption.
- Input security: Dual sourcing of critical inputs and buffer stocks of cotton and MMF protect production continuity.
- Buyer partnerships: Capacity reservation and co-investment bind exporters more closely to their buyers.
- Regional footprint: Leading Indian groups operate in Bangladesh, Sri Lanka, Vietnam and Egypt to diversify tariff and origin risk.
- Export impact: Buyers are increasingly reserving capacity 12 months ahead, so suppliers with verified compliance and digital visibility will capture the strongest demand.

9. Conclusion

Geopolitics has become a core competitive factor for Indian textiles and apparel. US tariffs, West Asia shipping disruption and tighter EU and US compliance rules have held export growth to just 1.8% in FY'26, yet the same forces open a path to faster growth. Drawing on Sections 1 to 8, India can strengthen its exports through six priorities:

- Convert market access into orders: With the US and EU taking nearly 49% of exports, India should use its UK and EU trade agreements to diversify markets, recognizing that a tariff advantage alone does not win orders, since buyers reward reliability, speed, product breadth and compliance.
- Close the competitiveness gap: Address fragmented garmenting, lift apparel productivity through 3D sampling and CAD, automated cutting, digital printing and shop-floor analytics, and shift toward MMF, which made up about 57% of US apparel imports in 2025.
- Secure raw materials and inputs: Raise cotton yields, currently around 448 kg/ha, through the cotton productivity programme, and localize inputs now sourced from China so exporters can meet rules-of-origin requirements under new FTAs.
- Reduce logistics and energy risk: Use multi-port routing, shorten port dwell times and strengthen freight corridors to limit exposure to chokepoint disruption, freight surcharges and longer transit times.
- Make compliance a competitive advantage: Extend traceability and certifications such as GOTS, OEKO-TEX and Higg modules to MSMEs and prepare for digital product passports, turning a non-tariff barrier into a buyer-facing strength.
- Build resilience and buyer partnerships: Combine dual sourcing, buffer stocks and a regional manufacturing footprint with capacity reservation and co-investment, so that suppliers with verified compliance and digital visibility capture the strongest demand.

India has the raw-material base, scale, democratic credentials and policy framework to become a leading trusted sourcing platform for the world. Its success

will depend on delivering these measures for its MSMEs as quickly as the geopolitical opportunity is changing.

About the Author:



Rajarshi Sinha, is a results-driven Textile and Apparel professional currently serving as Sourcing Manager, Global Sourcing at Target, bringing a multidisciplinary perspective across textile engineering, fashion technology, global sourcing, merchandising, and strategic consulting.

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Professional experience across Target, PwC, Laguna Clothing, and ABFRL encompasses global sourcing, luxury fashion merchandising, supply chain strategy, product lifecycle management, and industry transformation. Strongly focused on advancing strategic sourcing, supply chain resilience, responsible business practices, sustainability, and innovation across the global fashion and textile value chain.



Introspection the MSME Capability Gap: A Data-Driven Analysis of On-Time Delivery and Quality Compliance in Tier 2-4 Indian Retail

By Sanjib Kumar Sinha | Head - Quality Assurance, Technical, Sustainability and Audits, V-Mart Retail Ltd.

Introduction

A comprehensive data driven approach is illustrated, how OTIF mandates and QA 2.0 are Reshaping India's Organized Value Retail Supply Chain. India's organized value and lifestyle retail sector, spearheaded by retail giants such as Vishal Mega Mart (717+ stores), V-Mart Retail (500–600+ stores), V2 Retail (245–415+ stores), Shoppers Stop & INTUNE (294+ stores), Style Baazar (232+ stores), and Baazar Kolkata (120–190+ stores)—is expanding rapidly across Tier 2, Tier 3, and Tier 4 cities.

However, an empirical analysis of the 4,500 to 6,000+ MSME manufacturing vendors and suppliers powering this ecosystem reveals a critical vulnerability: chronic delivery failures and upstream quality rejections are directly throttling targeted **Same-Store Sales Growth (SSSG)**. This study examines the data-driven causes of late deliveries, the escalating quality benchmarks mandated by organized retailers, and the binary strategic reality facing domestic suppliers today, modernize into "Green Channel/self QA mode" partners or be systematically consolidated out of the market.

Note:

OTIF (On-Time, In-Full): It is one of the most critical Key Performance Indicators (KPIs) in logistics, supply chain management, and retail. It measures a supplier's or logistics provider's ability to deliver shipments exactly when promised (On-Time) and exactly in the quantity ordered (In-Full))

QA 2.0: Enhance quality standard aligned with AQL mid-level and activities are digitized to review the product, vendor and supply-chain performance

The Empirical Reality of Late Deliveries:

In organized domestic retail, where 70% to 80%+ of revenue is generated in price-sensitive Tier 2–4 markets during compressed festive windows (Durga Puja, Diwali, Eid, Chhath, regional wedding seasons and other local festivals), a delayed shipment of 10 to 30 days translates directly into lost full-price sales and forced end-of-season markdowns or return to warehouse for next season.

Data across the pan-India vendor network highlights **four structural drivers** of late delivery:

1. High Shared-Vendor Overlap Without Capacity Locking:

Between Vishal Mega Mart (~781 own-brand vendors), V-Mart Retail (1,000+ active vendors), Style Baazar (1,226 vendors / 641 merchandise suppliers), V2 Retail (500–600 vendors), and Shoppers Stop (800+ brand partners & 200+ private-label vendors), nearly 70% to 100% of value apparel production is outsourced to overlapping MSME clusters in Delhi NCR, Tirupur, Surat, Ludhiana, Kolkata and

Bengaluru. In the absence of long-term fixed capacity contracts, vendors over-commit during peak seasons, resulting in 20%–35% slippage on Must-Arrive-By-Dates (MABD).

2. The "Quality-Delay Loop" at Pre-Dispatch:

Late deliveries are frequently triggered by failed inspections rather than transit slowdowns. Empirical QA data reveals that during peak seasonal build-ups, first-time Final Random Inspection (FRI) failure rates spike to 21%–30%. Every failed inspection adds 5 to 12 days of rework, re-offer, and re-inspection delay before an Advanced Ship Notice (ASN) can be generated.

3. Upstream Fabric & Garment Testing Bottlenecks:

Historical testing benchmarks show Fabric Performance Testing (FPT) pass rates hovering at ~65% and Garment Performance Testing (GPT) pass rates at ~60%. With 35%–40% of lots requiring corrective processing for shrinkage, colorfastness (wet/dry rubbing), or GSM deviations, Time and Action (TNA) calendars derail before cutting and sewing even begin. Most of the cases vendor wait for the commercial approval taking advantages of peak season reason, risking the merchandises.

4. Logistics & DC Gate Rejections:

Moving inventory across 15,000+ annual truck trips and 96+ routes (with an average target lead time of 7 days from DC allocation to store floor) leaves zero margin for error. Yet 29% of upstream rejections stem from technical non-compliance—specifically barcode/Legal Metrology errors (14%), conformity mismatches (8%), and non-standard carton specifications (7%).

The New Quality Expectation Matrix: From Reactive DCQC to Upstream "QA 2.0"

Historically, domestic vendors relied/pressurized on the retailer's Distribution Center Quality Control (DCQC) to filter defects. The limited capacity and slow platform quality checking are the big bottle necks at DC level QA Today.

Table 1: Comparative Analysis

Quality & Compliance Dimension	Legacy MSME Vendor Practice	New Organized Retail Mandate (QA 2.0 Standard)	Empirical Gap in Current Vendor Base
Factory Infrastructure & Machinery	Manual thread trimming, open floor stacking, un-calibrated sewing lines	Mandatory auto thread suckers, thread cutters, material floor bins, and stamped master patterns	91% lack auto thread suckers; 76% lack thread cutters; 51% lack floor bins
In-House Quality Governance	Ad-hoc owner/supervisor checks; heavy reliance on retailer's inspector	Dedicated, OJT-certified internal QA team executing inline & pre-final checks	30% of audited domestic factories lack a dedicated internal QA team
Workmanship & AQL Standards	High defect tolerance; dispatching	Strict AQL 1.5 / 2.5 (Major) and 4.0 (Minor); 100%	58% of all failures stem from workmanship (42%

	unscreened bulk lots under time pressure	goods packed (or min. 80% boxed) prior to FRI	finishing, 16% stitching)
Lab Testing & Chemical Safety	Unverified local dyeing and fabric sourcing	Mandatory NABL-accredited 3rd-party lab pass	35%–40% initial failure rate on FPT/GPT parameters (shrinkage, GSM, pilling, colorfastness)
Packaging & Digital Integration	Variable carton ply/sizes; manual paper invoices	Strict 5/7-ply cartons (+/- 5% weight tolerance), RFD tracking, and portal-locked ASN	Return-to-Vendor (RTV) or financial penalty for non-compliant dispatches

Vendor's strategic view- Upgrade or Face Market Exit

As organized retailers digitize their supply chains and tighten Open-to-Buy (OTB) windows—such as dynamic OTB adjustments that automatically cancel or reallocate delayed POs—suppliers face a stark bifurcation. Vendors can no longer survive on low cost alone; they will either ascend into consolidated strategic partnerships or be systematically phased out.

1. Path A: How Suppliers "Move Up" (The Consolidated Growth Flywheel)

Vendors that invest in machinery, QMS, and digital compliance are capturing disproportionate market share as retailers consolidate their supplier bases:

1. **Green Channel & Grade-A Accreditation:** Under structured Factory Evaluation frameworks (RAG rating), vendors achieving >80% audit scores (Grade A / Green) earn 1-year audit exemptions, self-certified dispatch privileges, and priority order allocation.
2. **Scale Concentration:** Retailers like Vishal Mega Mart generate over ₹8,900+ Cr in revenue through just ~781 own-brand vendors (~400 in apparel). Compliant vendors who meet OTIF and quality gates are rewarded with massive, predictable multi-season volume that lowers factory overhead per piece.
3. **Preferential Financial Liquidity:** To lock in reliable capacity, retailers like V2 Retail actively deploy working capital (₹165 Cr+ QIP allocation) for early-payment and vendor bill-discounting programs. Grade-A suppliers delivering on time receive immediate liquidity, lowering their borrowing costs by 3%–5% annually and enabling rapid capacity expansion.

2. Path B: How Non-Compliant Suppliers Are "Driven Away" (The Attrition Risks)

Conversely, vendors operating with legacy mindset, poor infrastructure, or ad-hoc trading models face four compounding risks that will force them out of organized retail within the next 24–36 months:

1. **Algorithmic Portal Blocking (The "3-Strike" Rule):** Modern vendor portals enforce automated lockouts. A first re-inspection failure triggers financial recovery; a second consecutive failure (or failed 3rd-party re-inspection, paid entirely by the vendor) results in automatic portal blocking and PO termination.

2. **Margin Erosion via Debit Protocols & RTVs:** When a vendor's shipment fails at the DC gate or triggers high store customer returns, cascading penalties—ranging from 100% 3rd-party re-inspection fees and penalty for carton repacking debits to Return-to-Vendor (RTV) freight write-offs—wipe out the thin 6%–10% net margins typical of value apparel manufacturing.
3. **Displacement by Captive Manufacturing & Direct Mill Tie-Ups:** To insulate themselves from chronic vendor delays, retailers are vertically integrating. V2 Retail now produces 10%–30% of its volume in-house via V2 Smart Manufacturing, while across the industry, retailers are eliminating middlemen ("umbrella traders") in favor of direct-to-factory and fabric-mill consolidation.
4. **The Looming ESG & Compliance Cliff:** As publicly listed retailers (V-Mart, Vishal Mega Mart, V2 Retail, Style Baazar, Shoppers Stop) face mandatory BRSR (Business Responsibility and Sustainability Reporting) disclosures, suppliers lacking Occupational Health & Safety (OHS), Zero Liquid Discharge (ZLD) dyeing compliance, and social audit clearances are being permanently delisted from approved vendor matrices.
5. **Quality failure:** Debiting for quality failure, frequent failure of the production leads to bar reputation and enhance the quality cost. The manufacturer having old mindsets not to keep any quality and experts are eroding the level of trust for the organized retail

Conclusion: The 2026–2030 Mandate for Indian Retail Supply Chains

The era of forgiving, relationship-driven procurement in Indian domestic retail is over. As organized value retailers push past 2,500+ combined stores in Tier 2, 3, and 4 India, supply chain competition has shifted from who can source the cheapest garment to who can guarantee 98%+ OTIF availability of defect-free merchandise on the store shelf in under 7 days.

For India's 5,000+ domestic retail suppliers, the data presents an unambiguous conclusion: investing in basic automation (thread suckers, cutters, CAD/pattern stamping), dedicated in-house QA, and digital TNA/ASN discipline is no longer an optional operational expense—it is the price of admission to stay in the game.

About the Author:



Dr. Sanjib Kumar Sinha, having experiences of 31 years in manufacturing and service industries in several international and domestic clients and retailers. His main working area are on strategic planning (Quality Assurance), risk assessment & analysis, supplier management, continuous process improvements, displayed excellence in managing social compliance, product safety, integrity audit and technical audits for key US, EU and domestic retailers and standard like ETI, Sedex, SA 8000.

The Future of Apparel Quality Assurance: Can AI Replace Human Expertise?

By Sushil Bala | Assistant Quality Manager at Vishal Mega Mart

The apparel industry is a dynamic and highly competitive sector where product quality plays a crucial role in customer satisfaction, brand reputation, and business success. Quality Assurance (QA) is an essential part of the apparel manufacturing process, ensuring that garments meet established standards, buyer requirements, and regulatory guidelines. From raw material inspection and fabric testing to stitching quality, measurement verification, colour consistency, and final garment inspection, every stage requires careful monitoring and evaluation. With the rapid advancement of technology, Artificial Intelligence (AI) is increasingly being adopted to improve the efficiency, accuracy, and consistency of quality-related activities.

AI-powered technologies, such as automated fabric inspection systems, computer vision, predictive analytics, and machine learning, can identify defects, detect inconsistencies, analyse quality data, and reduce human errors. These technologies help manufacturers improve productivity, minimise material wastage, reduce inspection time, and maintain consistent product quality. AI can also support early defect detection, enabling manufacturers to take corrective action before quality issues affect bulk production or reach the customer.

The biggest question now is, can AI replace the entire Quality Assurance process in the apparel sector? Let us discuss how this scenario can be in practice.

1. Which QA activities can AI replace or automate?

- **Fabric inspection and defect detection: High automation potential-**
  AI-powered cameras can identify holes, stains, weaving defects, shade variations, slubs, and other visible fabric irregularities at production speed. They can improve consistency compared with manual inspection.
  - Subtle or unfamiliar defects still require human verification.
- **Garment workmanship and visual inspection: High potential for defined defects-**
  Computer vision can detect open seams, skipped stitches, misplaced labels, incorrect buttons, stitching irregularities, and certain measurement or assembly issues. Complex construction defects, subjective workmanship judgments, and defects hidden inside a garment may still require physical inspection.
- **Laboratory testing and test-report review: Partial automation-**
  AI can review test reports, compare results against approved standards, flag missing comments, identify inconsistent fibre-content declarations, check recovery requirements, and highlight failures in colour fastness, seam strength, or other properties.
  However, physical tests still need suitable equipment, controlled

procedures, calibrated instruments, and competent personnel. AI cannot independently prove an unmeasured fabric property simply by reviewing a report.

- **Documentation, specifications, and compliance checks: High automation potential-**
  AI can compare purchase orders, garment specifications, approved samples, test reports, and product declarations. It can flag discrepancies in article numbers, colour names, composition, metallic yarn disclosure, and required test-report details.
- **Supplier audits, corrective actions, and final approvals: Human oversight essential-** AI can identify recurring defects, analyse root-cause evidence, draft corrective-action requests, monitor supplier performance, and recommend corrective measures.
  -Physical audits, verification of corrective actions, and consequential quality-acceptance decisions still need accountable human oversight.

What AI cannot fully replace in apparel QA?

The biggest limitation is that quality acceptance depends on more than defect detection. It requires technical interpretation, knowledge of product requirements, physical verification, and an understanding of commercial risk.

Explanation with practical examples:

(i) Technical judgment and quality acceptance: AI can identify that fabric GSM is higher than the approved specification. However, deciding whether the deviation is acceptable depends on buyer requirements, product characteristics, and commercial considerations.

(ii) Physical verification: AI can review laboratory test reports, but it cannot independently verify the actual fabric properties without physical testing.

For example, fibre composition, seam strength, and colour fastness require appropriate testing methods and equipment.

(iii) Root cause analysis: AI can identify possible causes of defects, but a QA professional must investigate and confirm the actual root cause.

For example, visible staining may be caused by dyeing, finishing, handling, or contamination during production.

(iv) Corrective action validation: AI can recommend corrective actions, but human expertise is required to determine whether the proposed action is technically sufficient and whether it has been implemented effectively.

(v) Supplier accountability: AI can monitor supplier performance and identify recurring quality issues. However, supplier discussions, escalation, and accountability require human involvement.

(vi) Final approval and rejection decisions: AI can provide recommendations based on test results and specifications, but final quality acceptance or rejection should remain with an authorised QA professional.

Table 1: Comparison between AI's Role and Human QA's role in QA activities

QA activity	AI's role	Human QA's role
Fabric inspection	Detect visible defects	Assess defect acceptability
Garment inspection	Identify workmanship defects	Evaluate overall garment quality
Laboratory reports	Extract and compare results	Verify technical reliability
Sample approval	Compare specifications	Make final approval decisions
Supplier monitoring	Analyse performance	Manage supplier accountability
Root cause analysis	Identify possible causes	Confirm actual root causes
Corrective actions	Recommend solutions	Validate implementation
Compliance	Flag missing documents	Interpret requirements and ensure compliance
Quality deviations	Identify discrepancies	Decide acceptance or rejection
Final approval	Provide recommendations	Take responsibility for approval

Consider these situations:

- A fabric has higher GSM than the approved specification. Is it acceptable?
- Seam strength is below the required limit. Should the material be rejected?
- Viscose content is present but not disclosed on the taffeta. Can the report be accepted?
- Staining is visible. Is the defect acceptable for the intended product?
- A supplier proposes a corrective action. Is it technically sufficient?

Research supports the potential of AI for textile defect detection, but also identifies challenges involving fabric variation, training data, and performance on defects not adequately represented in the model.

What level of automation is realistic?

These are practical planning estimates, not measured industry-wide adoption rates.

Potential AI automation by activity:

Illustrative estimates of potential task automation not validated forecasts or a guarantee of accuracy. Actual performance depends on the product, standards, data quality, equipment, and workflow.

How AI Could Transform the Current Apparel QA Process?

The implementation of AI automation may differ between an apparel brand/buying-house QA department and a garment manufacturing factory. They may use many of the same technologies, but the implementation differs significantly because their responsibilities, data, workflows, and business objectives are different.



1. Garment Factory QA:

Artificial Intelligence (AI) has the potential to transform garment factory Quality Assurance (QA) by shifting the focus from traditional defect detection to real-time quality monitoring, early defect prevention and continuous production improvement, thereby reducing rework and rejection costs.

A. Fabric Inspection:

AI-powered cameras and computer vision systems inspect fabric during the fabric inspection process. The expected benefit is to prevent defective fabric from entering production.

B. Cutting Section:

AI monitors fabric spreading, marker placement and cutting accuracy. The expected benefit is to reduce cutting defects, fabric wastage and garment measurement problems.

C. Stitching and Sewing Section:

This is one of the most important areas where AI can improve garment quality. The expected benefit is to identify sewing problems immediately and prevent defective garments from moving to the next operation.

D. Finishing Section:

AI-based visual inspection can help identify garment appearance and finishing defects. The expected benefit is to improve garment appearance and reduce finishing-stage rejections.

E. Final Inspection and Packing:

AI can assist with final garment verification before dispatch. The expected benefit is to minimise customer complaints, shipment rejections and packing errors.

Brand/Buying-House QA:

Unlike factory QA, which primarily focuses on controlling manufacturing processes, brand/buying-house QA focuses on supplier accountability, product conformity, technical approvals and protecting the brand's quality standards

A. Fabric, Garment and Laboratory Test Report Verification:

AI can automatically review test reports and compare the results with the brand's testing standards and technical requirements. The expected benefit is to reduce manual report verification and prevent incorrect laboratory reports from receiving approval.

B. Sample Verification Against Approved Specifications:

AI can compare submitted samples with approved technical specifications, measurement charts, construction details and reference samples. The expected benefit is to ensure submitted samples meet approved specifications before bulk production approval.

C. Supplier Quality Performance Monitoring:

AI can consolidate supplier quality data and generate performance reports for different factories, fabric mills and vendors. The expected benefit is to improve supplier accountability and support data-driven supplier selection and development.

D. Approval and Deviation Management:

AI can help manage the approval process from initial sample submission through bulk production and final product acceptance. The expected benefit is to prevent unauthorised changes and ensure proper approval control throughout the product lifecycle.

E. Product Compliance and Quality Risk Monitoring:

AI can help verify whether products comply with the brand's applicable technical, safety and regulatory requirements. The expected benefit is to reduce the risk of non-compliant products entering the supply chain or reaching consumers.

Future Vision: Moving from Defect Detection to Defect Prevention:

The traditional garment factory QA approach is largely based on inspection: Identify defects, report failures and arrange rework. The AI-enabled approach will be more proactive in near future.

Traditional QA	AI-enabled QA
Inspection after production	Inspection during production
Manual defect identification	Automated defect detection
Correct defects after occurrence	Prevent defects through early alerts
Manual quality reports	Automated dashboards
Reactive corrective action	Data-driven predictive intervention
Periodic quality monitoring	Continuous quality monitoring

The important point that the AI does not automatically guarantee zero defects. Its effectiveness depends on camera quality, training data, inspection standards,

machine integration and the factory's ability to act on alerts.

Conclusion:

AI can transform garment factory QA from a traditional inspection-based function into an intelligent production control and defect prevention system. In a buying-house environment, AI can support supplier quality control and product acceptance by ensuring that suppliers deliver products that meet approved specifications. Together, these two applications can create a stronger quality management ecosystem—from raw material selection and manufacturing to final product acceptance and market delivery.

Based on this analysis, we can conclude that AI will increasingly replace individual QA tasks, but replacing the entire apparel QA function is a different matter.

The strongest opportunity lies in reducing manual effort, improving consistency, detecting problems earlier, and enabling decisions based on better evidence.

In fact, the future QA professional may spend less time checking reports manually and more time on risk management, technical interpretation, supplier development, and the prevention of quality failures.

The future of apparel QA is not about replacing human expertise with AI, but about combining AI capabilities with human judgment to achieve better quality, greater efficiency, and stronger quality control.

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About the Author



Shri Sushil Bala holds a B. Tech. degree in Textile Technology, obtained in 2005 from GCETTS. He has over 20 years professional experience in the textile industry, having worked with export house and various multinational laboratories. Currently, he is working as an Assistant Quality Manager at Vishal Mega Mart, one of India's leading corporate retail groups. With his strong technical background and extensive industry experience, he brings valuable expertise in textile testing, quality assurance, and product quality management, contributing to the organization's commitment to maintaining high standards of quality.

Major Challenges Faced by Indian Textile Mills in Current Global Geopolitical Situation

By Sukhendu Mallick | Senior Manager at Vardhman Textiles

Introduction

Global geopolitical situation is such a dynamic subject that it continuously changes its face but never stop challenging the current viability and future possibility of different industry at different times. Textile industry is also no exception. It is also facing severe challenges from the current global geopolitical situations of recent times starting from war between Russia & Ukraine, war between USA, Israel & Iran, Trade Tariff between USA & India etc.

These wars causing major instability in the global commodity prices like crude oil and Natural gases an also disrupting the global supply chain pathways and destinations.

Additionally, tariff war with USA is hurting the textile industry to the core. Being severely impacted by higher raw material prices, disrupted supply chain pathways causing higher finish product prices at the end to the end consumer.

Though Indian textile mills are continuously finding new routes and destinations for its marketplaces facing painful challenges at USA. However, mean it or not, USA is driver of global consumption cycle. Due war and tariff, higher prices at consumer end cooling the driver's engine of consumption.

The textile industry in India is the second largest in the world by production and a major economic pillar, contributing roughly 2% to India's GDP and about 11% to manufacturing Gross Value Added (GVA) as of early 2026. It directly employs around 45 million people (with a large share being women) and over 100 million indirectly, making it one of the country's biggest job creators.

Key Market Size and Position of Indian Textile Market:

- **Market Value:** The market is valued at roughly $160 billion to $174 billion and is projected to expand significantly to between $230 billion and $350 billion by 2030.
- **Global Standing:** India is the world's largest producer of cotton and jute, and the second-largest producer of silk and man-made fibers (MMF).
- **Exports:** India ranks among the top global textile and apparel exporters (roughly top 2 to top 5 depending on the specific category), with long-term export goals aiming toward US$ 100 billion.

In global competitive spaces, other than China India's stand is far higher than Bangladesh, Indonesia, Pakistan and Vietnam etc. depending upon different product structure of the country.

Indian textile mills have long global reputation of quality, quantity and reliability of supply and standards maintaining ethical sustainability norms. However, when global consumption goes down due to wars, commodity prices and tariffs it is obvious for Indian Textile mills also to feel the heat.

Possible Hope: Growth Drivers & Emerging Segments:

- **Technical Textiles:** This is one of the fastest-growing segments. The Indian technical textiles market (used in automotive/mobiltech, healthcare, geotextiles, and sports) was valued at US$ 29 billion and is projected to scale rapidly through government missions and rising industrial demand.
- **Free Trade Agreements (FTAs):** Trade frameworks like the India-UK FTA and CETA provide competitive duty-free or reduced-tariff access for labor-intensive goods like home textiles and technical textiles, positioning India well against regional competitors and tariff pressure of USA alongside looking for alternative market for Indian Textile mills.
- **Government Schemes:** Programs like the Production-Linked Incentive (PLI) Scheme (focused on MMF and technical textiles), the PM-MITRA Parks scheme (building mega integrated textile regions), and skill-development initiatives like Samarth are actively modernizing the ecosystem.

Core Challenges and Bottlenecks:

- **Unorganized Structure:** A vast majority of weaving and processing operations remain unorganized and fragmented among small and medium enterprises (MSMEs) utilizing older machinery and low-efficiency shuttle-less looms.
- **Raw Material Volatility & Cost:** The sector is heavily skewed toward cotton (~80% of exports), leaving manufacturers vulnerable to raw material price swings, import duty fluctuations, and high input costs in man-made fibers compared to global peers. Geopolitical conflicts (such as disruptions in the Middle East and energy routes) have spiked raw material and freight costs by 35% to 40%. However, mills can only pass about 70% of these increases down to consumers, squeezing profit margins and stressing working capital. However to help Indian textile industry particularly to mills to cope up with the export challenges, government has extended duty free import of cotton fibre till 31st December 2026.
- **Policy and Export Pressures**: Exporters have faced headwinds from adjustments in export incentive schemes, global inflationary pressures, and shifting demand patterns in key Western markets like the US and the EU.
- **Sustainability and Circularity Pressures:** Over 124 million tons of textiles are produced annually, yet only about 10% is recycled. Strict new regulations—such as the EU Strategy for Sustainable and Circular Textiles and extended producer responsibility (EPR) rules—are forcing brands to address massive landfill waste, high carbon footprints, and toxic chemical usage.
- **Recycling Blended Fabrics:** Separating and recycling blended materials (like polyester-cotton blends) remains technically difficult and expensive, causing most discarded clothes to end up in landfills or incineration.
- **Labor Shortages and Turnover:** Many garment and textile regions deal with severe shortages of skilled labor, high turnover rates, and pressure to improve poor working conditions and fair wages.

- **Outdated Technology and Fragmentation:** A large portion of production—particularly in weaving and small-to-medium enterprises (SMEs)—remains fragmented, reliant on manual labor, or tethered to aging machinery that offers low productivity and frequent breakdowns. Upgrading to automated or smart-factory systems requires high capital investment and technical training.

China and India are two of the largest suppliers of textiles and apparel to the United States market, though they operate at very different scales and hold distinct competitive advantages.

Market Share & Scale in the U.S.

- **China:** Remains a dominant force and one of the largest single suppliers of textiles and clothing to the U.S., historically capturing roughly 35% to nearly 40% of U.S. textile and apparel import shares (with past totals scaling around $47 billion). However, its share has faced gradual diversification as U.S. buyers adopt "China plus one" strategies.
- **India:** Acts as a major, fast-growing alternative supplier to the U.S., holding a smaller but substantial market share (historically around 8% to 14% of U.S. raw/specific segments or billions in annual trade), and steadily benefiting as brands shift sourcing away from heavy reliance on China.

Core Strengths & Capabilities

China

- End-to-End Supply Chain: Unmatched integration from raw synthetic fibers to finished garments.
- Capacity & Speed: Massive factory scale, high automation, single-window clearances, and faster turnkey production turnaround.
- Material Focus: Strong dominance in synthetic and man-made fibers.

India

- Raw Material & Natural Fibers: Major advantage in natural fibers like cotton, yarn, and traditional made-up articles.
- Cost-Competitiveness: Landed-cost competitiveness for U.S. buyers, backed by an abundant and lower-cost labor force (roughly 45 million in the textile workforce compared to China's 100 million+).
- Specialization: High comparative advantage in specific garment categories (such as women's wear, men's shirts, and home textiles).

Challenges & Shifts

- **China:** Faces rising domestic manufacturing costs, aging demographics, and ongoing geopolitical and tariff pressures from Western markets.
- **India:** Must scale up factory size, improve worker productivity, streamline logistics, and expand man-made fiber (MMF) production to better rival China's end-to-end velocity and compete with regional alternatives like Vietnam and Bangladesh

Lead Times

- **India:** 30–45 days production + 7–25 days shipping depending on destination
- **China:** 25–40 days production + 12–30 days shipping depending on destination.

Lead times are broadly comparable. India has a slight disadvantage on shipping time to East Asian markets, but is competitive for Middle East, European, and US destinations.

Conclusion

For buyers prioritizing quality, compliance, and long-term supply chain resilience - especially for the US, UK, and European markets - India in 2026 offers a compelling alternative to China. The combination of raw material quality, competitive post-tariff landed costs, and improving documentation standards makes India the smart sourcing choice for premium hospitality textiles.

In the end it is the sustainability of you as business entity… your quality, cost, scale and service as a package to sustain in geopolitically difficult time. Because difficult time in global geopolitical scenario will continue to come. However, textile industry is a key industrial sector from India point of view may not be directly due to GDP or financial contribution but from employment point of view.

We are a large population country and textile being the largest industrial employer and 2nd largest sectoral employer after agriculture, Textile as a sector becomes even more important to India. In current scenario with this huge population job creation remains key challenge to government.

Therefore, without maintaining necessary growth requirement for the industry to sustain job creation pace, it will not only be a financial problem but a socio-political problem for the country.

As a result, current global geopolitical challenge will peculate down too many other aspects of country.

So, it becomes very important for country as well as company/mills to sustain of challenging times like now and future by staying strong in finance, quality, cost, scale and service.

About the Author:



Sukhendu Mallick holds a B.Tech from the Government College of Engineering and Textile Technology (GCETTS). Following four years of industry experience at Auro Textile (a unit of Vardhman Textiles Ltd.), he earned his M.Tech from the Indian Institute of Technology, Delhi (IITD) in 2013. Since then, he has been with the corporate office of Vardhman Textiles in the Fabric Business department, managing a diverse portfolio across the textile sector.

PLI Scheme for Textile & Apparel: Mission MMF for India

Dr. Prabir Jana | Co-Founder at Apparel 4.0 Technologies Pvt. Ltd. And Former Professor, NIFT

Who is investing under the textile PLI scheme, where, in which fibre, and whether the 2025–26 reforms fix what went wrong. Prabir Jana writes…



India's Production Linked Incentive (PLI) Scheme for Textiles was notified in September 2021 with an outlay of Rs 10,683 crore. It had one clear mission: to build scale in man-made fibre (MMF) apparel, MMF fabrics and technical textiles, the segments where India trails China and Vietnam. Five years on, the scheme has approved 170 companies with committed investment of about Rs 41,533 crore, more than double the Cabinet's original projection of Rs 19,000 crore. A closer look at 18 recently approved companies, read against the scheme-wide data, shows where the money is actually flowing and where it is not.

Where the investment is coming, and why?

By segment, technical textiles take the lion's share.

Of the Rs 41,533 crore committed, Rs 27,832 crore (about 67%) sits with 89 technical textile companies. MMF apparel accounts for Rs 7,613 crore across 43 companies, and MMF fabrics only Rs 6,087 crore across 38. Technical textiles attract capital-heavy projects such as composites, nonwovens and hygiene, where one plant can absorb hundreds of crores. That is why a single company in Goa (3B Advanced Composites) shows Rs 1,355.87 crore, and six companies in Karnataka Rs 1,515.99 crore.

By geography, Gujarat leads in both count and value.

The state has 46 of the 170 approved companies and the highest investment, Rs 1,903.38 crore, as of 31 March 2026. Our sample of 18 confirms the pattern. Ten of the 18 plants are in Gujarat, all in the Surat–Navsari belt: Jalalpore, Dhabhel,

Karanj (Mandvi taluka) and Surat itself. Two Delhi-based groups, RMP Fab Sourcing and Shyam Lal Goyal, chose south Gujarat over their home bases. The reasons are structural. Surat already has India's densest synthetic weaving and processing ecosystem: filament yarn supply, water-jet looms, dyeing and printing houses, and traders who move polyester fabric across the country. A PLI investor there buys into an existing supply chain rather than building one.

By company type, it is established groups, not greenfield newcomers.

16 out of the 18 companies, whose incorporation date could be traced, 13 are more than ten years old. Vardhman, Nobletex, Gujarat Flotex and Ruchi Twisters are adding MMF lines. Anand Rayons, a yarn trader listed on BSE SME, is moving into PV weaving. Newer entities such as Jindal Textile Industries (2022) and Shrestha Spinknit (2023) are vehicles of older family groups.

Where investment is not happening, and why?

The headline numbers hide a large execution gap. Against Rs 41,533 crore committed, actual investment stood at only **Rs 8,117.64 crore** as of 31 March 2026, roughly one-fifth, with 33,427 jobs created. Incentive payouts have been negligible: just Rs 54 crore was provisionally disbursed in FY 2024-25, to two applicants that met the investment and sales targets. An official review in 2024 had already listed textiles among the laggard PLI sectors, with Rs 1,049 crore invested against a target of Rs 7,420 crore in the first nine months of FY24.

Three gaps stand out.

Garments: of our 18 companies, only Mittal Weaves is a pure MMF apparel project, and just two (Meera Cotton and Shrestha Spinknit) combine fabric with garments. The labour-intensive end of the chain, where employment would multiply, is under-represented.

Knits: 11 of the 18 projects are woven. Only three involve knitted fabric, and none declares warp-knitted fabric, even though warp knits underpin activewear, lingerie and sportswear, the fastest-growing MMF categories.

Regions: Maharashtra, with 24 approved companies, had invested only Rs 167.51 crore by March 2026, while Punjab, West Bengal and Odisha recorded nil.

The causes are well documented. The original eligibility bar of Rs 300 crore investment and Rs 600 crore turnover in Part-1, and Rs 100 crore and Rs 200 crore in Part-2, was steep for an MSME-dominated industry. Benefits also required a newly incorporated company and a 25% year-on-year jump in turnover. Weak export and domestic demand made firms cautious about committing capacity ahead of orders.

Do the new rules fix the old shortcomings?

Largely, on paper. From 1 August 2025 the minimum investment was halved, to **Rs 150 crore (Part-1) and Rs 50 crore (Part-2)**. The incremental-turnover condition fell from 25% to 10%. Units may now be set up inside existing companies. Seventeen HSN codes (product classification codes) were added for MMF apparel and fabrics. The effect is visible in our list: established names like Vardhman could apply without forming a subsidiary, and Surat MSMEs such as DNB Textiles, Ruchi Twisters and Quantify Weave now clear the bar. In Round 3, 65 of the 96 applications came from MSMEs. On 28 October 2026 the Ministry went further for Round 4. It cut the Part-2 minimum turnover from Rs 200 crore

to **Rs 100 crore**, extended the scheme to **FY 2033-34** for Round 4 approvals, and allowed earlier-round companies that have not claimed any incentive to withdraw and migrate. The portal is open from 1 November to 31 December 2026. These changes address the entry barrier and the time squeeze. They do not, by themselves, address weak demand, the garment deficit or the near-absence of knit capacity. Those need targeted nudges such as a knit- or garment-specific tier, faster incentive payouts and fibre-price parity.

Which fibre is really winning?

Out of declared product lists of the 13 fabric-making projects the answer is unambiguous: polyester. Polyester appears in 12 of 13 fabric projects, as unbleached, dyed and printed suitings and shirtings, and as textured-filament wovens. Nylon follows in seven, chiefly as taffeta, brasso, georgette and furnishing fabric; Vardhman's performance-fabric unit at Baddi is the one clear high-value nylon play. Viscose appears in six, almost always blended with polyester as PV suiting or as spun-rayon shantung and linen-look prints. Elastane blends, recycled polyester and specialty cellulosics such as lyocell or modal are absent from the declarations. In other words, the scheme is so far scaling up what Surat already does well, rather than pushing India into new MMF frontiers.

The road ahead

Mission MMF is real, but it is still largely a mission of commitments. The first test of Round 4 will be whether lower thresholds bring in garment and knit investors outside the Surat cluster. The second is whether the Rs 33,000-crore gap between committed and actual investment closes before the extended deadline. The third is whether incentives finally flow at a scale that makes the arithmetic worth an MSME's while. Until then, India's MMF story will remain a polyester-woven story, written mostly in south Gujarat.

Data sources: *Ministry of Textiles / IFCI PLI Textiles portal (applicants list and segment summary); PIB releases of October 2025, June 2026 and October 2026; Rajya Sabha reply, August 2025; Apparel Resources, KNN India, Indian Textile Magazine and company filings. The 18-company analysis is based on products declared to the PLI Project Management Agency.*

About the Author:



Dr. Prabir Jana is a technology professional specialising in apparel manufacturing, Industry 4.0 and smart manufacturing. After beginning his career in the apparel industry, he served NIFT for nearly 33 years, retiring as Professor in August 2026, and was Shahi Chair Professor Industry 4.0 till 2025. He is currently Co-Founder and Director of Apparel 4.0 Technologies Pvt. Ltd. His work spans automation, AI, sewing technology, industrial engineering and smart textiles. He has authored over 300 articles, contributed to numerous books and holds five patents.

Photo Gallery: TANTU AGM and Get-together 2026



Fig-1: Tantu AGM 2026-27 | 16th August 2026



Fig-2: Bengali New Year Get-together on April 2026



Fig-3: Bengali New Year Get-together on April 2026

BEST WISHES

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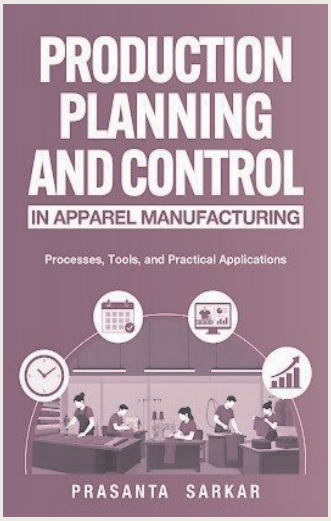
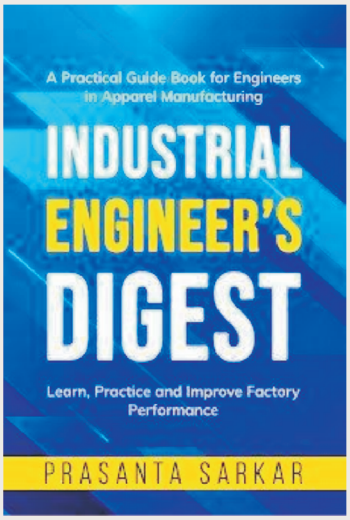
Thanks to all the organizing members to make
it a wonderful event & enriching us.

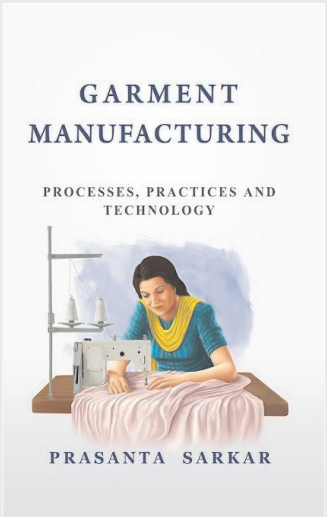
Shri Chandan Saha

Read Online Clothing Study

online clothing study







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Seminar Report 2025: Sustainability and Recycling in the Textile and Apparel Industry

By Tantu Editorial Team



TANTU organized its Annual Event addressing **Sustainability and Recycling in the Textile and Apparel Industry**. Experts, policymakers, and industry leaders gathered at the TANTU Seminar to discuss pressing issues surrounding sustainability and recycling in the textile and apparel industry. The event at India International Centre aimed to explore innovative solutions to minimize waste, promote circular economy practices, product life cycle analysis, and drive sustainable manufacturing.

The keynote address was delivered by **Dr. Ashok Kumar**, Deputy Director General, Bureau of Energy Efficiency, New Delhi, who emphasized the urgent need for industry-wide collaboration. 'Why the Textile Industry should take actions right now on sustainable practices." He reminded the delegates about the goals of the Paris Agreement 2015. Under that agreement, all countries are to limit global warming to well below 2 Degree Centigrade above pre-industrial level and to reduce Green House Gas (GHG) emissions as soon as possible and reach net zero emissions by the middle of the 21st Century. He advised the delegates to move into action as the time of research and discussion is over by now.

Gaurav Seth, Head Strategic Partnership, Indo-German Yarn and Fibre LLP, discussed about recycling, and re-engineering of performance textiles. With the increased use of technical textiles, the usage of performance fibres such as para-aramid, meta-aramid, carbon fibres are increasing day by day. Process waste of these materials and end-of-life technical textile products are becoming burden to the earth. They have successfully developed

methods to recycle them and supplying the recycled products to various companies, engaged in technical textile manufacturing.



Gaurav Seth

Ajitesh Upadhyaya, Senior Section Expert – Textile, BEE, India detailed the Indian Carbon Market Framework, Carbon Credit Trading Scheme (CCTS) In India, PAT Cycle – Textile Target & Savings in MTOE to CCTS, Alignment with International Carbon Tax Regulations.



Ajitesh Upadhyaya

Chinky Tyagi Khare, Green Story detailed the way for navigating sustainability regulations and the Role of product life cycle assessment (LCA) in the textile and apparel industry. She added how Green Story is helping the industry in life cycle assessment through the Green Story tools for LCA. She had emphasized the shrinking regulatory timeline and rising pressure. “Manufacturers risk losing deals and reputational damage if they cannot provide the required environmental footprint information as responsibility shifts up the supply chain” she stated.



Chinky Tyagi Khare

Pankaj Kapoor, Independent Director, Green Consulting, shared his views on the climate change and scope and Impact in the textile and apparel industry. He detailed the negative impact areas in the textile and apparel industry. He demonstrated the Key Metrics for Sustainability measures and pointed out the Key ESG regulatory deadline in 2025.



Prof. Abhijit Majumder and Dr. Rabi Shankar Chattopadhyay

Prof. Abhijit Majumder, IIT Delhi, shared the success of their experiment they are doing on post-consumer textile and apparel recycling and regenerating yarns for fully fashion apparel items and other uses. Prof. Majumder elaborated on the fiber regeneration techniques, and closed-loop systems, which enable better waste management and resource efficiency.

"The fashion industry has a responsibility to rethink its environmental impact," said **Sutanu Goswami,** Senior General Manager, TUV SUD, South Asia. "By adopting responsible sourcing, ethical production, and recycling initiatives, we can move towards a more sustainable future.



Sutanu Goswami

Sanya Arora, Engagement Officer at CDP, emphasized the growing need for disclosure, particularly for SMEs. Transparency in environmental reporting is now a business necessity, she noted.



Ms. Sanya Arora is receiving memento from Mr. PC Das

Dr. Arindam Basu, DG, and Lalit Goswami, Senior Scientific Officer, NITRA, presented a paper on optimization of process parameters while using recycled cotton as a component in 100% cotton yarn. Also, they mentioned about the limitation in usage of recycled cotton to the extent of 20% and 30% of the blend while using ring spinning and rotor spinning respectively, to produce acceptable quality of yarns.



Dr. Arindam Basu, and Lalit Goswami

The event concluded with a commitment from various stakeholders to enhance transparency, improve recycling infrastructures, and support policies that encourage sustainability.



Seminar Participants

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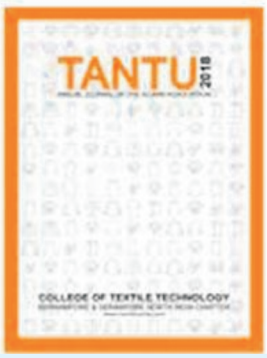

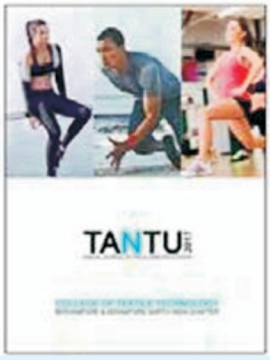



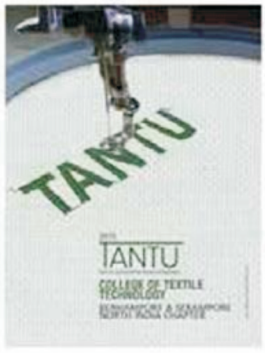

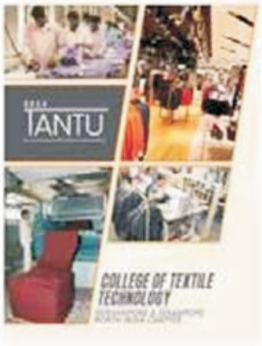






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