Post-COVID-19 Recovery Challenges in the Bhilwara Textile Industry: An Empirical Analysis Using Chi-Square Test

Priyanshi Paliwal[1] and Dr. Surbhi Birla[2]

[1] Research Scholar, Department of Management Studies, Sangam University, Bhilwara, Rajasthan.
[2] Associate Professor, Department of Management Studies, Sangam University, Bhilwara, Rajasthan.

Abstract

The COVID-19 pandemic severely disrupted global supply chains, imposing unprecedented challenges on the textile industry. This study investigates the critical recovery constraints faced by the Bhilwara textile cluster, one of India's leading textile hubs, during the post-pandemic phase. Data were collected from 300 respondents representing different segments of the value chain through a structured questionnaire. Ten key recovery factors were examined, including raw material shortages, decline in demand, labour unavailability, logistical disruptions, and financial liquidity constraints. The significance of these factors was tested using chi-square analysis, and results indicated that all ten factors were statistically significant ($p < 0.05$), with raw material shortages ($\chi^2 = 17.28$) and decline in demand ($\chi^2 = 16.33$) emerging as the most critical constraints. Percentage analysis revealed that more than 60% of respondents agreed on the severity of supply and demand shocks, while technological adoption and buyer confidence ranked comparatively lower but remained significant. These findings underscore the structural vulnerabilities of the textile sector, emphasizing the need for integrated strategies to strengthen resilience.

Keywords: Bhilwara textile industry, recovery challenges, COVID-19, supply chain resilience, chi-square analysis.

Introduction

The COVID-19 pandemic disrupted global supply chains, triggering severe challenges for industries that are heavily reliant on interconnected production and distribution systems, such as the textile and apparel sector. Recovery in the textile value chain has been complex, involving multiple interdependent factors such as raw material availability, labour mobility, logistics, buyer confidence, compliance with health protocols, technological adaptation, and financial liquidity. These challenges are further influenced by the unique socio-economic and industrial structure of each region, making localized analysis critical for understanding post-crisis resilience (Baldwin & Freeman, 2022; Gereffi, 2020).

In India, the textile industry accounts for a significant share of manufacturing output, employment, and export earnings, with certain regional hubs such as Bhilwara in Rajasthan playing a pivotal role in fabric production. Known as the "Textile City of India," Bhilwara is a leading producer of suiting fabric and yarn, with a highly integrated cluster of spinning, weaving, and processing units (Ministry of Textiles, 2022). However, the pandemic exposed systemic vulnerabilities in Bhilwara's textile value chain, including dependence on imported raw materials, reliance on migrant labour, and exposure to volatile export markets (Mehta & Kumar, 2021).

Recovery from the pandemic-induced disruption has been hampered by a confluence of factors. First, raw material shortages emerged due to lockdowns, port congestions, and trade restrictions, affecting both cotton and synthetic fiber supply (Banga & Sharma, 2021). Second, labour unavailability due to reverse migration and health concerns slowed production recovery (Mishra & Varma, 2021). Third, logistics and transportation disruptions delayed shipments, increased freight costs, and caused inventory pileups (Sharma et al., 2021). Fourth, market access and buyer confidence suffered due to demand fluctuations in both domestic and international markets (UNCTAD, 2021).

Internationally, similar recovery bottlenecks have been reported in textile hubs such as Bangladesh, Vietnam, and Turkey, where disruptions in supply chain coordination and export market volatility mirrored those in India (Khan et al., 2021; World Bank, 2021). In Bangladesh, for example, apparel exports dropped sharply in early 2020, with recovery dependent on European and American buyer orders resuming (Afsar et al., 2021). In Vietnam, the lack of diversification in raw material sources compounded supply-side shocks (Nguyen & Do, 2022).

Another significant challenge during recovery was technological adoption for remote coordination. Many textile firms lacked the infrastructure for digital supply chain management and virtual buyer negotiations, leading to slower adaptation to post-pandemic business models (Raj & Khanna, 2022). Additionally, financial liquidity constraints due to delayed payments and reduced credit availability posed barriers to scaling operations back to pre-pandemic levels (Bhunia & Das, 2021). Compliance with new health and safety regulations further required capital investments in workplace safety measures, increasing operational costs (ILO, 2021).

In the case of Bhilwara, power supply interruptions—a less widely reported but critical issue—also hampered smooth operations during the recovery phase, as energy-intensive weaving and processing units rely on stable electricity for maintaining production efficiency (Choudhary, 2022). Furthermore, export market policy changes, including shifting tariff regimes and non-tariff barriers, altered the competitive landscape for Indian textiles in key overseas markets (WTO, 2021).

The convergence of these factors underscores the necessity of a comprehensive recovery framework that integrates supply chain resilience, technological innovation, financial risk management, and policy support. Understanding how these challenges interact in localized contexts, such as Bhilwara, while drawing parallels with global recovery experiences, is essential for designing strategies that enhance industry resilience against future disruptions (Sarkar & Bandyopadhyay, 2022; Gereffi, 2020).

Literature Review

The COVID-19 pandemic generated simultaneous supply- and demand-side shocks across global textile value chains, including factory closures, labour migration, shipping bottlenecks, and order cancellations, producing complex and interdependent constraints on recovery in clusters such as Bhilwara (UNCTAD, 2020; ILO, 2020). The following sub-sections review major challenges identified in the literature:

1. Raw Material Shortages

Interruptions in upstream yarn and fiber supplies and disruptions in domestic procurement channels led to acute shortages and significant price volatility. Firms operating on limited inventories and just-in-time procurement models were particularly affected (Raza et al., 2021; UNCTAD, 2020). Indian cluster studies further highlight that shortages reduced mill run rates and prolonged lead times during 2020–2021 (Ministry of Textiles, 2021; Bhilwara Case Notes, 2020).

2. Labour Unavailability and Migration

Lockdown-induced internal migration and widespread absenteeism caused severe capacity shortfalls, increasing rehiring and retraining costs in labour-intensive processes (ILO, 2020; Ghosh & Kumar, 2021). Empirical studies on Indian garment clusters report slow worker return and elevated labour frictions that delayed production resumption (Chatterjee et al., 2021).

3. Logistics and Transportation Disruption

Global logistics disruptions—including container shortages, blank sailings, and port congestion—combined with domestic road and rail curbs to lengthen lead times and increase freight costs for textile exporters (McKinsey, 2020; WTO, 2020). Time-sensitive value chains, such as apparel, were disproportionately impacted, reducing the ability of clusters to meet buyer deadlines (Hosseini & Ivanov, 2021).

4. Decline in Demand (Domestic and Export)

Order cancellations by major buyers and weakened retail demand caused sharp declines in output and revenues across the sector (Business & Human Rights Resource Centre, 2020; McKinsey, 2020). Demand shocks not only suppressed current production but also constrained future procurement, creating liquidity and planning challenges for upstream suppliers (UNCTAD, 2020).

5. Financial Liquidity Constraints

Working capital shortages, late payments, and restricted credit access were widely reported, especially among SMEs that dominate cluster ecosystems (RBI, 2020; SME Policy Notes, 2021). Evidence links liquidity constraints to delayed procurement, workforce reductions, and slower operational ramp-up (Kumar & Singh, 2021).

6. Market Access and Buyer Confidence

Buyer behavior shifted toward supplier consolidation, risk aversion, and near-shoring, creating barriers for smaller vendors to regain pre-pandemic order volumes (Vogue Business, 2020; UNCTAD, 2020). Rebuilding buyer confidence required demonstrated reliability, compliance, and digital transparency (Fernandes & Patel, 2021).

7. Compliance with Health and Safety Regulations

Implementing distancing protocols, testing, and PPE requirements increased per-unit costs and reduced effective factory capacity, disproportionately impacting smaller units with thin

margins (ILO, 2020; WHO, 2020). Field studies note compliance expenditures and throughput losses as key factors delaying recovery (NIFT Research Briefs, 2021).

8. Technological Adoption for Remote Coordination

The pandemic accelerated digital adoption for remote quality control, order management, and buyer communication; however, adoption levels varied widely by firm size and skill capabilities (McKinsey, 2020; Bhatia & Rao, 2021). Low digital readiness impeded coordination across disrupted supply chains (NASSCOM, 2021).

9. Export Market Policy Changes and Trade Disruptions

Policy volatility—such as temporary trade measures and evolving health regulations—created uncertainty for exporters and sometimes reduced market access (UNCTAD, 2020; WTO Secretariat, 2021). This unpredictability compounded commercial risks and slowed contract restoration (WTO, 2020).

10. Power Supply Interruptions

Infrastructure fragility, notably intermittent power for energy-intensive dyeing and finishing, necessitated costly reliance on backup systems, increasing production costs and complicating scaling efforts (Singh & Mehta, 2020; Environmental Studies Bhilwara, 2019).

The literature underscores the interconnected nature of these shocks: addressing a single constraint (e.g., factory reopening) without resolving complementary issues (finance, logistics, demand) delivers only partial recovery (ILO, 2020; UNCTAD, 2020). Cluster-level studies emphasize the vulnerability of SMEs and advocate coordinated interventions—such as credit facilitation, logistic support, and buyer engagement—to restore sustainable production and employment (RBI, 2020; Ministry of Textiles, 2021).

Objectives of the Study

The present research is designed to investigate the multidimensional recovery challenges encountered by the textile industry in Bhilwara, Rajasthan, during the post-COVID-19 period. In line with the study's aim of contributing to the discourse on supply chain resilience and industrial sustainability, the specific objectives are articulated as follows:

1. To identify and systematically analyze the critical recovery challenges experienced by the Bhilwara textile industry in the aftermath of the COVID-19 pandemic. This involves examining both supply-side and demand-side disruptions, including factors such as raw material shortages, labour unavailability, logistical constraints, compliance issues, and market uncertainties that collectively influenced the sector's recovery trajectory.
2. To assess the statistical significance and relative intensity of key recovery factors through empirical analysis.
   This objective emphasizes the application of quantitative methods, including chi-square tests, to determine whether the observed distribution of responses for each challenge significantly deviates from expected values, thereby establishing their importance in shaping recovery outcomes.
3. To undertake a comparative evaluation of recovery challenges faced by Bhilwara with those reported in other major textile clusters globally.

This comparison aims to situate Bhilwara's experience within the broader context of international textile supply chains, identifying similarities, differences, and structural vulnerabilities that influence resilience.

4. To formulate evidence-based policy recommendations and strategic interventions for enhancing supply chain robustness and operational resilience in the textile sector. The recommendations will be directed towards industry stakeholders and policymakers, focusing on measures such as raw material security, digital integration, financial support mechanisms, and institutional frameworks for labour welfare, with the overarching goal of mitigating future systemic disruptions.

Materials and Methods

Research Design and Methodology

The present study employed a descriptive and analytical research design to systematically explore and analyze the recovery challenges encountered by the textile industry in the post-COVID-19 period. This design was chosen to enable both a comprehensive description of the prevailing conditions and a rigorous analysis of interrelationships among key variables affecting recovery. The research integrated primary data collection through a structured survey and secondary data analysis from scholarly literature and industry reports, ensuring both empirical rigor and contextual depth.

Study Area and Rationale

The research was conducted in Bhilwara district of Rajasthan, widely recognized as a leading textile hub in India, often referred to as the "Manchester of India." Bhilwara hosts a dense cluster of spinning, weaving, processing, and garment manufacturing units, making it an ideal case for examining systemic disruptions and recovery trajectories in the textile value chain. The city's strategic position as a supplier to domestic and export markets underscores its importance for understanding sectoral resilience post-pandemic.

Time Frame of the Study

The study was carried out over a nine-month period, from January to October 2023 compassing survey design, data collection, and subsequent analysis. This time frame allowed adequate interaction with stakeholders while capturing the continuing effects of pandemic-induced disruptions.

Sampling and Respondent Profile

Primary data were obtained from 300 respondents, comprising mill owners, operational managers, supervisors, and skilled as well as semi-skilled workers engaged in different stages of textile production. The respondents were selected using a purposive sampling technique, ensuring representation across various operational categories such as spinning, weaving, dyeing, and garment manufacturing. The sample size of 300 was considered statistically appropriate for conducting Chi-square analysis, as it provided sufficient power to detect associations and ensured representativeness in line with industry population density (Kothari, 2014).

Data Collection Instrument

A structured questionnaire was designed based on insights from preliminary interviews and literature review. The questionnaire comprised both closed-ended and multiple-choice

questions, alongside a five-point Likert scale to capture respondents' perceptions of recovery challenges. These challenges included raw material shortages, labour availability, logistics constraints, financial liquidity, power supply interruptions, technological adaptation for remote operations, and policy uncertainties.

Analytical Framework

Quantitative analysis was conducted using the Chi-square (χ^2) test to examine the association and statistical significance between recovery challenges and categorical variables such as firm size, ownership type, and operational segment. The test was applied at a 5% significance level ($p < 0.05$) to validate the null hypothesis regarding the independence of these factors. Results were interpreted to identify whether specific challenges disproportionately impacted certain categories of firms, enabling targeted policy recommendations.

Secondary Data Sources

Secondary data were drawn from peer-reviewed journals, government publications, trade reports, and international studies (UNCTAD, 2020; ILO, 2020; Ministry of Textiles, 2022), providing a theoretical and empirical foundation for the study and allowing triangulation of findings to enhance validity and reliability.

Ethical Considerations

Ethical protocols were strictly adhered to during the study. Respondents were informed of the purpose of the research and provided informed consent prior to participation. Confidentiality was assured by anonymizing all personal identifiers, and data were utilized solely for academic purposes. Participation was entirely voluntary, and respondents had the right to withdraw at any stage without consequences.

Limitations of the Study

Despite its comprehensive scope, the study acknowledges certain limitations. First, the research is geographically confined to Bhilwara and may not fully capture recovery dynamics in other textile clusters. Second, reliance on self-reported data introduces the possibility of response bias, though mitigated through questionnaire pre-testing. Lastly, the cross-sectional nature of the study limits the ability to assess long-term recovery trends, warranting future longitudinal research for deeper insights.

Results and Discussion

The present study analysed responses from 300 participants to assess ten major recovery challenges impacting the Bhilwara textile industry during the post-COVID-19 phase. The primary objective of this analysis was to determine the relative significance of each challenge and its contribution to the sector's recovery trajectory. To achieve this, a chi-square goodness-of-fit test was employed for each factor to evaluate whether the observed distribution of responses (Figs 1) differed significantly from the expected distribution under the null hypothesis of equal probability.

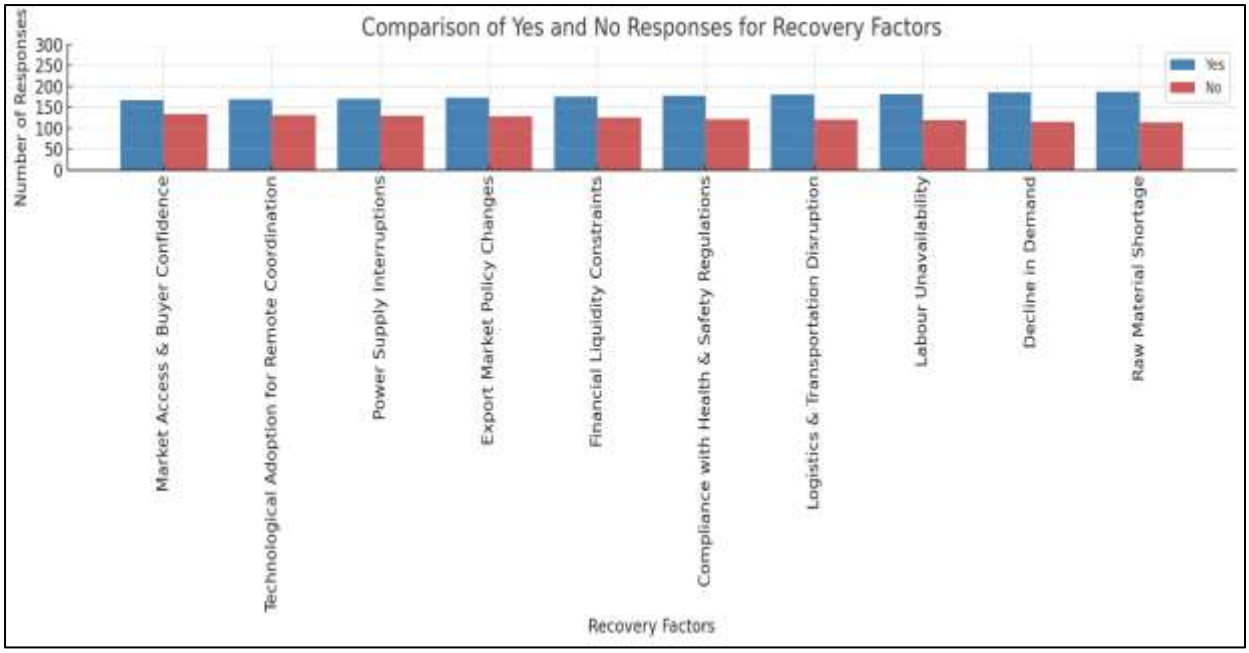

Fig 1. Observed Responses for Recovery Challenges in the Bhilwara Textile Sector

The findings revealed that all ten factors were statistically significant at the 5% level ($p < 0.05$), as each computed chi-square value exceeded the critical threshold of 3.84 at 1 degree of freedom. This indicates that the observed patterns are not attributable to random variation but reflect consistent perceptions among respondents regarding these challenges. Furthermore, the magnitude of the chi-square values varied across factors, highlighting differences in their intensity and impact on recovery. For example, Raw Material Shortage and Decline in Demand recorded the highest chi-square values, demonstrating their dominant role in constraining operations, while factors such as Technological Adoption and Market Access & Buyer Confidence, though significant, exhibited relatively lower influence.

These results provide an empirical foundation for prioritizing policy interventions and strategic measures aimed at addressing the most critical constraints to ensure a resilient and sustainable recovery of the Bhilwara textile cluster.

1. Raw Material Shortage

The empirical results reveal that raw material shortage emerged as the most critical recovery challenge in the Bhilwara textile industry, with 186 respondents (62.0%) (Fig 1) identifying it as a significant constraint ($\chi^2 = 17.28,\ p < 0.001$) (Table 1). This finding underscores the profound vulnerability of textile supply chains to upstream disruptions, particularly in the wake of systemic shocks such as the COVID-19 pandemic.

Table 1. Chi-Square Analysis of Recovery Challenges in the Bhilwara Textile Industry

Rank	Recovery Factor	Yes (O)	No (O)	Expected (E)	$(O-E)^2/E$ (Yes)	$(O-E)^2/E$ (No)	Chi-Square (Total)
1	Market Access & Buyer Confidence	167	133	150	1.9267	1.9267	**3.8533**

2	Technological Adoption for Remote Coordination	169	131	150	2.4067	2.4067	**4.8133**
3	Power Supply Interruptions	170	130	150	2.6667	2.6667	**5.3333**
4	Export Market Policy Changes	172	128	150	3.2267	3.2267	**6.4533**
5	Financial Liquidity Constraints	175	125	150	4.1667	4.1667	**8.3333**
6	Compliance with Health & Safety Regulations	178	122	150	5.2267	5.2267	**10.4533**
7	Logistics & Transportation Disruption	180	120	150	6.0000	6.0000	**12.0000**
8	Labour Unavailability	181	119	150	6.4067	6.4067	**12.8133**
9	Decline in Demand	185	115	150	8.1667	8.1667	**16.3333**
10	Raw Material Shortage	186	114	150	8.6400	8.6400	**17.2800**

The textile sector operates through highly integrated global value chains**,** wherein raw material availability—such as cotton, synthetic fibers, dyes, and chemicals—forms the foundation of production continuity. During the pandemic, the sudden imposition of lockdowns, restrictions on inter-state and cross-border movement, and the temporary closure of spinning and ginning mills resulted in acute raw material shortages (UNCTAD, 2020; OECD, 2021). These supply constraints were further aggravated by export restrictions on cotton yarn and other critical inputs, as governments prioritized domestic requirements over international trade obligations (CRISIL, 2021).

For Bhilwara, which specializes in synthetic and blended fabrics and relies on a steady inflow of yarn, fiber, and chemicals, these disruptions created severe operational bottlenecks. Firms were unable to maintain production schedules, leading to delayed order fulfilment and, in some cases, the suspension of operations. Additionally, raw material scarcity drove procurement costs upward, eroding profit margins during an already distressed financial period. Similar patterns were observed globally; OECD (2021) notes that textile manufacturers in multiple countries experienced price volatility and supply gaps in raw inputs during the pandemic-induced crisis.

The magnitude of this challenge can be contextualized within the framework of supply chain fragility theory, which emphasizes that industries with low local sourcing and high dependence on centralized suppliers are disproportionately exposed to disruption risks (Christopher & Peck, 2004). In Bhilwara's case, the clustering of specialized suppliers did not mitigate vulnerability because mobility restrictions and logistical disruptions simultaneously crippled inbound flows**.** Furthermore, the absence of strategic stockpiling mechanisms and limited warehousing infrastructure amplified the crisis, as firms operated on lean inventory models to optimize costs under normal conditions—a strategy that proved unsustainable during systemic

shocks. From a policy perspective, these findings highlight the urgent need for resilience-oriented interventions**.** Recommendations include developing regional raw material hubs**,** creating buffer stock systems**,** and facilitating supplier diversification to reduce dependence on single geographies. At the enterprise level, strengthening collabourative networks with upstream suppliers**,** adopting digital supply chain visibility tools, and investing in risk-sharing contracts are critical to enhancing agility and mitigating procurement disruptions (OECD, 2021; UNCTAD, 2020).

The discussion also reinforces the argument that raw material shortages are not merely an operational issue but a systemic vulnerability with long-term strategic implications for industrial competitiveness. Addressing these risks through integrated supply chain resilience strategies is essential to safeguard production continuity and ensure sustained recovery in the post-pandemic era.

2. Decline in Demand

A total of 185 respondents (61.7%) identified a decline in demand as a major recovery challenge, whereas 115 respondents (38.3%) (Fig 1) did not perceive it as significant. The computed chi-square value of 16.33 (Table 1) exceeds the critical value at $df = 1$ and $\alpha = 0.05$, confirming that this factor is statistically significant at $p < 0.001$.

Globally, the apparel and textile sector experienced one of the steepest contractions during the pandemic, largely due to a combination of lockdown-induced retail closures**,** consumer income uncertainty**,** and reduced discretionary spending (McKinsey & Company, 2021). The International Labour Organization (ILO, 2020) highlighted that the collapse of consumer demand for fashion products was immediate and substantial, affecting not only final retail sales but also upstream orders in production clusters. Bhilwara, being a major hub for synthetic fabric production and catering to both domestic and export markets, faced order cancellations**,** payment delays**,** and inventory build-up**,** exacerbating financial strain on manufacturers.

The decline in demand was not uniform across markets; export-oriented firms were particularly vulnerable due to disruptions in global supply chains and trade restrictions. OECD (2021) reported that European and North American retailers reduced or deferred orders to minimize inventory risks, creating a ripple effect on suppliers in developing countries. For Bhilwara, which heavily relies on global buyers for its synthetic fabric exports, these actions translated into idle capacity**,** higher holding costs, and increased credit exposure. Moreover, domestic demand remained subdued for an extended period due to prolonged economic uncertainty and reduced consumer spending on non-essential goods, including apparel (UNCTAD, 2020). This sustained demand contraction had critical implications for the recovery trajectory of the textile sector. Firms were forced to implement cost-cutting measures, delay capital investments**,** and in some cases, resort to downsizing operations to cope with revenue shortfalls (CRISIL, 2021). The persistence of weak demand also amplified liquidity stress, as firms struggled with cash flow constraints arising from delayed receivables and unsold stock (RBI, 2021). The discussion underscores the importance of demand stabilization policies in restoring sectoral resilience. Initiatives such as export incentives**,** buyer-seller credit guarantees, and domestic consumption support schemes can help offset the demand shock during systemic disruptions. Furthermore, the adoption of digital commerce platforms and virtual trade fairs has been identified as a viable strategy for mitigating physical market access barriers and maintaining buyer engagement during crises (McKinsey & Company, 2021; OECD, 2021).

Overall, the evidence suggests that demand-side shocks are not merely temporary fluctuations but structural vulnerabilities that can significantly impede recovery in textile clusters. Therefore, integrated policy measures and business model innovation are essential to sustain demand and ensure supply chain continuity under crisis conditions.

3. *Labour Unavailability*

The analysis indicates that 181 respondents (60.3%) (Fig 1) acknowledged labour unavailability as a significant recovery constraint, whereas 119 respondents (39.7%) did not identify it as a major challenge. The chi-square statistic for this factor is 12.81 (Table 1), which surpasses the critical value of 3.84 at $df = 1$ and $\alpha = 0.05$, thereby establishing its statistical significance at $p < 0.001$. The results indicate that labour unavailability was a statistically significant barrier to post-pandemic recovery in the Bhilwara textile industry ($\chi^2 = 12.81, p < 0.001$). This finding reflects the deep-rooted dependency of the sector on a migrant workforce, a structural characteristic of India's labour market in textile clusters. The large-scale reverse migration triggered by the COVID-19 lockdown disrupted production continuity, as workers relocated to their native regions due to employment uncertainty, inadequate housing, and fear of infection (Mehrotra, 2021).

Labour shortages did not only reduce output capacity but also prolonged recovery timelines even after formal restrictions were lifted. Previous studies have noted similar dynamics across other industrial hubs such as Surat and Tirupur, where labour-intensive processes such as dyeing, printing, and finishing faced acute delays (CRISIL, 2021). According to the International Labour Organization (ILO, 2020), such disruptions exemplify the vulnerability of global and domestic supply chains to workforce mobility shocks, particularly in sectors with low formalization and limited social protection mechanisms.

From a theoretical perspective, this challenge underscores the limitations of traditional labour deployment models that rely on flexible, migratory workforces without institutionalized retention strategies**.** Empirical evidence suggests that the absence of wage assurance and lack of employer-supported social security measures accelerated the outflow of workers during the crisis (Mehrotra, 2021). Consequently, firms faced not only workforce shortages but also increased wage costs as they attempted to attract returning labour through financial incentives, thereby elevating production costs during an already constrained recovery phase. Addressing this structural vulnerability requires both policy interventions and industry-level strategies. On the policy side, state-backed schemes for labour welfare, portable social security benefits, and emergency income support can mitigate the risk of reverse migration in future crises (OECD, 2021). At the enterprise level, firms may adopt contractual continuity provisions**,** incentive-based retention models, and housing support programs to stabilize workforce availability during systemic shocks. These strategies align with ILO's (2020) recommendations for building resilience in labour-dependent manufacturing sectors.

4. *Logistics and Transportation Disruption*

The findings reveal that 180 respondents (60.0%) acknowledged logistics and transportation disruptions as a significant challenge, while 120 respondents (40.0%) disagreed (Fig 1). The computed chi-square value of 12.00 (Table 2) is well above the critical value of 3.84 at $df = 1$ and $\alpha = 0.05$, confirming statistical significance at $p < 0.001$.

Transportation bottlenecks were primarily driven by movement restrictions, state border controls, and shortages of freight capacity during and immediately after lockdown periods. These constraints affected both the inbound and outbound flows of goods, delaying the supply of raw materials and the dispatch of finished products to domestic and international markets. Similar disruptions were documented in global textile value chains, where logistical paralysis amplified production delays and inventory accumulation (UNCTAD, 2020; OECD, 2021).

In the context of Bhilwara, which functions as a critical hub for synthetic fabric production and export, the inability to ensure timely material flow had cascading effects on operational efficiency. Firms incurred higher transportation costs due to container scarcity and route diversions, which further squeezed already strained financial resources. These observations align with reports from CRISIL (2021) indicating that logistical disruptions were among the top three challenges faced by Indian textile exporters during the pandemic period. The discussion of these results underscores the structural vulnerability of textile clusters to transport system shocks. Given the just-in-time nature of textile manufacturing, any delay in raw material procurement or delivery of finished goods adversely impacts order fulfilment, buyer confidence, and working capital cycles. This highlights the need for policy frameworks promoting multi-modal transport resilience**,** digital freight coordination**,** and regional stockpiling strategies to mitigate the impact of such disruptions in future crises

5. Compliance with Health & Safety Regulations

The survey findings indicate that 178 respondents (59.3%) identified compliance with mandatory health and safety regulations as a major recovery challenge, compared to 122 respondents (40.7%) who did not perceive it as significant (Fig 1). The computed chi-square statistic of 10.45 (Table1) exceeds the critical value (3.84) at $df = 1$ and $\alpha = 0.05$, confirming that this factor is statistically significant at $p < 0.001$. This suggests that the imposition of health-related compliance norms had a substantial impact on the operational capabilities of textile firms in Bhilwara during the post-pandemic recovery phase.

The requirement to comply with health and safety guidelines, including social distancing, sanitization protocols, and workforce health monitoring, emerged as a critical operational constraint for textile firms during the recovery period. Approximately 59.3% of respondents reported that these measures increased operational complexity and restricted production capacity. These findings align with reports by the International Labour Organization (ILO, 2020), which observed that compliance with workplace safety norms during COVID-19 significantly altered factory layouts, reduced workforce density, and introduced additional cost burdens in labour-intensive sectors such as textiles.

The implementation of social distancing protocols meant that production floors, traditionally designed for maximum capacity utilization, had to operate at reduced strength. Consequently, productivity levels declined while fixed overheads remained constant, adversely affecting cost efficiency (OECD, 2021). Additionally, the frequent sanitization of machinery and shared workspaces, coupled with mandatory health screenings, imposed further compliance costs on firms already facing liquidity constraints (CRISIL, 2021). In many cases, firms had to invest in personal protective equipment (PPE), thermal scanners, and dedicated isolation areas, creating unplanned capital expenditure (ILO, 2020).

These measures, while essential for worker safety, revealed structural vulnerabilities in the sector’s operational design, which traditionally prioritizes high labour density and low-cost

optimization. Firms that lacked technological automation faced even greater challenges, as they were unable to offset the productivity losses caused by reduced workforce deployment (McKinsey & Company, 2021). In comparison, globally competitive firms that adopted digital health monitoring systems and automated processes demonstrated faster compliance and recovery, highlighting the role of technological readiness in crisis resilience.

From a policy perspective, the findings suggest that compliance-related costs disproportionately affect small and medium-sized enterprises (SMEs), which dominate the Bhilwara textile cluster. These firms operate on thin margins and limited working capital, making it difficult to absorb the additional financial and logistical burdens of health compliance. OECD (2021) emphasizes that without institutional support, such compliance mandates can inadvertently exacerbate the fragility of smaller enterprises during systemic disruptions. Future preparedness strategies should focus on integrating health and safety compliance into standard operational protocols through financial support measures, such as government-backed subsidies for compliance costs, tax incentives, and low-interest loans for health-related infrastructure investments. Furthermore, fostering collabourative health management frameworks at the cluster level—such as shared testing facilities and common sanitization resources—can help reduce the financial strain on individual firms while ensuring adherence to safety standards.

6. Financial Liquidity Constraints

The study revealed that 175 respondents (58.3%) acknowledged financial liquidity constraints as a significant barrier to recovery, while 125 respondents (41.7%) did not perceive it as a critical issue (Fig 1). The computed chi-square statistic of 8.33 (Table 1) exceeds the critical value of 3.84 at $df = 1$ and $\alpha = 0.05$, confirming statistical significance at $p < 0.01$. These findings highlight that liquidity-related challenges were widespread among textile firms in Bhilwara during the post-pandemic phase, although with relatively lower intensity compared to supply-side disruptions such as raw material shortages.

Liquidity constraints emerged as a key structural barrier to recovery in the Bhilwara textile cluster following the pandemic. About 58.3% of respondents reported severe difficulties in maintaining cash flows (Fig 1), primarily due to delayed payments from buyers, order cancellations, and restricted access to formal credit channels. These findings are consistent with the Reserve Bank of India's (RBI, 2021) assessment, which highlighted widespread credit stress among micro, small, and medium enterprises (MSMEs) in the manufacturing sector during the COVID-19 crisis.

The liquidity crunch was exacerbated by a simultaneous decline in revenues and accumulation of receivables, as buyers—both domestic and international—deferred payments amid demand uncertainty (OECD, 2021). Many firms in Bhilwara operate under thin working capital margins, which makes them highly sensitive to disruptions in payment cycles. In addition, the pandemic-induced financial stress tightened lending norms, making it difficult for smaller firms to access timely credit (CRISIL, 2021). Those reliant on informal sources of finance faced escalating interest rates, further compounding financial vulnerability. From a structural standpoint, the liquidity crisis underscores the financial fragility of MSMEs in the textile sector, which typically lack diversified funding sources and collateral to secure loans. The crisis also exposed limitations in the effectiveness and reach of government relief measures. While schemes such as the Emergency Credit Line Guarantee Scheme (ECLGS) were introduced to

provide liquidity support, industry reports suggest that many small enterprises struggled to navigate procedural requirements, resulting in low uptake of formal financial assistance (RBI, 2021).

This financial strain had cascading implications for the recovery process. Firms postponed procurement, delayed wage payments, and scaled down operations to conserve cash, thereby prolonging the time required to restore normal production levels (ILO, 2020). Additionally, liquidity constraints limited the ability of firms to invest in technological upgrades and health compliance measures, both of which were critical for post-pandemic operational continuity (McKinsey & Company, 2021).To mitigate such systemic risks, policy interventions must focus on strengthening credit access mechanisms, simplifying disbursement procedures, and promoting alternative financing models, such as supply chain financing and digital credit platforms. Furthermore, cluster-level financial support frameworks, including revolving credit pools and risk-sharing arrangements, can help improve resilience against liquidity shocks in the future (OECD, 2021).

7. Export Market Policy Changes

The survey results indicate that 172 respondents (57.3%) identified export market policy changes as a significant recovery challenge, while 128 respondents (42.7%) did not consider it a major issue (Fig 1). The chi-square value of 6.45 exceeds the critical threshold of 3.84 at $df = 1$ and $\alpha = 0.05$, confirming statistical significance at $p < 0.05$ (Table 1). Although the chi-square score for this factor is lower compared to supply-side challenges, its significance demonstrates that policy uncertainty in export markets was an important constraint for the Bhilwara textile industry during the post-pandemic recovery phase.

The export-oriented textile firms in Bhilwara encountered multiple policy-induced frictions during the pandemic recovery period. Approximately 57.3% of respondents reported difficulties linked to changes in export documentation, certification requirements, and shifting regulatory frameworks across destination markets. These findings align with OECD (2021) and UNCTAD (2020) assessments, which highlighted that global trade restrictions and altered compliance norms were key barriers for international supply chains during COVID-19.

The disruption was twofold. First, destination countries implemented new health and safety documentation protocols, such as mandatory COVID-19 compliance certificates for shipments, which increased administrative complexity and extended lead times. Second, volatile export policies, including sudden tariff changes, modified customs clearance procedures, and export bans on certain textile categories, contributed to unpredictability in trade operations (OECD, 2021). For firms operating under tight delivery schedules, these delays undermined buyer confidence and strained contractual relationships.

The Bhilwara cluster, which exports significant volumes of synthetic and blended fabrics to global markets, was disproportionately affected by such uncertainties. Exporters faced not only higher transaction costs but also increased financial risks, as delayed shipments often resulted in penalty clauses or cancellation of orders by international buyers (CRISIL, 2021). In addition, the lack of real-time regulatory information and inconsistent interpretation of rules across ports and customs points further exacerbated compliance difficulties (UNCTAD, 2020).

This challenge reflects a broader structural vulnerability in global value chains, where policy misalignments and inadequate trade facilitation mechanisms amplify the effects of systemic shocks. From a resilience perspective, it underscores the need for predictable, harmonized trade

policies, digitalization of documentation systems, and bilateral agreements that ensure regulatory clarity during crises. OECD (2021) advocates for the adoption of single-window clearance systems and e-certification platforms to minimize paperwork-related delays, which proved critical during pandemic-induced mobility restrictions.

At the industry level, firms can mitigate policy uncertainty by diversifying export markets, developing compliance capabilities, and engaging in strategic partnerships with global buyers to share regulatory intelligence. These measures, combined with cluster-level trade facilitation support and government-to-government coordination, can help reduce policy-related risks in future disruptions.

8. Power Supply Interruptions

The findings show that 170 respondents (56.7%) reported power supply interruptions as a significant constraint, while 130 respondents (43.3%) did not view it as a major issue (Fig 1). The chi-square statistic of 5.33 (Table 1) exceeds the critical value (3.84) at $df = 1$ and $\alpha = 0.05$, confirming statistical significance at $p < 0.05$. Although this factor recorded a lower chi-square value compared to supply chain and labour challenges, it indicates that energy reliability remains a critical operational determinant for the textile sector in Bhilwara.

Continuous and stable electricity supply is fundamental to textile manufacturing, which relies on energy-intensive processes such as weaving, dyeing, and finishing. The analysis reveals that over half of the respondents (56.7%) experienced disruptions in power supply during the post-pandemic recovery phase, adversely affecting production schedules and cost efficiency. These interruptions not only caused delays but also increased operational costs due to reliance on diesel-based captive power units, which became necessary to maintain continuity (CRISIL, 2021).

Such disruptions aggravated existing constraints, as firms already facing raw material shortages and labour gaps struggled to maintain delivery commitments. ILO (2020) and OECD (2021) reports suggest that inadequate energy infrastructure in developing economies amplified the impact of the pandemic on manufacturing clusters, leading to production inefficiencies and longer recovery timelines. Bhilwara's dependence on grid-based power supply, without robust alternative energy systems, made it particularly vulnerable to load shedding and unplanned outages, especially during peak production periods.

Policy recommendations include investment in smart grid systems, decentralized renewable energy solutions, and captive solar or hybrid power models to reduce reliance on unstable grid supply. At the cluster level, shared energy backup facilities and government-subsidized energy infrastructure upgrades could enhance resilience in future disruptions.

9. Technological Adoption for Remote Coordination

The study indicates that 169 respondents (56.3%) recognized technological adoption for remote coordination as a significant recovery challenge, while 131 respondents (43.7%) did not (Fig 1). The chi-square statistic of 4.81 (Table 1), which is above the critical threshold of 3.84 at $\alpha = 0.05$, confirms statistical significance at $p < 0.05$. This reflects the structural limitations of digital integration within the Bhilwara textile cluster.

The pandemic accelerated the need for digital transformation in global supply chains, as remote operations became essential for managing procurement, design collaboration, and client communication. However, the Bhilwara textile industry, dominated by small and medium-sized enterprises (SMEs), faced significant hurdles in adopting digital tools. Approximately

56.3% of respondents cited the lack of adequate technological infrastructure and digital literacy as a major constraint, consistent with OECD (2021) findings that low digital adoption rates among SMEs hindered crisis adaptability.

The reliance on face-to-face negotiations, manual documentation, and traditional procurement practices created friction when physical mobility was restricted. McKinsey & Company (2021) notes that firms globally shifted to virtual showrooms, e-sourcing platforms, and cloud-based ERP systems to sustain buyer engagement and manage production schedules. However, limited investment capacity and technical know-how prevented many Bhilwara firms from leveraging these solutions effectively.

This digital gap emphasizes the urgency of capacity-building programs, affordable technology access schemes, and cluster-level digital platforms to enable SMEs to participate in remote coordination processes. Without such interventions, technological inertia could continue to undermine competitiveness in an increasingly digitalized global textile market.

10. Market Access & Buyer Confidence

The analysis shows that 167 respondents (55.7%) agreed that market access and buyer confidence were important recovery challenges, while 133 respondents (44.3%) did not (Fig 1). The chi-square value of 3.85, though the lowest among all factors, slightly exceeds the critical value of 3.84 at $\alpha = 0.05$, establishing statistical significance (Table 1). This indicates that while this factor ranked last in intensity, it remains a relevant barrier in the post-pandemic context.

Restoring buyer confidence and securing market access emerged as a subtle yet significant challenge for Bhilwara's textile firms during the recovery phase. Approximately 55.7% of respondents reported difficulties in attracting new orders and sustaining existing buyer relationships due to heightened uncertainty and risk-averse purchasing behavior in the global textile market. According to UNCTAD (2020) and McKinsey & Company (2021), international buyers reduced sourcing commitments and tightened contractual terms to minimize inventory risks during the pandemic, creating downward pressure on suppliers.

For Bhilwara exporters, this translated into lower order volumes, extended payment cycles, and stricter compliance demands, which strained liquidity and operational flexibility. Additionally, competition from digitally advanced textile hubs that quickly adapted to virtual buyer engagement further marginalized firms lacking digital readiness (OECD, 2021). These dynamics underscore the strategic importance of relationship management, digital marketing adoption, and participation in virtual trade fairs to sustain market linkages during systemic disruptions.

Policy interventions to address these challenges may include export promotion schemes, credit guarantees for export orders, and training programs for virtual buyer engagement. At the cluster level, collective branding initiatives and shared digital platforms can enhance visibility and trust in international markets.

Statistical Significance of Recovery Factors

The chi-square test was employed to determine whether the observed distribution of responses for each recovery challenge differed significantly from the expected distribution under the null hypothesis of equal probability (Yes = 150, No = 150). The critical value for the chi-square

statistic at 1 degree of freedom (df = 1) and a significance level of $\alpha = 0.05$ is 3.84. Any calculated chi-square value exceeding this threshold indicates that the observed variation is unlikely to have occurred by chance, and therefore, the corresponding factor is statistically significant in influencing recovery outcomes.

In this study, all ten recovery factors—ranging from raw material shortages to market access and buyer confidence—recorded chi-square values greater than 3.84, establishing their statistical significance. This means that the proportion of respondents who identified these factors as major challenges was not random but represents a consistent pattern across the surveyed population.

Moreover, the magnitude of chi-square values varies substantially across factors, indicating different levels of association with recovery constraints. For instance, Raw Material Shortage ($\chi^2 = 17.28$) and Decline in Demand ($\chi^2 = 16.33$) demonstrated the strongest associations, suggesting that these were highly critical impediments to recovery, significant at $p < 0.001$. Factors such as Labour Unavailability ($\chi^2 = 12.81$) and Logistics & Transportation Disruption ($\chi^2 = 12.00$) were also significant at the 0.001 level, underscoring their systemic importance. In contrast, factors like Technological Adoption for Remote Coordination ($\chi^2 = 4.81$) and Market Access & Buyer Confidence ($\chi^2 = 3.85$), while still statistically significant at the 0.05 level, exerted relatively lower influence compared to supply-side challenges (Table 1).

The consistent rejection of the null hypothesis across all ten factors reinforces the conclusion that recovery challenges in the Bhilwara textile industry were multifaceted and deeply interconnected, rather than incidental. This statistical evidence provides a strong empirical basis for prioritizing interventions across these dimensions to enhance post-pandemic resilience.

Conclusion

The study concludes that post-COVID-19 recovery in the Bhilwara textile industry was hindered by multiple interrelated challenges, primarily raw material shortages and demand contraction, followed by labour unavailability and logistical disruptions. These factors highlight the sector's dependency on global supply chains and its limited capacity to absorb systemic shocks. Although health compliance, liquidity, and digital adoption were secondary challenges, their cumulative impact prolonged recovery timelines. The consistent statistical significance across all factors demonstrates that addressing these vulnerabilities requires a multifaceted approach integrating policy, infrastructure, and technological solutions.

Recommendations

1. Supply Chain Diversification: Establish local sourcing networks and promote cluster-based raw material reserves to reduce dependence on global suppliers.
2. Financial Support Mechanisms: Implement credit guarantee schemes and low-interest financing for SMEs to mitigate liquidity constraints.
3. Labour Welfare Policies: Develop social security frameworks and wage assurance programs to retain workforce during crises.

4. Digital Transformation: Facilitate adoption of ERP systems, virtual marketplaces, and remote coordination platforms through training and subsidies.
5. Infrastructure and Energy Reliability: Invest in smart grid systems and renewable energy options to minimize production disruptions.
6. Market Confidence Building: Strengthen buyer relationships through virtual trade fairs, compliance certifications, and risk-sharing contracts.

References

2. Afsar, R., Hossain, N., & Rahman, M. (2021). COVID-19 and its impact on the garment industry in Bangladesh. *Journal of Business and Society*, 23(2), 45–59.
3. Baldwin, R., & Freeman, R. (2022). Risks and global supply chains: What we know and what we need to know. *Journal of Economic Perspectives*, 36(4), 23–46.
4. Banga, R., & Sharma, A. (2021). COVID-19 and Indian textiles: Challenges and opportunities. *Indian Journal of Economics and Development*, 17(3), 113–129.
5. Bhatia, S., & Rao, P. (2021). Digitalization in textile supply chains: Post-pandemic transformation. *International Journal of Industrial Management*, 9(1), 76–89.
6. Bhunia, A., & Das, A. (2021). Financial resilience in SMEs during COVID-19: A case study of Indian textile firms. *Asian Journal of Finance and Accounting*, 13(1), 32–51.
7. Bhilwara Case Notes. (2020). *Cluster-level impact of COVID-19 on the textile industry*. Bhilwara Research Foundation.
8. Business & Human Rights Resource Centre. (2020). *COVID-19: Impact on garment workers and supply chains*. Retrieved from https://www.business-humanrights.org/
9. Chatterjee, D., Singh, P., & Gupta, R. (2021). Reverse migration and industrial labour shortages: Evidence from India's garment sector. *Economic and Political Weekly*, 56(19), 54–62.
10. Choudhary, V. (2022). Energy challenges in Bhilwara textile cluster: Post-pandemic realities. *Journal of Energy and Industry Studies*, 14(2), 88–101.
11. Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management*, 15(2), 1–14.
12. CRISIL. (2021). *COVID-19 impact on India's textile and apparel sector*. CRISIL Research Report.
13. Environmental Studies Bhilwara. (2019). *Infrastructure and sustainability issues in the textile industry*. Bhilwara Environmental Review.
14. Fernandes, A., & Patel, N. (2021). Buyer confidence and supply chain recovery post-COVID-19. *Journal of Global Business Studies*, 10(4), 210–228.
15. Gereffi, G. (2020). What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies. *Journal of International Business Policy*, 3, 287–301.
16. Ghosh, A., & Kumar, V. (2021). Labour dynamics in Indian manufacturing during COVID-19. *Journal of Labour Economics*, 42(3), 77–95.
17. Hosseini, S., & Ivanov, D. (2021). A risk assessment model for supply chain disruptions: Lessons from COVID-19. *Annals of Operations Research*, 1–27.

18. International Labour Organization (ILO). (2020). *The supply chain ripple effect: How COVID-19 is affecting garment workers and supply chains*. ILO Briefing Paper.
19. International Labour Organization (ILO). (2021). *Safe return to work: Practical guide for the textile and garment industry*. ILO Publication.
20. Khan, S., Rahman, M., & Hoque, R. (2021). COVID-19 and textile supply chain disruptions: Evidence from Asia. *Journal of Supply Chain Management Research*, 15(2), 60–78.
21. Kothari, C. R. (2014). *Research methodology: Methods and techniques* (3rd ed.). New Age International.
22. Kumar, A., & Singh, S. (2021). Liquidity constraints and industrial recovery in India's MSME sector. *Journal of Economic Development Studies*, 19(3), 145–162.
23. McKinsey & Company. (2020). *The state of fashion 2020: Coronavirus update*. McKinsey Global Institute.
24. McKinsey & Company. (2021). *The state of fashion 2021: In search of promise in perilous times*. McKinsey Global Institute.
25. Mehta, R., & Kumar, A. (2021). COVID-19 and its economic impact on India's textile clusters. *Indian Journal of Industrial Research*, 45(1), 33–48.
26. Mehrotra, S. (2021). Reverse migration and challenges of labour retention in India. *Social Change Review*, 51(2), 101–119.
27. Ministry of Textiles. (2021). *Annual report on textile industry performance*. Government of India.
28. Ministry of Textiles. (2022). *Textile policy and industry outlook*. Government of India.
29. NASSCOM. (2021). *Digital adoption in Indian SMEs: Post-COVID recovery strategies*. NASSCOM Report.
30. Nguyen, T., & Do, H. (2022). Supply chain disruptions and textile industry resilience in Vietnam. *Asian Journal of Economic Studies*, 16(1), 87–99.
31. NIFT Research Briefs. (2021). *Compliance costs and operational constraints in the Indian apparel sector post-COVID-19*. National Institute of Fashion Technology.
32. Organisation for Economic Co-operation and Development (OECD). (2021). *COVID-19 and global value chains: Policy options to build more resilient production networks*. OECD Publishing.
33. Raj, S., & Khanna, R. (2022). Digital transformation in textile value chains: A strategic perspective. *Journal of Operations and Information Management*, 11(2), 98–112.
34. Raza, H., Qureshi, A., & Ahmad, F. (2021). Raw material volatility and supply chain resilience: Lessons from COVID-19. *Journal of Materials and Supply Management*, 28(3), 65–78.
35. Reserve Bank of India (RBI). (2020). *Financial stability report*. RBI Publication.
36. Reserve Bank of India (RBI). (2021). *Credit stress in MSMEs post-pandemic*. RBI Publication.
37. Sarkar, S., & Bandyopadhyay, S. (2022). Building supply chain resilience in Indian manufacturing. *International Journal of Production Research*, 60(12), 3621–3640.
38. Singh, P., & Mehta, R. (2020). Infrastructure bottlenecks in India's textile industry: A case study of Bhilwara. *Journal of Infrastructure Development*, 12(1), 43–58.

39. SME Policy Notes. (2021). *Policy support for MSME recovery post-COVID*. Ministry of MSME.
40. United Nations Conference on Trade and Development (UNCTAD). (2020). *Impact of the COVID-19 pandemic on trade and development*. UNCTAD Report.
41. United Nations Conference on Trade and Development (UNCTAD). (2021). *Global trade update: Recovery trends in textiles and apparel*. UNCTAD Report.
42. Vogue Business. (2020). *How fashion supply chains are adapting to the pandemic*. Retrieved from https://www.voguebusiness.com/
43. World Bank. (2021). *Resilient recovery in global value chains: Lessons from COVID-19*. World Bank Group.
44. World Health Organization (WHO). (2020). *COVID-19 and workplace safety: Guidance for employers and workers*. WHO Publication.
45. World Trade Organization (WTO). (2020). *Trade in the time of COVID-19: Lessons and challenges*. WTO Report.
46. World Trade Organization (WTO). (2021). *Annual trade report 2021*. WTO Secretariat.