Material waste in fashion industry in Bangladesh: a mixed method study on 10 selected factories

By

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Declaration

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Approval

The thesis titled "Material waste in fashion industry in Bangladesh: a mixed method study on 10 selected factories" submitted by Md. Mainul Islam Sajib, ID: 21282034 of fall 2021 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of MPSM.

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Ethics

Ethics Statement In order to ensure the research was conducted with honesty and transparency; as well as to avoid harming any participants, the thesis was regulated by the following ethical considerations:

● Participants were briefed regarding the nature of the research and questionnaire and their full consent were obtained before the study.

● Respondents' identities have been kept confidential.

● Works of other authors used in the dissertation have been acknowledged with the use of numbered referencing system.

● Misinterpretation regarding the objective of the paper has been avoided.

● All possible sources of conflict, affiliations and sources of funding has been declared.

● All type of bias in the primary data findings has been avoided as best to the researcher's abilities.

● All research related communication was conducted with honesty, integrity and transparency.

Abstract

This study investigates the material wastage at different stages of textile and apparel production, including spinning, fabric manufacturing, apparel manufacturing, and wet processing (dyeing/finishing/washing). The spinning stage exhibits a material conversion rate of 78%, with process losses and quality-related rejections contributing to the wastage. In fabric manufacturing, the weaving process results in a material conversion rate of 92%, with factors such as poor material handling and lack of expertise leading to wastage in warping, sizing, drawing-in, weaving, and inspection sections. Apparel manufacturing consumes finished fabric at a rate of 120.4 kg for every 100 kg of final products, and the cutting section accounts for a significant 10% wastage. Sewing, finishing, and inspection sections also contribute to wastage due to various issues. In wet processing, the material conversion rate is 82%, with fabric dyeing experiencing a wastage of 21 kg per 100 kg of fabric, primarily attributed to uneven dyeing. The study underscores the importance of understanding and addressing the sources of wastage, including poor material handling, quality issues, process losses, and rejections, to enhance production efficiency and reduce costs in the textile and apparel industry. The findings emphasize the need for industry stakeholders to focus on process optimization, quality control, and improved material handling practices for a more sustainable and efficient production chain.

Keywords

Textile waste, apparel production, material wastage, spinning, fabric manufacturing, wet processing, quality control, sustainability, efficiency

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Chapter-I: Introduction

1.1Background

The global textile industry is a vast and intricate web of production, trade, and consumption that significantly affects economies and daily lives. This worldwide sector, which has its roots everywhere, encompasses a wide range of activities, from the farming of raw materials to the production of different finished commodities.

Essentially, the textile industry employs a large number of people, contributes significantly to national GDPs, and generates employment for millions of people. Like a worldwide tapestry, its supply chain links raw resources from all over the world, including as cotton, wool, and synthetic fibers. Spinning, weaving, knitting, dyeing, and other intricate procedures are some of the stages these materials go through to become textiles used in clothing, home goods, and technical uses.

Due to fast fashion, the number of production and usages of apparel items is increasing day by day (Maeen, 2022), which generates a substantial amount of waste in every stage of manufacturing, including spinning, knitting/weaving, dyeing, apparel making, and finishing. There is also the issue of overproduction; only 30% of the clothing produced today is sold at the recommended retail price, another 30% goes in the sales and 40% remains unsold or even fails to reach the shops (Koszewska, 2018). Only in 2014, 92 million waste is generated by global textile industry, where merely a minimum amount being repeatedly used. (Pensupa, 2017). The weight of 577,000 tons, discarded like old toys. That's the annual textile waste generated by Bangladesh's garment industry and fabric mills. 250,000 tons of pure, recyclable cotton. That's almost half the total waste, representing a potential value of 100 million USD. Bangladesh is currently heavily reliant on the importation of textile fiber: in 2019, the country imported 1.63 million tons of staple cotton fiber for a value estimated to be US$3.5 billion. (Pavarini, 2021). Besides, global textiles waste is estimated to increase 60% each year between 2015 and 2030, generating an additional 57 million tons of waste every year, and reaching a total of 148 million tons annually (Niinimamp, 2020)
The textile business is closely associated with fashion, shaping and reflecting contemporary trends and tastes. Fast fashion has taken off due to the quickening pace of fashion cycles, completely changing the ways in which clothing is made, worn, and discarded. Discussions over sustainability,

working conditions, and the industry's effects on the environment have been spurred by this occurrence.

With the introduction of automation, digital printing, and smart textiles that adapt to customer demands or changes in the environment, technological innovation has completely changed the textile production industry. This explosion of technology has made it possible to produce goods with greater efficiency, with less waste, and with more individualized customer experiences.

1.2 Textile sector in Bangladesh

The fashion industry in Bangladesh, particularly the Ready-Made Garment (RMG) sector, has positioned the country as a key player in global textile trade. The focus on value chain integration, from sourcing raw materials to producing garments, has not only boosted the nation's economy but has also established Bangladesh as a major exporter of apparel worldwide. This growth has translated into millions of job opportunities and has significantly contributed to the GDP of the country.

In the apparel industry the waste that is generated is known as ‘Jhut' (Patnaik, 2021) . Because of environmental impact, material waste is one of the top reason as it creates the direct environmental impact (Sarkar, 2020); (Uddin, 2021). Bridging the data gap on textile waste is like building a bridge over a mountain of discards. This step is essential to connect the present with a sustainable, circular future for the industry. (Shirvanimoghaddam, 2020) Alongside its adverse effects on the surrounding environment, material waste results in potentially a massive loss in value and business opportunity in the textile-apparel production chain. Bangladesh is a key manufacturing hub for global apparel and textiles products, and the industry plays a significant role in the country's socioeconomic development (Habib, 2021). Under SDG umbrella, a 10-year Framework Programme (10YFP) on Sustainable Consumption and Pattern (SCP) was adopted, known as SDG12, to accelerate practices of SCP and resource efficiency initiatives (UNDESA, 2014). The framework targets environmental sustainability to minimize resource consumption, waste generation, and pollution levels throughout the supply chain, from manufacturing to post-end use. The GOB took several steps to reduce waste by recycling and reuse (SDG Cell, 2018).Striking the right balance among these elements will be crucial as the sector continues to evolve and contribute to Bangladesh's journey of development and global engagement.

1.3 Textile product waste (Material)

Textile product waste, stemming from discarded materials, represents a critical concern within the broader context of sustainability and resource management. The sheer volume of textile waste generated globally, ranging from clothing to home goods, highlights the environmental challenges associated with consumption and disposal.

The value of the material wastage in textile industry was USD 1.3 trillion only in 2015. It consumed approximately 53 million tons of textile fiber, of which 73% was landfilled or incinerated. Less than 1% of material is recycled for new clothing, representing a loss of more than USD 100 billion worth of materials each year (MacArthur Foundation, 2017). The major fibers that were used to manufacture apparel in 2018 were mostly synthetic fibers (~62.2%), followed by cotton (~24.4%) and others such as rayon and wool (~14%). (Khan, 2015) .The production waste, produced during textiles and apparel manufacturing, includes fiber, yarn, fabric, and apparel. During spinning, short fiber stays on the machine which is readily familiar as 'cotton lint' (Meloy, 1918). Material waste from these stages consists of fly fibers and greige or unfinished fabrics (Sadi & Guha, 2016). The wet processing industry represents the dyeing, finishing, printing, and washing stages, where the greige fabric is colored and treated with the required chemicals for the desired quality of finished fabric (Khan, 2020); (Uddin, 2015) . Dyed or fabrics rejected due to quality issues become material waste from the wet processing stage (Pensupa, 2017). In garment section cut pieces generated which is mainly responsible for wastage (Kavitha, 2014).

Approximately 65% of a garment's climate impact stems from fabric production. With 53 M tons of fiber produced every year and 87% ending in landfills, the fashion industry is polluting and wasting precious resources. (Cristina, 2023)The development of the convection industry is increasing due to the fast fashion trend. The impact of this increase is the accumulation of fabric waste because fabric is an inorganic waste that is difficult to decompose. It is necessary to explore waste materials as a form of concern for the environment through sustainable design. (Fanny A.d, 2021) Recent reports have estimated that 75% of materials used in the production and after the use of clothing are landfilled or incinerated. 4,11 Approximately 23% of discarded clothing is collected for recycling, with less than 1% of the recovered fibers used to reproduce clothing, closing the loop in fiber-to-fiber recycling. (Rivalani, 2023)

After China, Bangladesh is the second-largest exporter of readymade apparel globally (Hamja, 2019) with a strong production capacity, quality and growth (Miguel, 2021). It consists of more than 83% of Bangladesh's total exports, worth over 33 billion USD in 2019, and holds a 6%market share of global apparel exports (BKMEA, 2019). More than 4 million worker is in apparel sector (BKMEA, 2019) and again more than 5 million people is worked in textile sector (BTMA, 2019). In just 3 years back, more than four thousand factories found covering of 1487 textile companies, 432 spinning units, 809 weaving units, and 246 wet processing units (BTMA, 2019).

Bangladesh's textile industry's success hinges heavily on imported raw materials, with cotton leading the charge. In 2019, a staggering 1.785 billion kilograms of cotton were brought in, alongside nearly 100,000 tons of polyester and viscose. (BTMA, 2019). 100% of raw fibers, 65% of woven fabrics, and 10% of knitted fabrics are imported to meet the demand of the apparel industry (BKMEA, 2019). Material waste can make or break profits in apparel production, where it represents the biggest chunk of the cost. Yet, in Bangladesh, the amount of discarded fabric remains a mystery, shrouded in limited data. (Rahman, 2016) Reported 26.5% fabric wastage in their investigation of a knit T-shirt factory. According to their study, 13.57% of this waste is unavoidable cutting section waste, whereas the rest can be optimized. Another report says that 550 tons of apparel waste is exported from Chittagong port every day (TextileToday, 2017) . Even with the best optimization methods, we have found the volume cannot be lower than 20% (Runnel, 2019). The report throws a staggering figure: the apparel industry discards at least 500,000 tons of leftovers annually, not to mention additional waste generated throughout production. But while these mountains of scrap hold significant economic potential if managed correctly, we still lack crucial data on their exact size and value.

1.4 LCA:

In the ever-evolving world of the Fashion Industry, the Textile sector plays a crucial role in creating the latest trends that we see on the runways. However, with great innovation comes great responsibility. It is essential to understand the environmental impacts of textile products throughout their entire life cycle.

LCA provides a holistic view of the environmental consequences associated with textiles, helping to guide sustainable decision-making within the industry. The increased awareness of the importance of environmental protection, and the possible impacts associated better understand and address these impacts. LCA is a powerful tool emerging to dissect the environmental footprint of textiles. (STANDARD, 2006)

Unlike other tools, LCA tackles the tricky issue of environmental problems jumping from one area to another, ensuring a holistic assessment. (Curran, 2013).LCA offers several benefits, including a holistic perspective, informed decision-making, and the identification of environmental hotspots. These advantages have been discussed and highlighted in literature on environmental management and sustainability. (Curran, Mary Ann, 2012)

1.5ResearchGap:

In the context of textile production, there hasn't been much effort to comprehensively assess and quantify material waste by considering a life cycle assessment. Here the intention is to fill this gap by conducting a study focused on understanding material waste at every stage of the textile operation process. This research aims at investigating material waste in the fashion industry of Bangladesh from a LCA perspective. In achieving the goal, the research will conduct a comprehensive analysis of various stages of the fashion product life cycle, including raw material extraction, production, and consumption, and eventually identify “hotspots” of materials waste.

1.6 Objective of the study:

The main objective of this study are as follows,

1. Find out the material wastage in different segment of textile and apparel production: spinning, weaving, apparel manufacturing and wet processing.
2. Quantify the material conversion rate at each stage for better understanding of the extent of wastage.
3. Analyze the factors affecting to wastage, including raw material quality, poor material handling, other quality issues, process losses, and rejections.
4. Find out the strategies for reducing material wastage in the textile and apparel industry.

Chapter-II: Methodology

2.1. Method and sampling

We investigated this study thoroughly by analyzing a range of individual cases in an exploratory manner. (Yin, 2014). Purposive sampling followed by snowball techniques was undertaken to select the case company and the participants who would answer the research questions (Yin, 2014) and they were selected according to topic relevance, experiences and knowledgeability, (Patton, 2015).

2.2. Data collection and analysis

The study utilized both quantitative and qualitative data to capture a wide range of information related to material waste. For the quantitative section, data was collected directly from the approved factory. This involved relying on production reports and floor issue reports. The primary method of data collection was a survey questionnaire distributed to the selected respondents. The questionnaire comprised structured questions to gather quantitative data on various aspects of material waste, such as material wastage in spinning, weaving, apparel and wet process sections.

To ensure comprehensive data, the research protocol targeted a broad range of participants across various stages of apparel production (spinning, knitting, dyeing, etc.) and different levels of the company hierarchy (directors, managers, executives, etc.) (Easterby-Smith, 2018). To collect the raw data for calculation, the questionnaire was sent to the company contact person through email, followed by follow-up communication with the industries over telephone and email. Starting with a small group, the study gradually recruited more companies through the snowball method, ultimately forming a representative sample spanning all stages of textile-apparel production (spinning, knitting, dyeing/finishing, apparel) and diverse product categories (knitted, woven, denim). Collaborations with participating companies and the researcher's network played a crucial role in identifying new participants. Information from the case company website, archival records, documents, relevant industry sources and follow-up communications were employed to ensure the greater reliability and validity of the collected data (Houghton, 2013)

2.3 Sample size & Source of data:

A multi-stage sampling method has been implemented. Building upon established industry networks, the initial pool of case companies was established by examining available directories and membership lists from textiles and apparel organizations**.** Case companies were approached through email or directly via phone. Selection criteria were: (i) the company should be based close to Dhaka Bangladesh, (ii) involved in the textiles and apparel export-oriented manufacturing business, and (iii) willing to share information for research purposes. Although we approached 23 companies comprising different manufacturing factories in the textiles-apparel production chain, only 10 companies, after repeated persuasion, including spinning, fabric manufacturing, dyeing/washing/finishing (wet processing) and apparel manufacturing, agreed to participate.

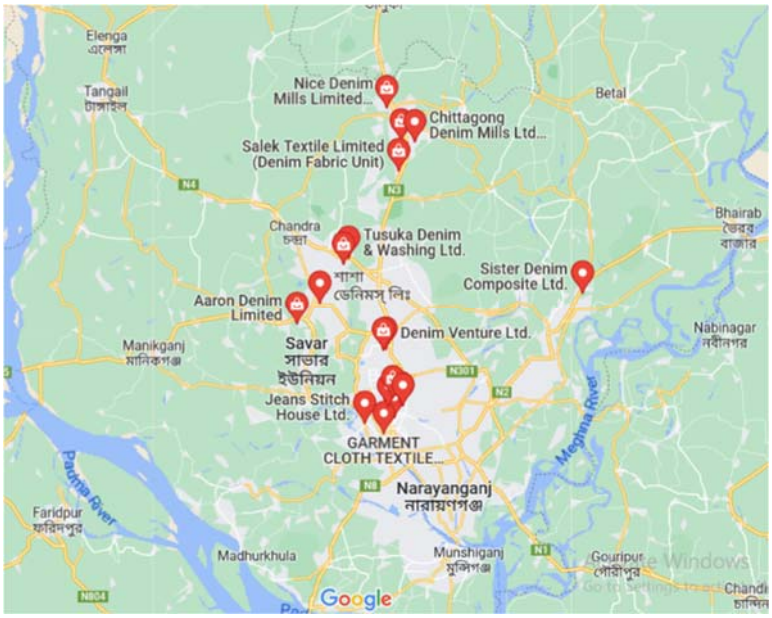

Fig 1: Location of selected factories for research.

A total of 10 textile factories in Dhaka, named Nice denim, Argon Denim, Chittagong Denim Ltd, Salek Textile Ltd. (Denim Unit), Jamuna Textile ltd, Shasha Denim Ltd., Aaron Denim Ltd., Denim Venture Ltd., Chittagong Denim mill Ltd., Sister denim Ltd. finally has been chosen. The questionnaire comprises structured questions to gather quantitative data on various aspects of material waste, such as fiber consumption and utilization in spinning, weaving, wash process and garments section. This information was collection from the production report and physical discussion. Participants who are participated on the research is mentioned on next page,

Production section	End product category	Respondent position
Spinning	Finished yarn	Manager, Spinning
Spinning	Finished yarn	Manager, Quality
Spinning	Finished yarn	Assistant general manager, Spinning
Spinning	Finished yarn	Deputy Manager, Spinning
Spinning	Finished yarn	Quality assurance, Spinning
Weaving	Fabric	Head of Weaving
Weaving	Fabric	Manager, Weaving
Weaving	Fabric	Shift in charge, Weaving
Apparel	Garment	Manager, Production
Apparel	Garment	Floor supervisor
Apparel	Garment	Line in charge
Apparel	Garment	Assistant general manager, production
Wet processing	Finished garment	Production Manager, Wash
Wet processing	Finished garment	Unit Manager, Wash
Wet processing	Finished garment	Floor in charge, Wash
Wet processing	Finished garment	Deputy Manager, Wash

Table 1: Participants profile.

With regard to qualitative data, several number key informant interviews (KIIs) were conducted. KII used a semi-structured questionnaire and industry experts, consumers, and stakeholders were the respondents. A list of respondents are given in Table 1. KII were conducted to gain qualitative insights into waste scenarios, industry practices, consumer behaviors, and motivations. These individuals were chosen for their in-depth understanding and experience with material waste, ensuring valuable insights into its implementation and utilization within the institute. Besides, industry reports, journal articles, and gray literature were reviewed for collection of relevant information. The data collection process did not require ethical approval due to the nature of the research. However, consents were received before interviews and the respondents and participants.

2.4 Data Analysis

Descriptive statistical methods employed to summarize and present the quantitative data, providing a clear overview of respondents' perspectives on material waste. Thematic analysis was conducted for qualitative responses obtained from the interviews.

Chapter-III: Findings

3.1 Spinning data analysis

Waste is generated in all stages of the denim spinning process, from the blow room to the winding machine. The amount of waste generated at each stage depends on a number of factors, including the quality of the raw material, the efficiency of the machines, and the operating practices.

3.1.1 Key Stages of Wastage in Spinning:

The following are the main stages where waste is generated in the denim spinning process:

- **Blow room**: This is the initial stage where raw cotton fibers are opened and cleaned to remove impurities such as dirt, leaves, and short fibers. Wastage can occur if the cleaning process is not efficient, leading to the loss of usable fiber along with the impurities.
- **Carding**: In the carding process, fibers are further cleaned, aligned, and formed into a thin web. Wastage can occur due to the removal of short fibers, dust, and other contaminants. The waste produced in this stage is known as "card waste" or "fly."
- **Draw frame**: During drawing and combing, the fibers are stretched and further aligned to improve their quality and consistency. Combing removes additional short fibers and produces comb waste.
- **Ring frame**: The carded and combed fibers are then twisted and elongated into roving, which are thicker strands of fiber. Some wastage can occur during the roving process due to breakage or inconsistencies. In the spinning process, the roving are twisted into yarns. Wastage can occur due to yarn breakage, poor yarn quality, or other issues with the spinning machinery.
- **Winding**: After spinning, the yarns are wound onto bobbins or cones for storage and transportation. Wastage can occur if the winding process is not properly managed, leading to tangles, breakage, or defects in the wound yarn packages.

  Here we collected the data from 10 Textile factories which highlighted on the next page,

Factory Name	Segment	Production Input in Kg	Production output in Kg	Wastage amount in Kg	Wastage %	Total wastage (factory wise)
Nice Denim	Blow room	60000	57520	2480	4.1%	24.3%
	Carding	70000	63500	6500	9.3%	
	Draw frame	75000	72540	2460	3.3%	
	Comber	50000	47850	2150	4.3%	
	Ring frame	80000	78120	1880	2.4%	
	Winding	65000	64360	640	1.0%	
Argon Denim	Blow room	51000	49120	1880	3.7%	31.6%
	Carding	55000	49300	5700	10.4%	
	Draw frame	61000	58100	2900	4.8%	
	Comber	41000	39200	1800	4.4%	
	Ring frame	67500	65720	1780	2.6%	
	Winding	48500	45720	2780	5.7%	
Chittagong denim ltd.	Blow room	35500	33700	1800	5.1%	35.1%
	Carding	41000	36200	4800	11.7%	
	Draw frame	48500	45820	2680	5.5%	
	Comber	38500	36000	2500	6.5%	
	Ring frame	62000	60110	1890	3.0%	
	Winding	51500	49800	1700	3.3%	
Salek Textile Ltd. (Denim Unit)	Blow room	41500	39200	2300	5.5%	35.3%
	Carding	46500	41500	5000	10.8%	
	Draw frame	48000	46100	1900	4.0%	
	Comber	38500	35000	3500	9.1%	
	Ring frame	72000	70110	1890	2.6%	
	Winding	51500	49800	1700	3.3%	
Jamuna Textile	Blow room	70000	68600	1400	2.0%	21.3%
	Carding	80000	72650	7350	9.2%	
	Draw frame	75000	72690	2310	3.1%	
	Comber	60000	58200	1800	3.0%	
	Ring frame	75000	73690	1310	1.7%	
	Winding	70500	68920	1580	2.2%	
Shasha Denim Ltd.	Blow room	58000	56980	1020	1.8%	22.3%
	Carding	70000	63250	6750	9.6%	
	Draw frame	70000	67850	2150	3.1%	
	Comber	55500	53320	2180	3.9%	
	Ring frame	85000	83690	1310	1.5%	
	Winding	60000	58580	1420	2.4%	
Aaron Denim Ltd.	Blow room	60000	57980	2020	3.4%	24.0%
	Carding	70000	62530	7470	10.7%	

	Draw frame	72580	71100	1480	2.0%	
	Comber	48650	46890	1760	3.6%	
	Ring frame	80000	77860	2140	2.7%	
	Winding	65000	63960	1040	1.6%	
Denim venture Ltd.	Blow room	52500	51200	1300	2.5%	24.2%
	Carding	67850	61000	6850	10.1%	
	Draw frame	67852	66980	872	1.3%	
	Comber	48982	46900	2082	4.3%	
	Ring frame	78560	76980	1580	2.0%	
	Winding	66325	63620	2705	4.1%	
Chittagong denim mills Ltd.	Blow room	58852	57100	1752	3.0%	26.3%
	Carding	65669	58200	7469	11.4%	
	Draw frame	74500	72200	2300	3.1%	
	Comber	55500	53622	1878	3.4%	
	Ring frame	78540	76500	2040	2.6%	
	Winding	62365	60569	1796	2.9%	
Sister denim Ltd.	Blow room	52500	50255	2245	4.3%	29.5%
	Carding	61668	54200	7468	12.1%	
	Draw frame	70255	68230	2025	2.9%	
	Comber	50500	47980	2520	5.0%	
	Ring frame	72500	70250	2250	3.1%	
	Winding	60250	58980	1270	2.1%	

Table 2: Wastage during spinning process across factories.

From the data, it is seen that, Chittagong Denim and Salek Textile stand out in a chilling way, with waste exceeding 35%. This is alarming, not just for its environmental impact, but also the lost resources and profitability. These factories urgently need targeted intervention – process audits, technology upgrades, and employee training – to curb their waste monster.

While Argon Denim (31.6%) and Sister Denim (29.5%) linger in the high-waste zone. While not as critical as the Chittagong Denim and Salek Textile, their numbers still raise concerns. Implementing efficient practices adopted by Jamuna and Shasha could significantly bring down their waste.

On the other hand, Jamuna Textile and Shasha Denim shine with their waste percentages below 22%. They are the industry's beacons, showcasing the potential for sustainable denim production. Their strategies - optimized cutting patterns, waste recycling initiatives, and responsible water usage - should be applauded and emulated.

Also, Nice Denim, Aaron Denim, Denim Venture, and Chittagong Denim Mills fall in the 24-29% range. They haven't cracked the Green code yet, but they're not drowning in waste either. Focused efforts on specific areas, like minimizing pre-cutting waste or improving fabric utilization, can propel them towards the Green Zone.

We noticed some differences on working procedure of these spinning factories. For example,

- Jamuna Textile and Shasha Denim are the market leader to maintain minimum material wastage and all of these factories source their raw material from abroad basically from China and Brazil.
- Moreover they have separate quality team to check the fiber quality (raw material of spinning) which plays a significant role here. In addition these two factory use the most updated machine for spinning which is also vital to mention here. If we compare these with the Chittagong Denim and Salek Textile, who has the maximum percentage of wastage, noticed that their raw material is procure from local sources and their machines are back dated. After raising this issues,

I discussed with the concern manager what other factors are responsible for spinning wastage. Below points arises,

3.1.2 Perceptions of manager to reduce wastage:

- **Use high-quality raw materials:** Using high-quality raw materials will help to reduce the amount of waste generated during processing.
- **Maintain and calibrate machines:** Machines should be properly maintained and calibrated to prevent them from causing waste.

- **Train operators:** Operators should be properly trained on how to use the machines and process the material.
- **Maintain Machine Condition and Settings**: Proper maintenance and calibration of spinning machines are essential to minimize waste. Machines that are not well-maintained or set incorrectly can result in excessive fiber breakage and waste production. By ensuring machines are in optimal condition and settings are adjusted correctly, spinning companies can reduce waste and enhance overall performance.
- **Prevent Operator Errors**: Operator errors can contribute to waste in the spinning process. Improper material feeding, equipment handling, or processing techniques can lead to fiber tangling or breakage, resulting in increased waste. By providing proper training and supervision, spinning companies can mitigate operator errors and minimize waste production.
- **Process conditions:** The process conditions, such as the temperature and humidity, can also affect the amount of waste generated. For example, if the humidity is too high, it can cause the fibers to become sticky and difficult to process.

3.1.3 Average segment wise wastage across factories:

On below table, we find out the segment wise average spinning waste generation considering all of the 10 factories. For example wastage in "Blow-room" segment is 4.1%, 3.7%, 5.1%, 5.5%, 2.0%, 1.8%, 3.4%, 2.5%, 3.0% and 4.3% in Nice Denim, Argon Denim, Chittagong Denim, Salek Textile, Jamuna Textile, Shasha Denim, Aaron Denim, Denim Venture, Chittagong denim and Sister Denim accordingly. Therefore the average wastage of "Blow-room" is 3.5%. We find out the average wastage in other segment in across all factories and analyzed below,

- **Blow room (3.5%):** The blow room process in denim spinning involves cleaning and opening the raw cotton fibers. During this stage, approximately 3.5% of the raw material is lost as waste. This wastage includes impurities, short fibers, and other undesirable materials removed from the cotton.
- **Carding (10.5%):** Carding is a critical step where the cleaned fibers are further aligned and made into a thin web. It is during this process that around 10.5% of the material is lost as waste. The waste in carding consists of shorter fibers, naps, and any remaining impurities that were not removed in the blow room.

- **Draw Frame (3.3%):** The draw frame process helps to further parallelize and draft the fibers. Approximately 3.3% of the material is wasted during this stage due to the removal of any remaining impurities and shorter fibers.
- **Comber (4.7%):** Combing is a process that refines the fibers even further by removing shorter and irregular fibers. Around 4.7% of the material is lost as waste during the combing process.

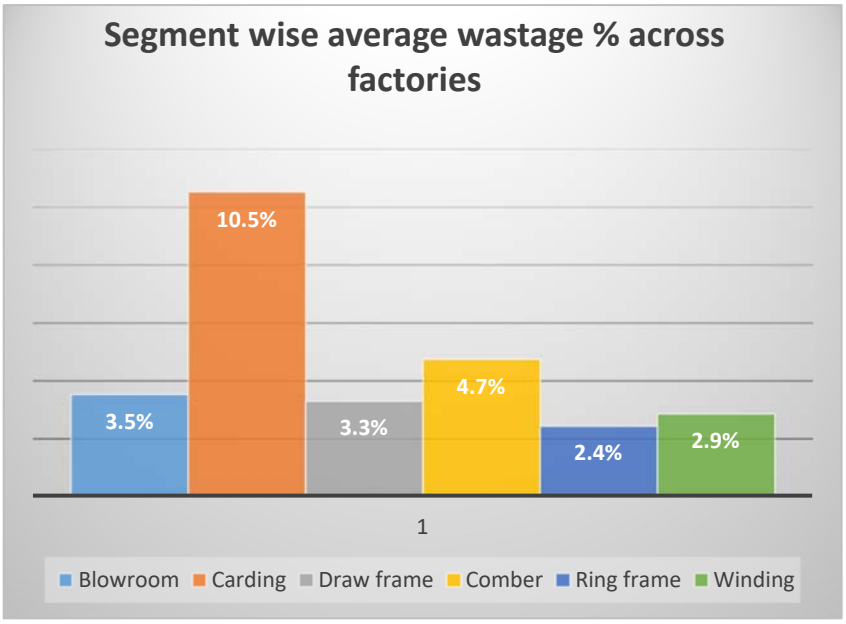

Fig 2: Segment wise Material wastage in each stages of spinning.

- **Ring Frame (2.4%):** In ring frame spinning of original yarn stands. In this section around 2.4% wastage generated mainly because of fiber breakage and irregularities.
- **Winding (2.9%):** Here spun yarn shift to bobbins. It seems that around 2.9% of the material is wasted mainly because of broken yarn ends and yarn defects.

Reducing wastage in spinning is critical for optimizing resource utilization and improving yarn quality. By identifying and addressing the root causes of wastage at each stage, spinning mills can enhance efficiency and profitability.

3.2 Weaving data analysis

Wage is a common issue in denim weaving, occurring at various stages of the production process. Denim weaving involves the creation of woven fabric used for jeans and other clothing items. Understanding the key stages where wastage can generate is crucial in optimizing production efficiency.

3.2.1 Key Stages of Wastage in Weaving:

1. **Warping and Sizing**: During the initial stages, the warp yarns undergo winding onto beams and sizing treatment. Size acts as a protective coating that enhances weaving characteristics. Wastage can occur if the yarns break during these processes, resulting in the removal of unusable sections.
2. **Drawing-In**: In this stage, warp yarns are threaded through the heddles and reed to prepare for weaving. Errors in the drawing-in process, such as misalignment, breakage, or incorrect threading, can lead to wastage.
3. **Weaving:** Numerous factors during the weaving process can contribute to wastage. One of them is broken warp yarn. It my results tension issues, sharp edges or yarn defects.

By addressing wastage at each stage of the denim weaving process, manufacturers can optimize and reduce material loss. Implementing quality control measures and training programs can help wastage and improve overall production outcomes.

Here we collected the data from 10 Textile factories which highlighted on the next page,

Factory Name	Segment	Input	output	Wastage amount	Wastage %	Remarks
Nice Denim	Warping and Sizing	13250	13000	250	1.9%	
	Drawing-In	10500	10350	150	1.4%	
	Weaving	55250	53900	1350	2.4%	
	Inspection and QC	45500	44800	700	1.5%	7.3%
Argon Denim	Warping and Sizing	11000	10810	190	1.7%	
	Drawing-In	10000	9780	220	2.2%	
	Weaving	60000	58410	1590	2.7%	
	Inspection and QC	60000	58950	1050	1.8%	8.3%
Chittagong denim ltd.	Warping and Sizing	15000	14650	350	2.3%	
	Drawing-In	13000	12700	300	2.3%	
	Weaving	55500	54100	1400	2.5%	
	Inspection and QC	48000	47100	900	1.9%	9.0%
Salek Textile Ltd. (Denim Unit)	Warping and Sizing	8000	7800	200	2.5%	
	Drawing-In	7500	7350	150	2.0%	
	Weaving	45000	43600	1400	3.1%	
	Inspection and QC	41500	40500	1000	2.4%	10.0%
Jamuna Textile	Warping and Sizing	22000	21500	500	2.3%	
	Drawing-In	15500	15200	300	1.9%	
	Weaving	75000	71000	4000	5.3%	
	Inspection and QC	62500	61590	910	1.5%	11.0%
Shasha Denim Ltd.	Warping and Sizing	25000	24700	300	1.2%	
	Drawing-In	18900	18500	400	2.1%	
	Weaving	55500	53800	1700	3.1%	
	Inspection and QC	65500	64500	1000	1.5%	7.9%
Aaron Denim Ltd.	Warping and Sizing	11000	10810	190	1.7%	
	Drawing-In	10000	9880	120	1.2%	
	Weaving	60000	58410	1590	2.7%	
	Inspection and QC	60000	58950	1050	1.8%	7.3%

Denim venture Ltd.	Warping and Sizing	11000	10810	190	1.7%	
	Drawing-In	10000	9880	120	1.2%	
	Weaving	60000	58241	1759	2.9%	
	Inspection and QC	60000	58950	1050	1.8%	7.6%
Chittagong denim mills Ltd.	Warping and Sizing	11000	10810	190	1.7%	
	Drawing-In	10000	9780	220	2.2%	
	Weaving	60000	58410	1590	2.7%	
	Inspection and QC	60000	58950	1050	1.8%	8.3%
Sister denim Ltd.	Warping and Sizing	11000	10810	190	1.7%	
	Drawing-In	10000	9740	260	2.6%	
	Weaving	60000	58410	1590	2.7%	
	Inspection and QC	60000	58950	1050	1.8%	8.7%

Table 3: Weaving wastages across factories.

The majority of factories now have wastage around the 7-10% mark, with Salek Textile (10%) and Jamuna Textile (11%) the only ones breaching the single-digit barrier. This downward trend is commendable, showcasing the positive impact of implementing best practices and industry-wide collaboration.

However, amidst the celebration, pockets of opportunity remain. Shasha Denim and Nice Denim stand out as stellar performers, demonstrating that waste minimization below 8% is achievable. When we dive into the backend story of their minimum wastage percentage, below issue appears,

- They use consistent and high quality yarn and all of the yarn had to gone through a strong quality team before further steps.
- They properly maintain yarn storage and handling procedure like maintaining conditioning temperature 22-24 degree centigrade, humidity 50-70%, keep away the fabric from direct source of sun light.
- As they use latest machinery, can maintain a proper rate of tension during weaving. Which is very important for weaving wastage.
- Operator looks more efficient and experienced.

- Some weaving machines may have built-in systems that collect and reuse short yarn ends.

Their strategies deserve to be shared and adopted by others. Additionally, while the single-digit range is a welcome improvement, it shouldn't be the finish line. Continued efforts in optimizing cutting patterns, adopting new technologies, and promoting responsible water usage can push the entire industry even closer to a zero-waste future. The denim journey from the "worrying waste warriors" to these promising results offers a blueprint for further progress. By learning from success stories, prioritizing knowledge exchange, and nurturing a collective commitment to environmental responsibility, the denim industry can weave a sustainable future, stitch by eco-friendly stitch. I discussed with the concern manager what other factors are contributing to generate waste. Below issue arises,

3.2.2 Perceptions of manager to reduce wastage:

- **Raw material quality:** The quality of the raw material, such as the yarn count, strength, and evenness, can have a significant impact on the amount of waste generated.
- **Operator error:** Because of operator error waste may generate. For an instances, if the operator unable to insert thread properly into the machine, it can cause breakage.
- **Process conditions:** Temperature and humidity is also responsible for wastage. It is imperative to process fiber and yarn in standard temperature and humid condition.
- **Poor material handling:** Because of poor handling the waste may generate.
- **Lack of training:** Only the proper trained operator can contribute to reduce wastage. There is no alternative of proper training.

3.2.3 Average segment wise wastage across factories:

The shared information illustrate weaving wastages within the textile industry, and it highlights the average wastage percentages at each stage across 10 factories. Here we analyze the every stages in details,

- **Warping and Sizing (1.87%**): The main task of this process is to prepare warp yarn for weaving look. In this stage around 1.87% material lost due to yarn breakage.

- **Drawing-In (1.91%)**: In this process the warp yarns passes through the heddles and reed of weaving loom. In this process around 1.91% of the material is wasted due to yarn breakage, misalignment, and threading errors.
- **Weaving (3.0%)**: In this stage the maximum wastage generates which is around 3.0%. This wastage happen due to yarn breakage, fabric defects, and the need for continuous machine adjustments to maintain the desired fabric quality.
- **Inspection and QC (1.76%)**: Following the weaving process, fabrics undergo inspection and quality control procedures. Roughly 1.76% of the material is considered waste at this stage, as not all fabric pieces meet the required quality standards and may be rejected or require rework.

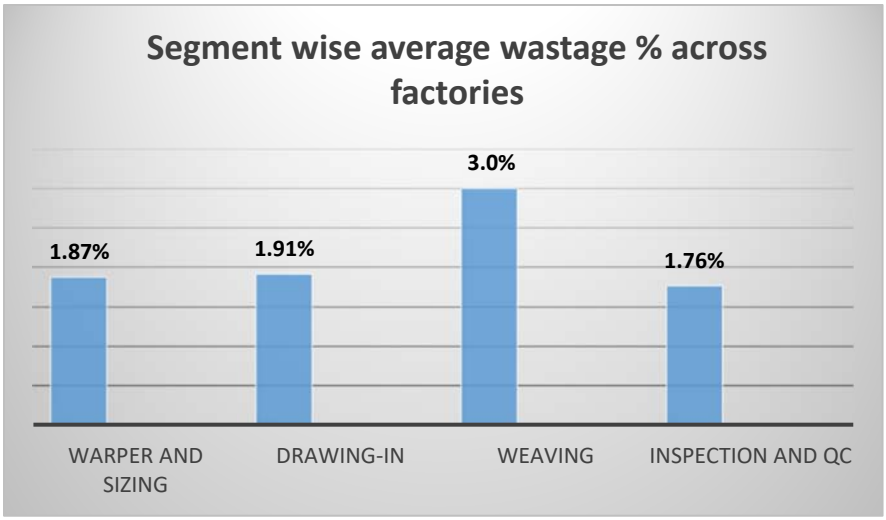

Fig 3: Material waste in weaving process.

Efforts to reduce weaving wastage are essential for enhancing the efficiency and cost-effectiveness of textile manufacturing. Minimizing these wastage percentages helps save materials and costs, ensuring higher product quality, and boosting the competitiveness of the weaving process within the textile industry. Advanced technology, process optimization, and stringent quality control measures are key strategies to mitigate weaving wastage.

3.3 Apparel data analysis

Wastage can occur at various stages during the denim garment making process, which involves transforming denim fabric into finished garments.

3.3.1 Key Stages of Wastage in Apparel:

Here are the stages where wastage can generate in denim garment making:

1. **Cutting :**
   Here's the wastage details that happen in cutting section,

- **Raw material quality**: Raw material quality is important in apparel segment. The good quality raw material ensure less wastage in production. In such case the fabric width, weight plays a significant role for wastage generation.
- **Machine condition and settings:** It is very much important to check the machine condition and setting before start production as wastage generation largely depends on it.
- **Operator error:** Operator plays an important role in apparel section. As an instance, if the operator does not properly position the fabric on the machine, it can cause the fabric to be cut incorrectly, resulting in waste.
- **Machine condition and settings:** Machine setting and condition is important for maintain wastage percentage. Before starting operation it is imperative to check the machine setting.

2. **Process conditions:** It is beneficial if we work in standard temperature and humidity. That's why it encourage to work in room temperature.

3. **Sewing**:
   During the sewing process, several factors can contribute to wastage:

- Sewing Errors: Incorrect alignment or stitching error may cause sewing error.
- Quality Control: If the garment do not meet the requirements for quality then garments may fail in inspection.
- Trimming and Notching: Small amount of wastage generates during trimming and notching.

4. **Finishing**:

   Finishing is the stage where garments check for quality and other necessary things. Wastage may occur is the garment fail to meet quality standard.

5. **Final Inspection**:

   Garments undergo a final inspection to identify defects, inconsistencies, or issues. Garments that do not pass inspection may be considered wastage.

Here we collected the data from 10 Textile factories which highlighted on below,

Factory Name	Segment	Input	output	Wastage amount	Wastage %	Remarks
Nice Denim	Cutting	15000	13650	1350	9.0%	18.5%
	Sewing	20000	19100	900	4.5%	
	Finishing	30000	29200	800	2.7%	
	Inspection	18000	17580	420	2.3%	
Argon Denim	Cutting	18500	16500	2000	10.8%	21.7%
	Sewing	20500	19500	1000	4.9%	
	Finishing	28500	27500	1000	3.5%	
	Inspection	16000	15600	400	2.5%	
Chittagong denim ltd.	Cutting	16500	14500	2000	12.1%	20.5%
	Sewing	17500	16800	700	4.0%	
	Finishing	26000	25510	490	1.9%	
	Inspection	16000	15600	400	2.5%	
Salek Textile Ltd. (Denim Unit)	Cutting	12000	10500	1500	12.5%	23.4%
	Sewing	16000	15100	900	5.6%	
	Finishing	22000	21300	700	3.2%	
	Inspection	14500	14200	300	2.1%	
Jamuna Textile	Cutting	15000	13650	1350	9.0%	18.5%
	Sewing	20000	19100	900	4.5%	
	Finishing	30000	29200	800	2.7%	

	Inspection	18000	17580	420	2.3%	
Shasha Denim Ltd.	Cutting	15000	13650	1350	9.0%	18.5%
	Sewing	20000	19100	900	4.5%	
	Finishing	30000	29200	800	2.7%	
	Inspection	18000	17580	420	2.3%	
Aaron Denim Ltd.	Cutting	18560	16590	1970	10.6%	23.5%
	Sewing	15320	14600	720	4.7%	
	Finishing	24589	23900	689	2.8%	
	Inspection	16800	15900	900	5.4%	
Denim venture Ltd.	Cutting	14500	12550	1950	13.4%	20.6%
	Sewing	18500	17800	700	3.8%	
	Finishing	28020	27500	520	1.9%	
	Inspection	17052	16800	252	1.5%	
Chittagong denim mills Ltd.	Cutting	22000	19758	2242	10.2%	19.7%
	Sewing	28560	27450	1110	3.9%	
	Finishing	31250	30500	750	2.4%	
	Inspection	18450	17850	600	3.3%	
Sister denim Ltd.	Cutting	13250	11950	1300	9.8%	19.1%
	Sewing	14580	13950	630	4.3%	
	Finishing	25692	25100	592	2.3%	
	Inspection	16980	16520	460	2.7%	

Table 4: Apparel wastage across factories.

From the table we can see, for cutting section Denim Venture Ltd. has the highest cutting wastage at 13.4%. Nice Denim, Jamuna Textile, and Shasha Denim Ltd. have the lowest cutting wastage, all at 9.0%. Cutting wastage across all factories ranges from 9.0% to 13.4%.

Denim venture and Chittagong Denim appear to have the lowest sewing wastage at 4.30%. Salek Textile Ltd. (Denim Unit) seems to have the highest sewing wastage at 5.60%.

Chittagong Denim Ltd. and Denim Venture Ltd. have the lowest finishing wastage both at 1.9% Salek Textile Ltd. (Denim Unit) has the highest finishing wastage at 3.5%

Aaron Denim Ltd. has the highest inspection wastage at 5.4%, Salek Textile Ltd. (Denim Unit) and Nice Denim have the lowest inspection wastage both at 2.1% and 2.3% respectively. Inspection wastage for most factories falls within a narrow range of 2.1% to 2.5%

As we can see cutting wastage is minimum in Nice Denim, Jamuna Denim and Shasha denim, sewing wastage less in Denim Venture and Chittagong denim, Finishing wastage minimum in Chittagong Denim and Denim Venture and finally Inspection wastage minimum in Salek Textile and Nice Denim. We find out a couple of reason why this is the case. The result is,

- All of the factory has more experiences manager/staff compared to other section or factory. Experienced staff really contribute to maintain a minimum wastage.
- We noticed the impact of training in all of these factories. The concern department arrange training session at least once in a month to maintain the rate of wastage.

Also discussed with the concern manager what other factors are contributing to generate waste. Below issue arises,

3.3.2 Perceptions of manager to reduce wastage:

Efforts to minimize wastage in denim garment making include accurate pattern design, skilled sewing techniques, efficient fabric utilization, effective quality control, and sustainable production practices. Designing with reduced waste in mind, optimizing cutting layouts, and implementing lean manufacturing principles can also help minimize wastage in this process.

3.3.3 Average segment wise wastage across factories:

The provided data pertains to different stages in the garment manufacturing process, and it indicates the percentage of average wastage at each stage across factories. Let's analyze each of these stages in detail:

- **Cutting (10.6%)**: During the cutting process in garment manufacturing, fabric pieces are shaped and cut according to the garment patterns. Approximately 10.6% of the material is wasted in this stage due to factors like pattern alignment, fabric defects, and leftover scraps that cannot be used in the final product.

- **Sewing (4.5%)**: In cutting section we found the wastage around 4.5%, the reason which cause this wastage is stitching error, thread breakage and other misalignment of components.

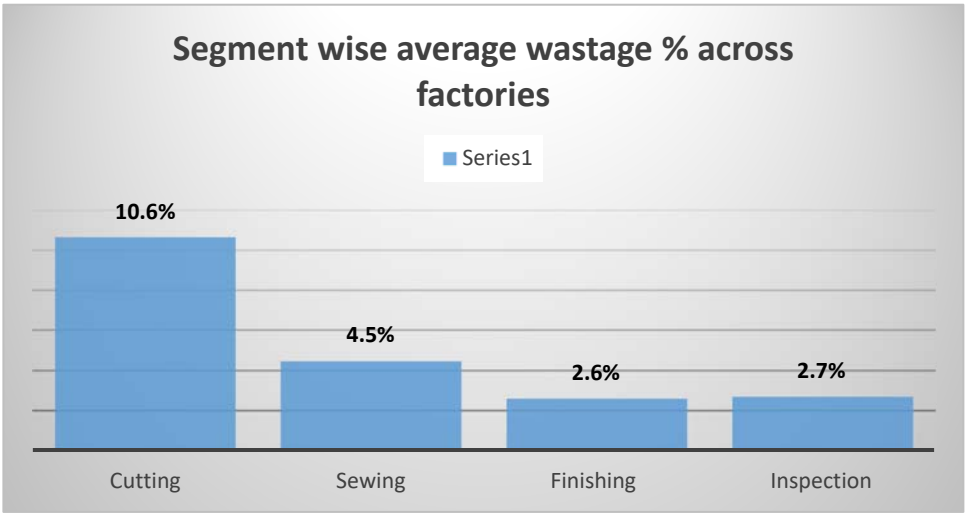

Fig 4: Graphical representation of apparel wastage in each department.

- **Finishing (2.6%)**: In the finishing stage a couple of steps are involved like ironing, pressing, and adding final touches to the garment. We found around 2.6% wastage in this segment.
- **Inspection (2.7%)**: Inspection section is very important for apparel section. We found inspection percentage is around 2.7%, this percentage become fail to meet the quality standard.

3.4 Wet process data analysis

The wet processing department in a textile factory is like a giant fabric salon, giving textiles the look and feel they need to become clothes, towels, or other end products. Here, water and various chemicals work their magic on fabrics.

3.4.1 Key Stages of Wastage in Apparel:

Denim wet processing generates waste at different phases, such as dyeing and desizing. Below are the segments where waste mainly generates,

- Control problems: Excessive treatment ruins cloth and renders it useless.
- Chemical difficulties: Inadequate chemical formulation leads to a variety of problems, including uneven dyeing.
- Equipment malfunctions: Processing errors are caused by poorly maintained or calibrated equipment.
- Human error: Fabric can be harmed by unintentional errors made during processing.
- Fabric flaws: After processing, any holes or tears become unusable.

Furthermore, waste is influenced by:

- Type of fabric: Denim that contains a lot of cotton is more likely to get damaged.
- Particular procedures: Compared to other dyeing techniques, indigo dyeing produces a greater amount of waste.
- Efficiency in manufacturing: Less waste is produced by water recycling and reuse processes.
- By comprehending these reasons and putting remedies into place, such as enhanced control, appropriate chemical

By taking these steps, denim manufacturers can reduce material wastage in the wet process and improve the efficiency and sustainability of their operations. Here we collected the data from 10 Textile factories which highlighted on the next page,

Factory Name	Segment	Input	output	Wastage amount	Wastage %	Total wastage (factory wise)
Nice Denim	Desizing	31250	30520	730	2.3%	19%
	Bleaching	28562	27250	1312	4.6%	
	Mercerizing	29512	29100	412	1.4%	
	Dyeing	12560	11420	1140	9.1%	
	Finishing	40250	39450	800	2.0%	
Argon Denim	Desizing	32750	31945	805	2.5%	22%
	Bleaching	30062	28200	1862	6.2%	
	Mercerizing	31012	30122	890	2.9%	
	Dyeing	14060	12845	1215	8.6%	
	Finishing	41750	40875	875	2.1%	
Chittagong denim ltd.	Desizing	28750	28120	630	2.2%	20%
	Bleaching	26062	24850	1212	4.7%	
	Mercerizing	27012	26700	312	1.2%	
	Dyeing	10060	9020	1040	10.3%	
	Finishing	37750	37050	700	1.9%	
Salek Textile Ltd. (Denim Unit)	Desizing	23750	23200	550	2.3%	21%
	Bleaching	21062	20130	932	4.4%	
	Mercerizing	22012	21600	412	1.9%	
	Dyeing	5060	4520	540	10.7%	
	Finishing	32750	32330	420	1.3%	
Jamuna Textile	Desizing	36250	35600	650	1.8%	19%
	Bleaching	33562	32200	1362	4.1%	
	Mercerizing	34512	33900	612	1.8%	
	Dyeing	17560	15920	1640	9.3%	
	Finishing	45250	44400	850	1.9%	
Shasha Denim Ltd.	Desizing	43250	42100	1150	2.7%	17%
	Bleaching	40562	38800	1762	4.3%	
	Mercerizing	41512	41200	312	0.8%	
	Dyeing	24560	22510	2050	8.3%	
	Finishing	52250	51950	300	0.6%	
Aaron denim	Desizing	33150	32320	830	2.5%	19%
	Bleaching	30462	29050	1412	4.6%	
	Mercerizing	31412	30900	512	1.6%	
	Dyeing	14460	13220	1240	8.6%	
	Finishing	42150	41250	900	2.1%	
Denim venture Ltd.	Desizing	18750	18220	530	2.8%	27%
	Bleaching	16062	14950	1112	6.9%	
	Mercerizing	17012	16800	212	1.2%	
	Dyeing	14500	12500	2000	13.8%	
	Finishing	27750	27150	600	2.2%	
Chittagong denim mills Ltd.	Desizing	23750	23220	530	2.2%	22%
	Bleaching	21062	19950	1112	5.3%	
	Mercerizing	22012	21800	212	1.0%	

	Dyeing	19500	17200	2300	11.8%	
	Finishing	32750	32150	600	1.8%	
Sister denim Ltd.	Desizing	29250	28400	850	2.9%	26%
	Bleaching	26562	24900	1662	6.3%	
	Mercerizing	27512	27100	412	1.5%	
	Dyeing	10560	9400	1160	11.0%	
	Finishing	38250	36450	1800	4.7%	

Table 5: Wet process wastage across factories.

We can see, Shasha Denim has the minimum wastage whereas Denim Venture has the maximum. For Nice Denim, Aaron denim and Chittagong denim, we found a moderate percent of wastage covering 19-21%. For "Desizing" operation, Jamuna Textile performed well and sister Denim had the maximum percentage of wastage. For "Bleaching" Jamun Textile performed well and Denim Venture has the highest rate of wastage. For other operation like "Mercerizing, Dyeing and Finishing" Shasha Denim performed will across all of these operation, whereas Jamuna Textile performed really badly across all of this operations. We found a couple of reasons why the wastage percentage of Shasha denim less compared to other factories,

- Shasha Denim has a high variety of chemical collection and all are ISO standard. They never use left-over chemical for their production.
- They are using latest machines that ensure complete dye take up and even applications of chemicals.

3.4.2 Perceptions of manager to reduce wastage:

- Implementing strict quality control measures: This is mainly to ensure that the wet process is controlled properly and also the chemical that is used are correct.
- Maintaining and calibrating equipment: This will help to prevent equipment failure and errors in the wet process.
- Training workers: This will help to reduce human error in the wet process.
- Inspecting fabric for defects: This will help to identify and remove fabric defects before the fabric is processed.

- Using sustainable materials and processes: This will help to reduce the environmental impact of the denim manufacturing process and reduce the amount of waste generated.

3.4.3 Average segment wise wastage across factories:

On an average across all factories, we found below segment wise wastage. It is clearly seen that, maximum wastage happened in Dyeing. Except dyeing the second most wastage is in bleaching.

- **Desizing (2%):** Desizing is the process of removing sizing agents from the fabric, which were applied during weaving to improve yarn strength and facilitate weaving. The 2% wastage implies that, on average, 2% of the materials involved in the desizing process may be lost or go unused. This could be due to factors such as inaccurate measurement, spillage, or incomplete removal of sizing agents.
- **Bleaching (5%):** Bleaching is a stage where the denim fabric is treated with chemicals to remove natural color and achieve a lighter shade. 5% rejection indicates the material is wasted during chemical process. This is mainly happen due to inaccurate measurement, spillage, or the need for additional processing due to uneven bleaching.
- **Mercerizing (2%):** This chemical treatment improves the luster, strength and dye affinity of fabric. The 2% wastage indicates that 2% of materials used in mercerizing may be lost or inefficiently utilized. The behind this is spillage, incomplete penetration of chemicals, or machine inefficiencies.

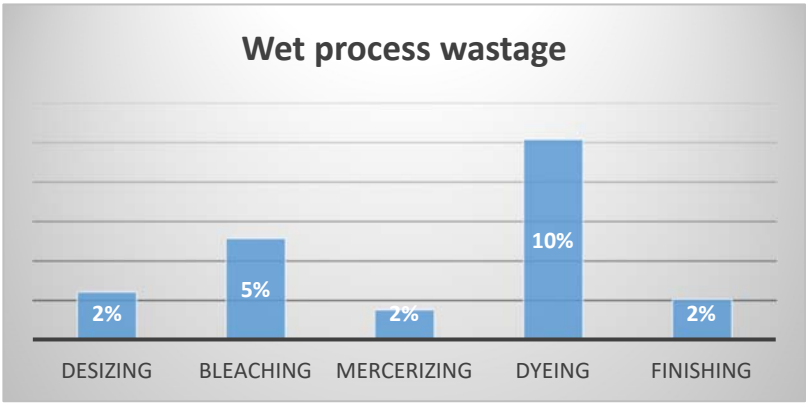

Fig 5: Graphical representation of wet process wastage in each segment.

- **Dyeing (10%):** Dyeing section is mainly responsible for dyeing the denim fabric. The 10% wastage suggests that, on average, 10% of the materials used in the dyeing process may be wasted. The reason behind the dyeing wastages are incomplete penetration of dyes, or defects in the final dyed product leading to rejection.
- **Finishing (2%):** Finishing processes are applied to enhance the fabric's properties, such as softness or texture. The 2% wastage indicates that 2% of materials used in finishing may be lost or go unused. This could be due to reasons such as inaccurate measurement, spillage, or defects in the finished product.

Chapter IV: Data analysis

4.1 Quantitative data analysis:

Spinning:

In the spinning stage, for every 100 kg of yarn produced, an average of 127.4 kg of cotton fiber is consumed, resulting in a material conversion rate of 78%. This means that only 78 kg of yarn is produced from processing 100 kg of cotton. The wastage in spinning results from a combination of process losses and quality-related rejections. Quality of fiber and production efficiency significantly impact material consumption. The discrepancy between yarn production and the quantity delivered to the next industry reveals a significant challenge in this stage. Thus it is very much important to pay attention to this segment as the rate of wastage is mainly depends on it and pay more concern on this issue can positively contribute to the situation.

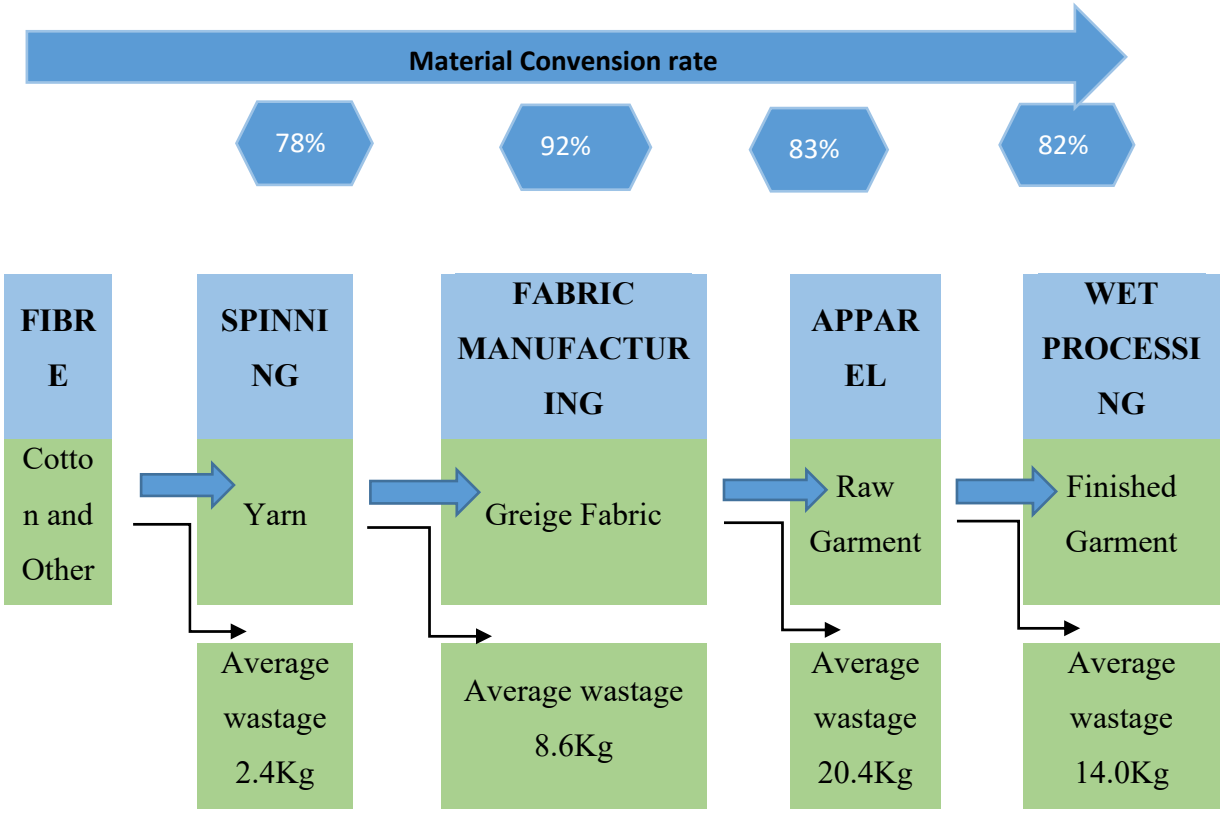

Fig 6: Amount of material waste in textile-apparel production chain

Fabric Manufacturing:

The weaving process within fabric manufacturing sees an average consumption of 108.6 kg of yarn for every 100 kg of woven greige fabric, with an associated wastage of 8.6 kg, resulting in a material conversion rate of 92%. Various factors contribute to this wastage. Warping and sizing sections generate approximately 1.9% of wastage due to poor material handling and a lack of expertise in warping. The drawing-in section contributes a similar amount of wastage for similar reasons. The weaving section, which sees a relatively high 3% wastage, is influenced by yarn quality, material handling, and the type of loom used. Additionally, inspection and quality control (QC) sections are responsible for 1.8% of wastage, mainly due to fabric faults, spots, and shade variations.

Apparel Manufacturing:

Apparel manufacturing consumes, on average, 120.4 kg of finished fabric for every 100 kg of final products. Notably, the cutting section is responsible for a substantial wastage rate of around 10%, leading to a need for 110 kg of fabric inventory for every 100 kg used, resulting in a material conversion rate of 83%. Sewing generates a wastage rate of approximately 4.5%, with the primary causes being faulty workmanship, poor material handling, and the use of low-quality fabric. The finishing section results in 2.6% wastage due to issues like spots, crease marks from poor handling, and poor dimensional stability. Finally, the inspection section contributes approximately 2.7% of wastage, primarily caused by measurement errors and spots due to poor handling.

Wet Processing (Dyeing/Finishing/Washing):

During wet processing, for every 100 kg of finished fabric, 121 kg of greige fabric is consumed. Material wastage in fabric dyeing stands at 21 kg for every 100 kg of fabric, resulting in a material conversion rate of 82% primarily due to uneven dyeing attributed to fabric faults and GSM (grams per square meter) issues. The main reason behind this wastage is uneven dyeing, shade variation, wash spot and so on.

The findings of this study reveal a significant level of material wastage at each stage of textile and apparel production. The wastage is attributed to various factors, including poor material handling,

issues with material quality, process losses, and rejections due to quality problems. Understanding these sources of wastage is critical for industry stakeholders, as reducing material wastage not only conserves resources but also improves production efficiency and reduces costs. The study highlights the need for process optimization, quality control, and better material handling practices to minimize wastage in the textile and apparel production chain. These findings can guide industry professionals in developing strategies for more sustainable and efficient production processes.

4.2 Qualitative data analysis:

We collected information across the personnel from different department to get more authentic data. Bellows are the summery,

Spinning Department (8):

- Management (3): Manager, Assistant General Manager, Deputy Manager
- Technical (5): Quality Assurance, Quality Manager

Weaving Department (6):

- Management (3): Production Manager, Unit Manager, Deputy Manager
- Production (3): Floor In-charge

Selection Criteria:

This selection focuses on personnel across various levels within spinning, weaving, and washing departments of 10 different Bangladeshi garment factories. This ensures a diverse range of perspectives on material waste, encompassing:

Management: Strategic decision-making, resource allocation, and waste reduction initiatives.

Technical: Quality control procedures impacting material utilization.

Production: Practical experience with fabric handling, cutting, and potential waste generation points.

This mix of roles provides a well-rounded understanding of material waste within the Bangladeshi fashion industry.

The "Year of experience" to deal with material management chart shows responses from 20 textile production personnel responses who are directly involved in textile production. Most respondents

has “more than 6 years of experience" (55%), followed by "4-6 years of experience" (30%) and other year of experience included "2-4 years (15%)".

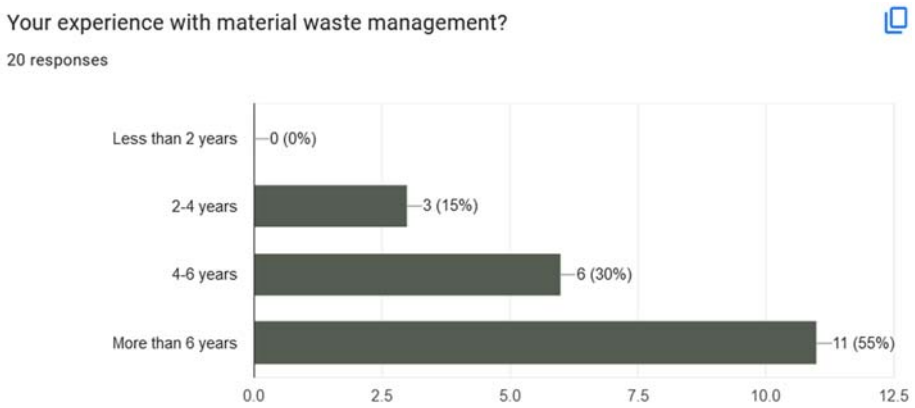

Fig 7: Year of experience

Another question was, how aware they are about material management. Most of the cases it is seen that, people pays less important on this and physically we see the same scenario. Around 25% personnel said that, they are “totally aware” about material management while another 75% mentioned, they are “Aware” about this issue.

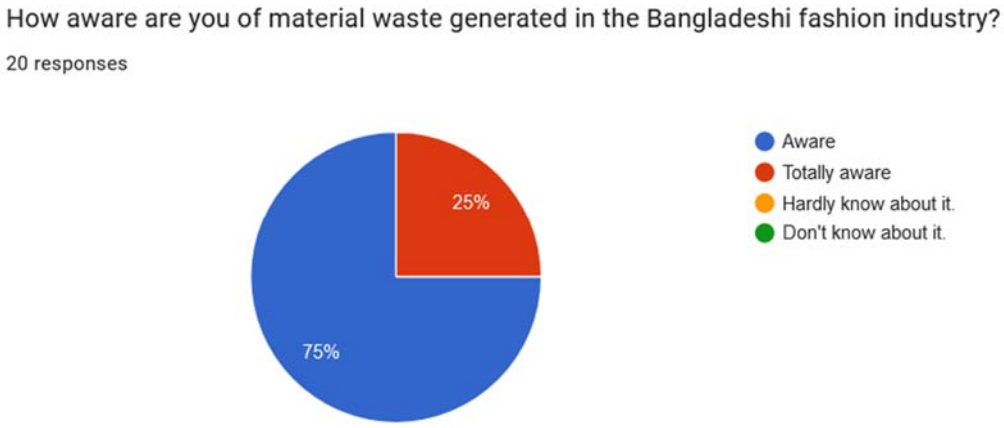

Fig 8: Awareness on material management

The “Responsible for material wastage” chart indicates, almost half of personnel (50%) believe raw material is mainly responsible for material wastage, another 40% believe that, knowledge of raw material pays a great rule to control material wastage, and another 10% believe that, due to lack of training, material wastage is increasing day by day. Mr. Salehin Abedin (Deputy Manager of Shasha denim Ltd.) says that, “Raw material quality undoubtedly define the material wastage

percentage but other aspects like knowledge of material waste, and worker training also play crucial roles."

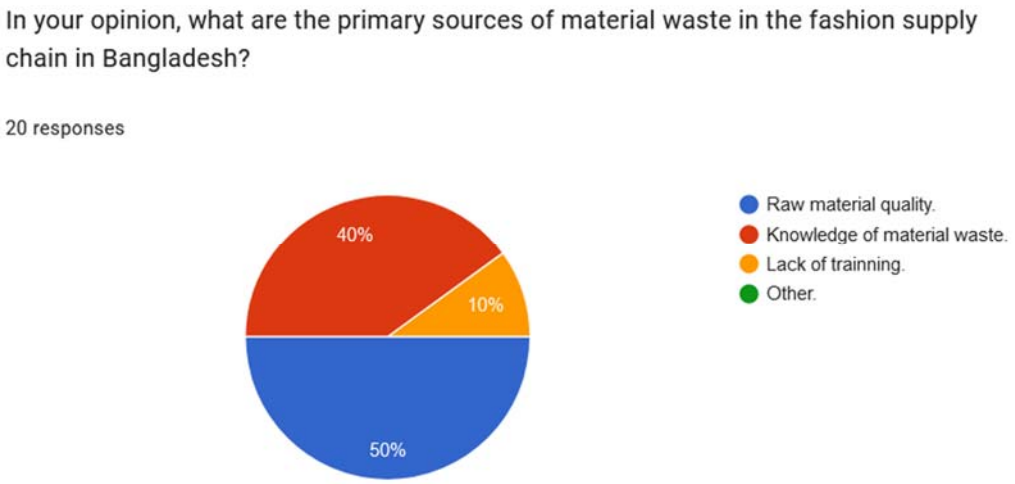

Fig 9: Responsible for material wastage

The "practices to reduce material wastage" chart indicates, focusing on raw material (60%) can play a vital rule to reduce material wastage. Another 30% personnel believe using latest technique is very much important to maintain material wastage percentage and another 10% believe focusing on training is also important to maintain the material wastage issue.

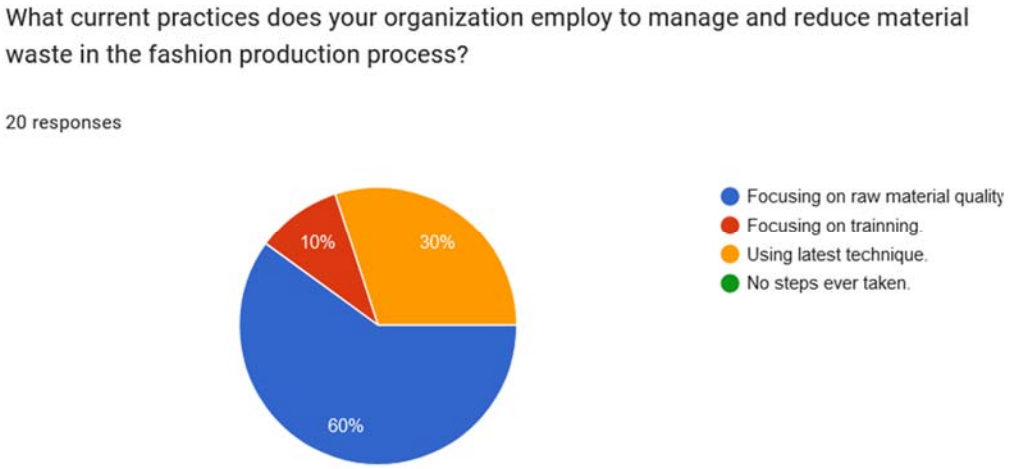

Fig 10: Practices to reduce material wastage.

The "challenges to face material wastage" chart paints a telling picture, revealing the invisible threads of "Lack of co-ordination" (60%) and "Lack of proper knowledge" (40%) as the biggest obstacles holding back waste reduction efforts. While "Lack of government support" may seem like a secondary concern at 5%, understanding the interplay between these factors is crucial to unraveling the knotty issue of material wastage. Imagine a factory floor like a complex tapestry. Efficient waste reduction requires every department – procurement, design, production, and quality control – to weave their actions in perfect harmony. But a staggering 60% of respondents point to a lack of this very co-ordination. This could manifest as mismatched material orders, inefficient production schedules, and poor communication regarding waste disposal practices.

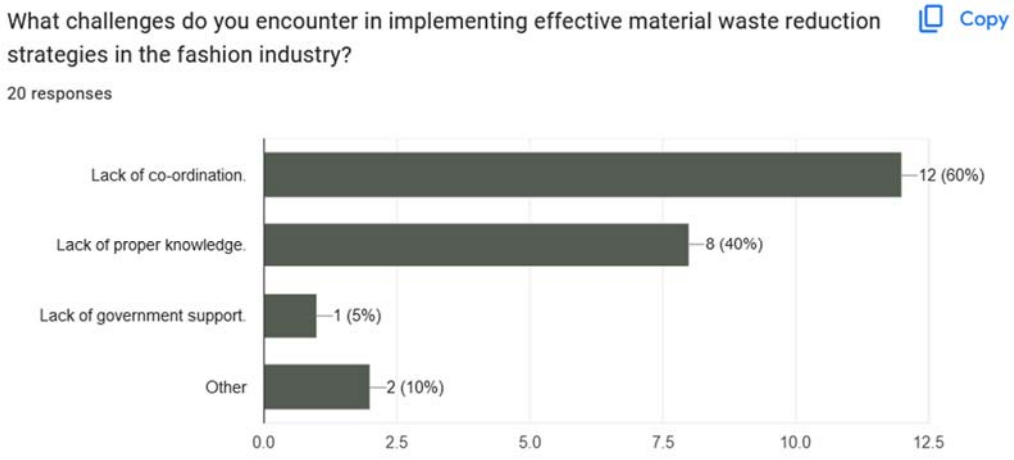

Fig 11: Challenges to face material wastage.

In “Opportunities to control material wastage” data, it is seen that,

- **45% say tech's the key:** Investing in cutting-edge tools and innovation is seen as the biggest opportunity to slash waste. Robots and recycling tech, anyone?
- **35% champion circularity:** Closing the loop with post-consumer denim and reusing materials can be a sustainable game-changer.
- **15% point to supply chain teamwork:** Working hand-in-hand with fabric makers and retailers can optimize materials and identify waste hotspots.

By weaving these threads together – tech, circularity, and collaboration – we can untangle the waste knot and craft a sustainable future for denim!

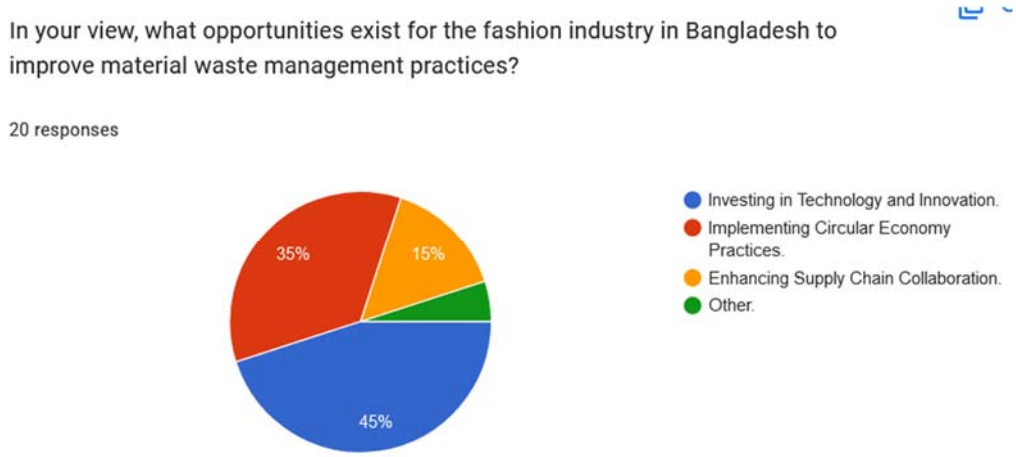

Fig 12: Opportunities to control material wastage.

In "Barrier to adopt sustainable approach" 45% personnel believe "Short term profit focus" is the biggest barrier, another 35% believe "lack of awareness and education" is also another barrier while another 15% believe "Cost consideration" is another barrier to minimize material wastage.

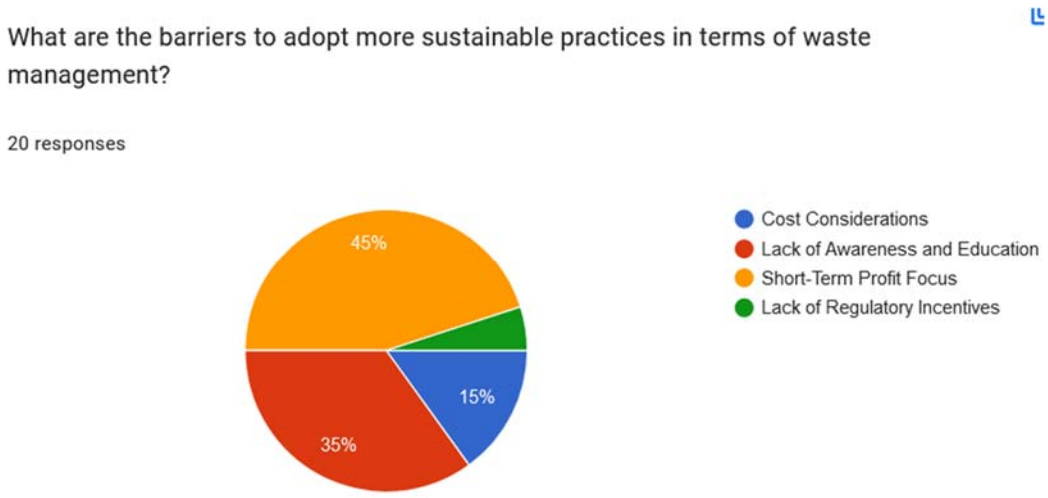

Fig 13: Barrier to adopt sustainable approach

The "Helpful resources" chart highlights "Research and development funding" will be most helpful to tackle this issue. About 63.2% personnel believe on this. Another 26.3% believe

"Government incentives and regulations" will be helpful and another 26.3% also believe "policy advocacy" also helps to tackle this issue.

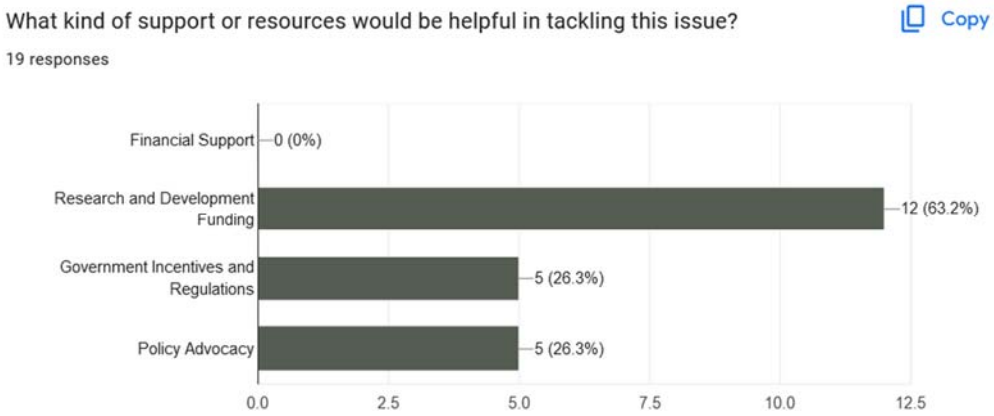

Fig 14: Helpful resources

In "Encourage greater awareness and action'' tackling material waste requires action from all angles, according to the research. 50% see continuous monitoring and reporting as the foundation, ensuring accountability and identifying improvement areas. 40% believe government advocacy and policy support are crucial, providing incentives and regulations to push industry-wide change. Finally, 30% highlight the importance of corporate responsibility programs, driving internal initiatives and promoting sustainable practices through the value chain. This multi-pronged approach – data-driven action, supportive policies, and committed businesses – offers the strongest thread to weave a waste-free future.

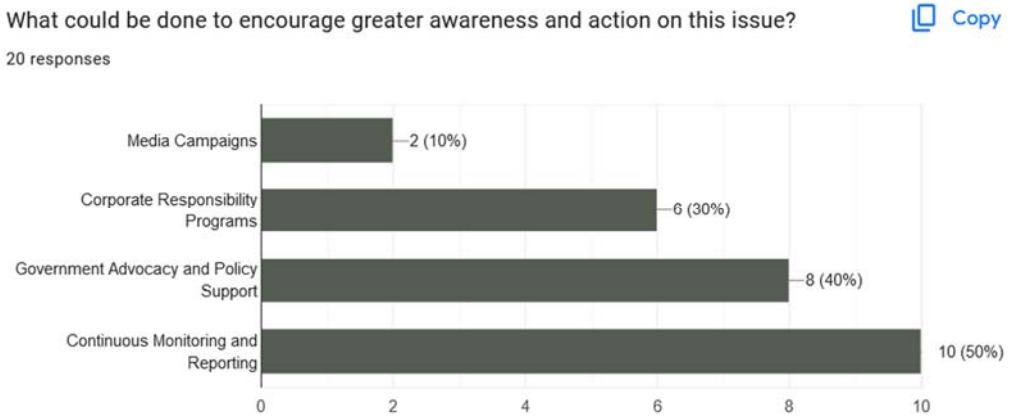

Fig 15: Encourage greater awareness and action.

Chapter-V: Discussion and Findings of the Study

The study's detailed analysis provides a clear picture of the specific stages within the textile and apparel production chain where material wastage is most prominent. Notably, the study highlights denim spinning as the stage generating maximum wastage. This indicates we need to pay attention on this area. Thus we have to pay more focus on denim spinning, such as inefficient processes and quality-related issues.

In the apparel section, the study identifies the cutting section as a significant source of wastage. Here the Computer-Aided Design (CAD) technology playing a great role to reduce wastage, it increased precision and efficiency, which open the door for further improvement. IT also suggest that while CAD systems have reduced human error, there are still challenges related to optimizing the software, enhancing operator skills, and refining the overall cutting process. Addressing these areas could further minimize wastage in the apparel cutting section.

Furthermore, the study underscores the role of fabric manufacturing and wet processing in contributing to material wastage. Fabric manufacturing stages, such as weaving, face challenges related to material handling and loom efficiency, leading to avoidable wastage. Similarly, wet processing stages, including dyeing and finishing, experience issues such as uneven dyeing and fabric faults, resulting in significant material wastage. These findings emphasize the importance of streamlining processes, enhancing equipment, and investing in training and quality control measures to reduce wastage in these critical production stages.

In summary, the study's detailed examination demonstrates that material wastage is a multifaceted issue, influenced by various factors at different stages of production. By pinpointing denim spinning and the cutting section in apparel manufacturing as areas with substantial wastage, the study highlights specific areas where industry stakeholders can focus their efforts. Continuous research, development, and training initiatives, coupled with the adoption of advanced technologies, can significantly contribute to minimizing material wastage throughout the textile and apparel production chain. These targeted interventions are essential for promoting sustainable practices, conserving resources, and enhancing overall efficiency in the industry.

Chapter-VI: limitation of study

This research has a few limitations. Firstly, due to minimal data regarding waste generation, we had to conclude this study with limited information within the study boundary. The inclusion of more factories might reveal more interesting insights. Secondly, exploring how the materials waste varies across the different production units and contextual issues of a specific industry (e.g., size, product category, value chain roles, geography, and others) would reveal a more comprehensive scenario. Finally, future research may adopt to run the research in bigger field including more no. of factories to get the more accurate data. This would produce more generalized results and a more comprehensive understanding of materials in the global fashion business, in order to achieve.

Chapter-VII: Conclusion

As the apparel industry produces more than 83% of Bangladesh's total exports, value retention in the production process can heavily contribute to the government's SCP move in line with SDG 12. This research reveals exciting and valuable insights by identifying, categorizing, and determining the value addition of materials waste alongside new business opportunities in the upstream manufacturing contexts. The research comprehensively portrays the scenario and potentials for empirical research extensions and materials waste management interventions. The textiles and apparel industry needs financial and technical support from the key stakeholders, i.e. brands, government, trade organizations and others, to establish a materials waste baseline throughout the supply chain to effectively manage them in the circular economy model and achieve SDG 12. Support is also needed to establish an informal economy and recycle/reuse business on a legitimate basis. At this moment, there is lots of secrecy surrounding this, and it requires transparent and viable solutions to make such a vast amount of materials waste into opportunities and to foster sustainability.

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