International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Reducing inventory waste and improving traceability of small fabric rolls in a knitted textile factory: A lean-based case study

Md Arshadul Islam [1] and Abdul Halim [2,*]

[1] *Operations, Truvant, USA.*
[2] *Department of Industrial & Production Engineering, Rajshahi University of Engineering and Technology, Bangladesh.*

International Journal of Science and Research Archive, 2025, 16(01), 2024-2041

Publication history: Received on 11 June 2025; revised on 20 July 2025; accepted on 22 July 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.16.1.2187

Abstract

By the end of 2024, the garments industry in Bangladesh which contributing to its economy over $50 billion in exports sector, faces significance challenges in inventory management, particularly in traceability of small fabric rolls. In this case study we investigate a Bangladeshi garments factory supplying major global brands such as H&M, PUMA, and Hugo Boss, where traditional inventory system and poor traceability of rolls often lead to wastage, re-knitting, delays in production, and delivery commitment failures. This study aims to find out the root causes of inventory inefficiency and determine some inventory KPIs (key performance index) that will improve efficiency by applying three lean manufacturing tools in the inventory like, 5S, Value Stream Mapping (VSM), and ABC analysis. We gathered a lot of data about our inventory and looked at it to sort it by contribution and consumption priority, find problems with our current processes, and measure how much better things got using key metrics. The application of lean tools led to mentionable improvements in key performance metrics. Retrieval time decreased by 30%, waste generation reduced by 25%, and machine idle time dropped by 45%. These improvements were possible by organized inventory management, and optimal scheduling, resulting in a more streamlined production process, with less retrieval time, less waste, and enhanced machine efficiency. The study provides a data-driven framework for inventory improvement, demonstrating the effectiveness of lean tools in addressing inefficiencies in garment factories, particularly in emerging economies.

Keywords: Inventory Management; Lean Manufacturing; 5s; Value Stream Mapping; Abc Analysis

1. Introduction

Bangladesh's largest source of exports is the ready-made garment (RMG) business [1]. It also helps the economy grow, make jobs, and assist businesses grow [2]. It has turned into the country's economic engine. According to the news published in 'Daily Star' on January 03, 2025, said that by the end of December 2024, Bangladesh's apparel exports would have hit an all-time high of $50 billion. This was 8.3% greater than the previous year. Over 4 million people work in this area, and most of them are women [3]. It also assists a lot of companies who create textiles, accessories, dyes, and provide logistics services. The company has gone a long way, but there is still a large gap between what it wants to do with exports and what it really does, especially when it comes to managing inventory and operations on the floor. These gaps not only slow down manufacturing, but they also make it harder for industry to keep developing in a very competitive worldwide market [4], [5].

One of the tricky things is that there isn't a set manner to keep track of stocks, especially when it comes to knitted fabric rolls [6], [7]. When brands like H&M, PUMA, Hugo Boss, and Tom Tailor place enormous orders, you have to weave thousands of kilograms of fabric to make garments. Cutting the product into rolls of varying weights is one phase in the process [8]. These rolls normally weigh between 30 and 50 kilograms, but there are also smaller rolls that weigh

* Corresponding author: Abdul Halim

between 4 and 7 kilograms that are needed to fill orders, do sample re-cuts, and keep the color the same. When an inventory system doesn't work right, these small rolls of cloth are the ones that are lost the most [9].

The problem is worse because a lot of Bangladesh's garment and textile companies are congested and not well-planned [10]. A lot of Bangladesh's factories are in historic structures that have been fixed up. There isn't much room in these buildings, the shelves aren't always the same size, and there aren't any clear places to put different kinds of stuff [11]. In developed economies, businesses don't use scientific layout planning like cellular production and U-layouts in this way [12]. This makes it hard to find things and keeps the storage dirty because fabric rolls end up in the wrong places.

Some businesses use barcodes to keep track of their stock, but this doesn't assist with the main problem, which is finding goods [13]. You can use barcodes to find goods online and connect orders, but they can't tell you where a roll is right now unless you use RFID or geo-tagging with them [14]. Because of this, workers often spend hours looking for small role models that they need right soon. If they can't obtain these rolls on time, production planners have to re-knit cloth [15]. This wastes raw supplies, puts greater strain on machines, and makes workers work harder. This makeover has several problems, such as late deliveries, trouble filling orders, and losing the trust of buyers from other nations. All these problems hurt the factory's ability to make money and its reputation in the market [16].

A lot of garments manufacturer in Bangladesh also don't know how to sort or rank their goods [17]. When it's hard to follow FIFO and JIT rules in a messy area, all rolls are treated the same, no matter how much they cost, how quickly they need to be moved, or how important the buyer is [18]. Without a clear framework, it's hard to recognize that this means vital resources aren't used enough, things that aren't used often build up for no reason, and activities aren't as efficient as they could be[19].

The study's results show that these difficulties could be fixed with a lean manufacturing strategy. The most important thing is to use the 5S method, Value Stream Mapping (VSM), and ABC inventory analysis together [20], [21]. These methods have all improved manufacturing in other industries, but they aren't typically employed together in Bangladesh's textile supply chain, and there hasn't been enough research on it [22],[23] [24]. The 5S architecture has five steps: Sort, Set in order, Shine, Standardize, and Sustain. Cleaning up the office and making things easier to see are two ways to keep it clean, organized, and productive [25], [26]. Value Stream Mapping displays the entire process, from making the fabric to sending it to customers. This helps you determine out which chores aren't worth your time, which ones take too long, and which ones you do more than once [27], [28], [29]. Lastly, ABC analysis assists with managing inventory by putting fabric rolls into groups based on how often they are used, how quickly the client requires them, and how they affect operations [30], [31].

The case study uses a huge synthetic dataset of 500 fabric rolls to show how a typical knit textile mill maintains track of what it has in stock. The study demonstrates that employing lean tools together can help you find things faster, use less fabric, keep track of small rolls more easily, and make machines work better when you schedule them. These fixes not only repair problems that are already there, but they also teach other garment companies in Bangladesh and other poor nations how to do things.

This study is helpful and comes at the appropriate time. It gives plant managers, supply chain engineers, and policymakers important information on how to make Bangladesh's main industry more competitive. The garment industry may become more modern in a way that is good for the economy and the environment by making sure that its business methods are lean. This will help the industry grow swiftly and make it strong, helpful, and efficient in the long run.

2. Literature Review

Inventory management; a big part of garment manufacturing plays an important role in overall efficiency. In Bangladesh, where garments account up more than 80% of export earnings, problems with inventories hurt profits and delivery schedules [4]. But a lot of businesses still utilize manual systems, have inventory layouts that aren't standard, and can't just find goods. Hamid et al. (2018) discovered that over 60% of small and medium-sized clothing enterprises in Bangladesh kept their fabric rolls without any means to sort or find them [32]. Lot of work had to be redone, which made productivity go down [33]. Enterprise Resource Planning (ERP) and barcode systems have been added; however, they don't always work with real-time RFID-based tracking, which makes it impossible to physically trace things [34].

Most of the time, investigations into fabric inventory focus on bulk raw materials. The small rolls that are left, on the other hand, are highly useful for finishing orders, altering samples, and making new cuts. These rolls usually weigh less than 10 kg. Basak and seddiqe (2014) say that short rolls make it difficult to understand inventory, cause more waste,

and slow down work more than other types of rolls, especially when you have to search for goods manually [35]. These challenges get worse when objects are stored in a chaotic way, such when small rolls get mixed up with big ones and you can't find them. Case studies from Vietnam show that not putting things in order leads to bad picking, missing materials, and too much work [36].

5S and lean manufacturing have been proved to help keep factory floors and supplies clean. Sort, Set in Order, Shine, Standardize, and Sustain are the five 5S pillars that make up the system for storing and processing things. Several studies indicated that employing 5S in textile warehouses made better use of space by 30% and lowered retrieval time by more than 40% [37]. On the other hand, Bangladesh doesn't use 5S very often, especially when they maintain track of their inventory [38]. This is noteworthy because 5S is simple to apply and can have a large impact.

Another lean tool, Value Stream Mapping (VSM) is a means to see where the process is blocked and how things are going right now [39]. Lean-based diagnostics use it a lot to save time that isn't useful, especially in systems that are hard to understand. The author showed how VSM can help detect delays in the process of handling cloth in the textile industry [39], [40]. To solve the delays, the storage method was changed and the staff were trained again [41]. VSM can help you determine out how much time is wasted when rolls are missed, machines sit idle, and re-knitting is done for no reason [42], [43], [44]. This is great for the study challenge right now.

According to the Pareto principle, a small number of things (A) are very beneficial or valuable, while a huge number of things (C) generate issues that happen a lot but aren't very serious. A common and helpful approach to maintain track of stock is to employ ABC analysis. Researchers in the textile sector have used ABC classification to locate hard-to-find goods that don't move quickly and only arrive in little volumes, like small rolls or materials that only exist in certain colors [45]. In a study author utilized ABC analysis at an Indian mill and were able to minimize the cost of retaining inventory by 25% [46]. ABC will help you locate the C-class little rolls that are most likely to go lost or need to be fixed and show you how to save them and get them back.

Researchers have studied how to employ lean techniques like 5S, VSM, and ABC in a variety of production settings. There hasn't been much research on how to use them all together to keep track of fabric inventories, though. In Bangladesh's textile sector, this is especially true when it comes to keeping track of little rolls. Also, most of the inventory studies that are out there don't look at the operational and economic effects of re-knitting since they don't have enough data. This is a big concern because it wastes materials, stresses out personnel, and doesn't work. This study fills in that gap by illustrating how applying lean ideas with real-world operational data can turn textile inventory systems that aren't operating well into ones that are cost-effective, responsive, and easy to keep track of.

3. Methodology

This research adopts a case study approach applying lean manufacturing principles to analyze and improve inventory management in a garments factory in Bangladesh. The focus is on reducing fabric waste, improving traceability of small fabric rolls, and enhancing retrieval efficiency by applying three lean tools namely 5S, Value Stream Mapping (VSM), and ABC Analysis.

3.1. Research Design

This is an explanatory case study based on a real-world scenario of a leading textile manufacturer in Bangladesh. The selected factory supplies fabric to renowned international buyers including H&M, PUMA, C&A, Hugo Boss, and Tom Tailor. To conduct the research follows the DMAIC (Define–Measure–Analyze–Improve–Control) structure of Lean Six Sigma to ensure a systematic improvement cycle given below in figure 1.

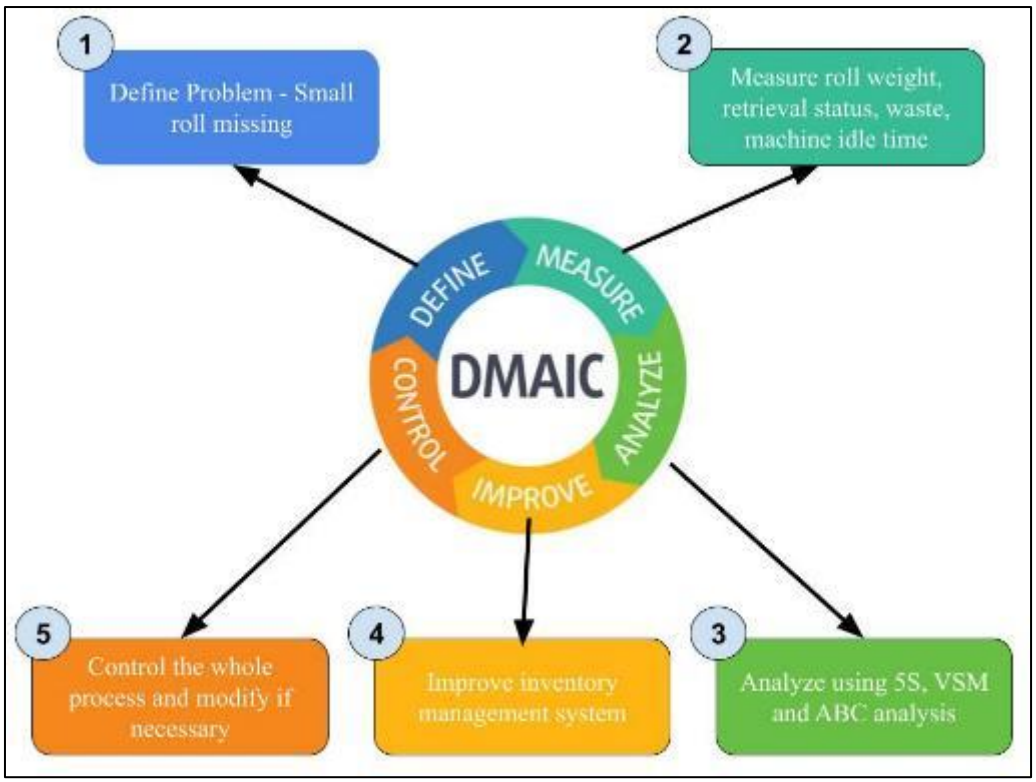

Figure 1 Research Methodology Using DMAIC Model

3.1.1. Define

Defining the problem is the mandatory and initial steps of all research. In this research the problem of traceability of small fabric role was identified by the 'Root Cause Analysis' diagram. The company maintains business with the world's top class fashion industry, that's why its needs to supply a big amount of quality fabric. But the problem is while knitting the fabrics are cut into roles. Sometimes there are small roles like 5-10 kg which are stored primarily in knitting floor. When the inventory personnel adding barcode those roles to inventory after quality checking, smalls roles tend to missing out as they stack in between other roles. Figure 2 depicts the reason behind the missing fabric.

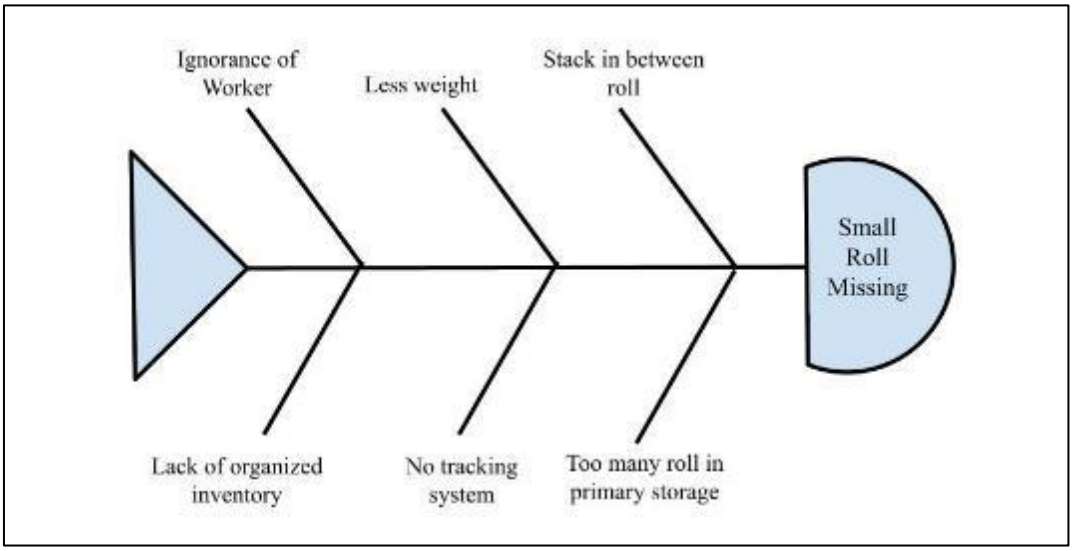

Figure 2 Fishbone Diagram of 'small role missing'

3.1.2. Measure

In the second step the process of the systems needs to measure. For this research data related to missing roles were collected like roll weight, retrieval status, waste, machine idle time, fabric types and delivery delays etc. We use a large dataset of that garment for calculation purposes.

3.1.3. Analyze

In the next step of the research, we apply lean tools; 5S, VSM and ABC analysis to understand the current situation and to identify bottlenecks and priority areas. We determine the amount of re-knitted fabric, waste generation by buyer wise and by fabric type wise and retrieval time on delivery delay.

3.1.4. Improve

After analyzing the current state of inventory and using dataset we proposed some lean tools made improvement in inventory management system to maximize the profit of the company. We implemented 5S and two other inventory management tools, namely ABC analysis and VSM.

3.1.5. Control

This is the final step of the model. After successfully applying all the methods now it's time to follow up the process and control it whether it is working according to a defined level. For controlling it may need to develop suggestions for standardized operating procedures (SOPs) and monitoring. We implemented lean tools in inventory management and for controlling purposes we reviewed it quarterly and found that the implemented processes are working according to shop with maintain a level of improvement.

3.2. Data Collection and Structure

3.2.1. Data Collection

The data are collected from the database management system of that investigated factory. We retrieve data only related to small roles. The dataset consists of 500 fabric rolls and contains the following variables shown in table 1.

Table 1 Data Variables and their properties

Variable	Description
Roll ID	Unique identifier for each roll
Buyer	Buyer's name (e.g., H&M, PUMA)
Fabric Type	Cotton, Polyester, Blend, etc.
Roll Weight (kg)	Numeric value (5–10 kg)
Retrieved?	Whether the roll was successfully retrieved
Retrieval Time (min)	Time taken to retrieve the roll
Re-knitted?	Whether re-knitting occurred due to unavailability
Waste Generated (kg)	Waste generated in rework
Machine Idle Time (min)	Downtime caused by missing rolls
Delivery Delay (days)	Shipment delay due to rework

3.2.2. Data Analysis

After data integration, data cleaning, data reduction, data transformation of the collected dataset we perform some analysis to understand the behavior of the dataset. The findings are given below in table 2.

Table 2 Data Analysis

Average weight of role (kg)	**22.65**
Average Retrieval Time (min)	10.96
Waste Generated (kg)	116.68
Machine Idle Time (min)	1366
Total missing role weight (kg)	2600

3.3. Tools and Techniques

The case was examined. Every activity and flow of the job, from cutting the role from knitting machine to storage in inventory, was documented, and photos and videos were taken to research and evaluate all processes. Each method was developed and implemented separately for the activities being carried out to identify anomalies in the production process, such as role transfer to the primary storage, quality check, barcode adding, transport to the final inventory, storage in a fixed area etc. Performance is measured by variables such as time savings, productive use of resources, better management of the workplace, and improved working conditions.

3.3.1. 5S Implementation

The 5S methodology, widely used to improve workplace efficiency and organization, consists of five phases: Sort, Set in Order, Shine, Standardize, and Sustain. Each phase plays a crucial role in creating a more efficient, organized, and safe working environment.

Sort (Seiri)

The first phase, Sort, focuses on identifying and removing unnecessary items from the workspace. This helps eliminate clutter, reduce inefficiencies, and create a cleaner, more organized work area. Key steps include determining what is necessary for the workplace and deciding whether to discard or relocate items that are not essential. By reducing unnecessary materials, the layout becomes more efficient, contributing to improved productivity.

Set in Order (Seiton)

The second phase, Set in Order, involves organizing the remaining materials in a systematic way. Items should be stored where they are most needed to avoid congestion and waste time. This phase encourages visual control by clearly labeling storage areas and ensuring items are ergonomically placed to minimize physical strain. The goal is to decrease search time and improve workflow. Proper storage practices, such as separating different items and avoiding clutter, contribute to a more organized and efficient environment.

Shine (Seiso)

Shine focuses on cleaning the workplace to eliminate dirt, waste, and potential hazards. Regular cleaning is essential for maintaining a safe and productive environment. This phase involves not just physical cleaning but also identifying the root causes of waste and dirt, ensuring that everything is in its proper place. Training employees on the importance of cleanliness and maintenance is critical for sustaining a clean work environment. Routine cleaning schedules should be set, and each employee should be responsible for cleaning their designated areas to ensure long-term cleanliness.

Standardize (Seiketsu)

In the Standardize phase, the procedures, rules, and expectations established in the previous phases are documented and standardized. This phase aims to maintain the improvements made through 5S by creating clear guidelines for daily operations. Visual standards and check sheets help workers follow the process consistently. The goal is to ensure that everyone adheres to the practices of sorting, organizing, and cleaning. Standardization reduces variability in the workplace, ensuring that good practices are followed consistently by all employees, which sustains long-term improvements.

Sustain (Shitsuke)

The final phase, Sustain, focuses on maintaining the changes made in the previous stages. This phase is about fostering self-discipline and ensuring that employees continue to follow the 5S principles. It involves continuous training, monitoring, and periodic audits to ensure compliance. Employees must be encouraged to take ownership of their workspaces, and managers should provide regular feedback to sustain momentum. Sustain also involves creating a culture of continuous improvement, where employees are motivated to maintain high standards. Recognition, incentives, and regular audits help keep the momentum alive.

In conclusion, 5S is a powerful system that improves workplace efficiency, safety, and cleanliness. Its implementation is a gradual process that requires commitment at all levels of the organization. By organizing, cleaning, standardizing, and sustaining, 5S can transform a cluttered, inefficient workspace into a productive and well-organized environment, contributing to enhanced performance and reduced waste.

3.3.2. ABC Inventory Analysis

ABC analysis was conducted by ranking rolls based on usage frequency, criticality to order completion, and buyer sensitivity. This classification helps prioritize storage accessibility and retrieval protocols. ABC analysis is simple classification of material that grouped the product according to frequency of the use and their value. ABC analysis classify the each item in to A, B and C class items so it will be easy to apply tight control to selected categories. The ABC analysis is as shown in table 3.

Table 3 ABC Classification strategy

	Percentage of Items	**Percentage of annual usage**	**Actions**
A-category	About 20%	About 80%	Close day to day control
B-category	About 30%	About 50%	Periodic review
C-category	About 50%	About 5%	Infrequent review

The annual consumption value is calculated with the formula:

Annual consumption = Annual Demand Item cost per unit …….. (Equation 3.1)*

- A-category: Small rolls frequently used in priority orders (e.g., H&M). A-items are fabric which annual consumption value is the highest; the top 80%of the annual consumption value of the company typically accounts for only 20% of the total inventory.
- B-category: Moderate usage rolls with occasional criticality. B-Items fabrics are the inter class items, with a medium consumption value typically accounts for 30% of the total inventory items.
- C-category: Rarely used, surplus rolls that can be relocated or disposed. C-Items are the contrary items with the lowest consumption value; the lower 5% of the annual consumption typically accounts 50% of the total inventory items.

This classification informs how space and retrieval effort should be allocated—e.g., A-class rolls near dispatch area, C-class rolls in rear storage.

3.3.3. Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is an important aspect of lean manufacturing that helps find and eliminate waste in the system so that things function more smoothly. We use VSM to develop ways to make it easier for a textile company that sells to huge firms like H&M, PUMA, and Hugo Boss to handle cloth rolls. SM is more than just a regular process map because it shows how both raw materials and information move. It shows you how everything is made and how it gets to you. This helps you see how things and information flow through the process, from making fabric rolls to sending them out.

The study used VSM to see how materials moved, find actions that wasted time, and sort operations into three groups: value-added (VA), necessary but non-value-added (NNVA), and non-value-added (NVA). We were able to find the main portions of the system that made waste by arranging these actions into categories. Most of these were about how long it took to get items back, how much waste was generated, and how long machines sat around doing nothing.

Mapping the Current State

The first step was to make a map of the current state that showed the whole process, from making fabric rolls to sending them out. The most important steps in the procedure were shown on this map, such as:

- Making fabric rolls (Value-Added)
- Storing (Non-Value-Added)
- Filling orders that have both value-added and non-value-added parts
- Roll Retrieval (which doesn't add value)
- Dispatch (Value-Added)

We looked at each of these procedures in terms of how long they took and found things that didn't provide value, such manual search, repeated handling, and re-knitting.

Classification of Activities:

Value-Added (VA) activities: These are the things that the consumer thinks will make the product better. In this scenario, rolling fabric, processing orders, and shipping were all considered as value-added steps because they are all necessary to make the final product and get it to customers.

Necessary but non-value-added (NNVA): These are things that must be done for the process of working, but they don't truly add value. One of these duties is to process orders, which entails checking the order's information and making sure there is enough stock. Even while it's required, it doesn't directly provide value for the customer's final product.

Non-Value-Added (NVA) activities: These activities don't improve the product and cost time and money. We learnt that storing, rolling up, and re-knitting were all things that didn't add value. These steps take longer, use up more materials, and cost more money. Sometimes, fabric rolls weren't well-organized because of how they were stored, which made it take a long time to get them. Getting rolls meant a lot of hunting and handling by hand, and re-knitting happened when the proper size fabric roll wasn't available, which wasted both time and materials.

Future State Mapping:

It was proposed that a future state map be produced to make the process better based on what was learnt from the current state map. The future state map was all about these important changes:

- Better storage: Using ABC Classification to sort fabric rolls so that the ones that are in high demand are kept close to where they can be located. This cuts down on the time it takes to find fabric rolls.
- Better roll retrieval: Using digital monitoring and visual tagging to cut down on human searches and make it easier to find the proper fabric rolls.
- Less waste: It's easier to maintain track of inventory and make sure that the proper fabric rolls are always available, so there is less need to re-knit.

VSM as a Lean Tool:

VSM is an aspect of the lean technique that helps uncover places where things were wasted, such excessive wait times and doing the same thing twice. VSM helped find the ideal process flow by getting rid of steps that didn't add value, like looking for fabric rolls that weren't needed and re-knitting. The future state map was designed to fix as many of these problems as feasible so that resources could be used in the best way possible and customers could get the most value.

3.4. Performance Metrics

To evaluate the effectiveness of the lean intervention, several Key Performance Indicators (KPIs) were defined and compared before and after applying lean tools:

Table 4 Key Performance Indicators

KPI	Description
Retrieval Time	Average time (in minutes) to locate a fabric roll
Re-knitting Incidence	Number of rolls re-knitted due to missing fabric
Fabric Waste	Total kilograms of fabric wasted
Machine Idle Time	Total minutes of lost machine time
Delivery Delays	Number of orders delayed beyond lead time

4. Calculation and Results

4.1. ABC Classification

4.1.1. Steps for ABC Classification

The steps of ABC analysis are presented below:

Step 1. Input the following:

- Total number of items.
- Item code, annual consumption in terms of units, and unit price for each of the items.

Step 2. For each item, compute the annual consumption value in terms of currency by multiplying its annual consumption units with its unit price by equation 3.1.

Step 3. Arrange the items and their details in descending order of the annual consumption values computed in Step 2.

Step 4. Compute cumulative values of the annual consumption values.

Step 5. Group the items into A, B, and C classes by dividing the items into 80 percent (A-class), 50 percent (B-class) and5 percent (C-class) of the annual consumption values, respectively, from top to bottom in the sorted list of Step 3.

4.1.2. Buyer Priority Based on Category A Fabric Rolls

Total Weight per Buyer: Find the summation of weight of fabric rolls per buyer.

Percentage of Category A Rolls per Buyer: 70 percentage of the total weight each buyer contributes to Category A.

Priority Ranking: Rank buyers based on the weight they contribute to Category A and suggest which ones should receive higher priority.

By calculating following the above steps we find that the buyers contributing the most to Category A (high-priority) fabric rolls, in terms of weight, are as showed in figure 3:

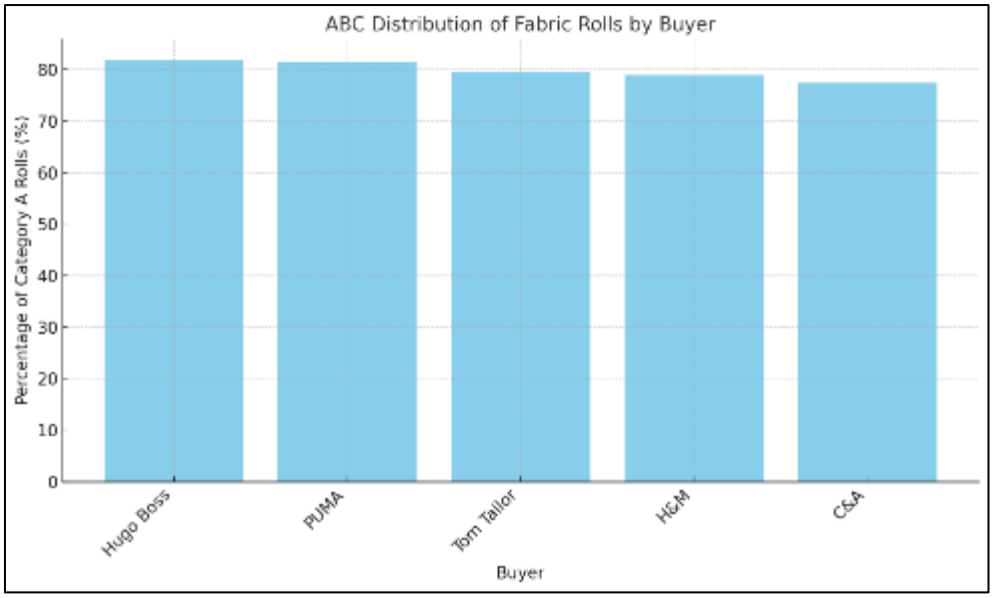

Figure 3 Buyer wise ABC classification

The above figure summarizes Hugo Boss contributes 81.84% of its total fabric weight to Category A rolls. Then PUMA, Tom Tailor, H&M Contributes 81.50%, 79.60%, 78.92% of its total fabric weight to Category A rolls respectively. As seen, Hugo Boss, PUMA, and Tom Tailor have the highest percentages of Category A rolls, highlighting their higher priority in the inventory management process.

4.2. VSM Analysis

To perform Value Stream Mapping (VSM) and analyze Retrieval Time (min) and Machine Idle Time (min), we will:

- Calculate the average retrieval time and average machine idle time for each buyer and fabric type.
- Identify bottlenecks by analyzing which areas are experiencing the longest delays in terms of retrieval and machine downtime.
- Highlight the total time loss due to these inefficiencies.

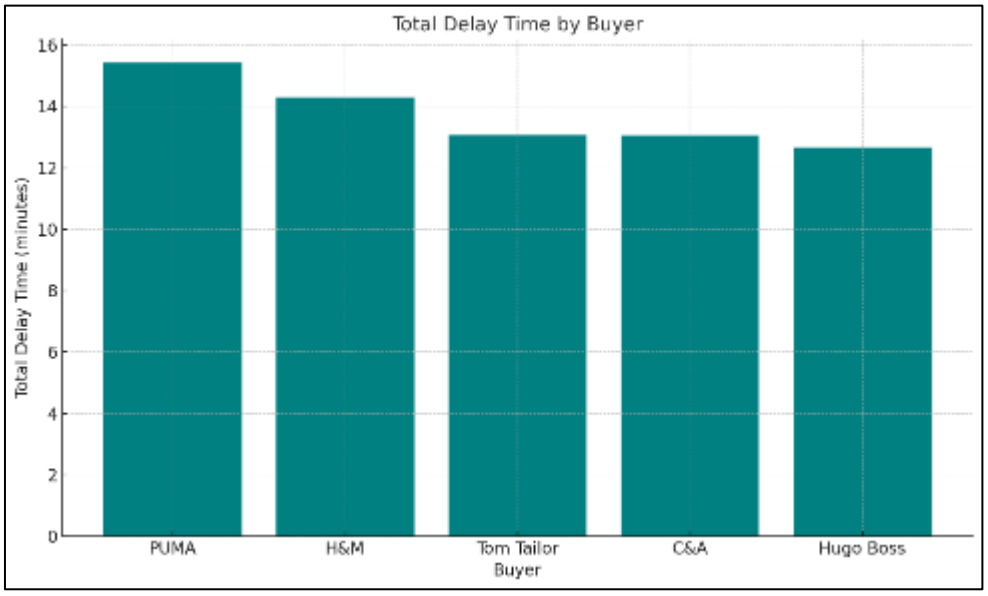

Figure 4 Buyer wise time delay

Figure 4 illustrates the Total Delay Time by Buyer, highlighting the time spent on retrieval and machine idle time for each buyer. PUMA experiences the highest delay, with a total delay time of 15.43 minutes, primarily due to delays in both retrieval and machine idle time. H&M follows with a delay of 14.29 minutes, mainly caused by retrieval time. Tom Tailor has a relatively lower total delay of 13.08 minutes, with less machine idle time. C&A and Hugo Boss have the lowest total delays, at 13.06 minutes and 12.67 minutes, respectively, indicating more efficient processes.

4.2.1. Delivery Delay vs. Fabric Roll Retrieval Time

We examine the relationship between the Delivery Delay (Days) and Retrieval Time (min) to see if delays in retrieving fabric rolls are linked to delays in fulfilling customer orders. This analysis could highlight inefficiencies in the fabric retrieval process that directly impact delivery timelines. The correlation between Retrieval Time (min) and Delivery Delay (Days) is -0.04, which indicates a very weak negative relationship. This suggests that longer retrieval times do not significantly correlate with higher delivery delays. While some delays may exist, retrieval time doesn't seem to be the primary cause of delivery delays in this case.

4.2.2. Re-knitted Fabric Rolls and Waste Generation

Furthermore, we investigate the correlation between fabric rolls that require re-knitting and the amount of Waste Generated (kg) to see the financial and material cost associated with re-knitting fabric and could be a significant point for process improvement. The average Waste Generated (kg) for re-knitted fabric rolls is 1.60 kg, while non-re-knitted rolls generate 0 kg of waste on average. This highlights that re-knitting fabric is associated with substantial material waste, which is an area that can be improved to minimize both raw material usage and waste.

Table 5 Waste & Rework Summary

Metric	**Value**
Total Fabric Rolls	500
Re-knitted Rolls	73 rolls
Total Fabric Waste	116.68 kg
Average Waste per Re-knitted Roll	1.60 kg
Total Machine Idle Time	1,365.9 minutes *(~22.8 hours)*
Average Idle Time per Re-knitted Roll	18.71 minutes
Total Delivery Delay	169 days *(cumulative)*

Table 5 presents the operational inefficiencies in the fabric roll handling process. The data shows that due to the failure in retrieving the original roll within due time, 73 out of 500 rolls i.e. 14.6% of fabric rolls, or, required re-knitting. Moreover, on average, each re-knitted roll resulted in approximately 1.60 kg of fabric waste and caused machine idle time. The consequences of this these inefficiencies contributed to a total delivery delay of 169 days, which could negatively impact buyer satisfaction and contractual compliance. This analysis focuses the significant operational impact of inefficient fabric retrieval processes and emphasizes the need for improvements to minimize waste and reduce delays.

4.3. 5S Implementation in the Primary and Final Inventory

4.3.1. Steps for the Analysis

- Baseline Data: We used dataset prior 5S Implementation as the baseline for Retrieval Time, Waste Generated, and Machine Idle Time.
- Improvement After 5S Implementation: We have collected data after implementation of 5S and made another dataset.
- Retrieval Time: Decrease due to improved organization and easier access to fabric rolls.
- Waste Generation: Reduction due to better inventory management and reduced fabric rework.
- Machine Idle Time: Decrease due to more efficient scheduling and fewer delays in fabric retrieval.
- Comparing Before and After: We'll compare the before and after scenarios to demonstrate the impact of 5S.

4.3.2. Improvements from 5S

Using the 5S method made the process of handling fabric rolls much better, which made it more efficient and reduced waste.

- Sort: The first phase, Sort, was to get rid of superfluous rolls of cloth that were in the way. This made the environment less messy and more ordered, which made it simpler to get things done. The factory was able to clear up essential space by getting rid of items that weren't used very often or weren't needed anymore. This made it easier to get to the cloth rolls that were needed for making things.
- Set in Order: The second step, Set in Order, was all about putting the fabric rolls in the right places so that they were easy to discover. The new ways of identifying and storing fabric rolls made it so that workers didn't have to waste time hunting for them anymore. It was easy to get to the rolls that were very important and used a lot. This made it easier to find them and helped things run more smoothly in the factory.
- Shine: The third step, Shine, was to keep the workspace neat and clean. The company was able to keep machinery functioning by making sure they were cleaned on a regular basis so that dirt and debris didn't build up. This also helped the machines perform at their best, which meant less delays in production and maintenance issues. A clean workplace not only made it safer, but it also made workers feel proud and like they owned the place. This improved the culture at work.
- Standardize: The Standardize phase brought in standard ways to handle inventory. This made guaranteed that the improvements gained in sorting and arranging stayed in place. There are now explicit standards and methods for keeping track of inventory. This makes it less likely that mistakes will be made, fabric rolls will be lost, or the production process will be confusing. People were also taught to follow these new regulations throughout this time, so everyone knew what they had to do to keep the system working smoothly.
- Sustain: Finally, Sustain made sure that the changes weren't just for show but were a permanent element of how the plant worked every day. Regular audits and continuing training were put in place to make sure that the factory preserved the improvements made through 5S. People were told to be in charge of the procedures and make sure that everyone else did their part to keep the changes continuing. The company made sure that changes would stay by making these practices a part of the factory's culture. This made the workplace emphasize cleanliness, orderliness, and productivity.

In the end, the plant was able to handle fabric rolls, cut down on waste, and keep the production flow flowing smoothly thanks to 5S. Not only did these modifications make workers more productive, they also made the workplace safer, cleaner, and better for the environment.

Figure 5 Inventory before 5S implementation

Figure 6 Inventory after 5S implementation

Figure 5 represents the inventory condition before 5S application, showing a messy workspace where fabric rolls are piled up which creates navigation and access difficult. The lack of organization in fabric inventory results in wasted time and inefficient retrieval, contributing to delays and increased waste.

While figure 6 refers the condition after 5S application in inventory. The workspace looked shiny and clean and much better organized than before. The clear pathways have been established, with dedicated areas for the rolls. This new arrangement makes it easier to find things and manage inventories, which makes the workspace more organized and efficient. The observable changes show how 5S may help reduce clutter, make things easier to find, and make the workflow more efficient.

Table 6 Comparing results before and after implementation of lean tools

Metric	Before Lean Tools Implementation	After Lean Tools Implementation	Improvement
Retrieval Time	10.96 minutes	7.67 minutes	30%
Waste Generated	0.23 kg	0.18 kg	25%
Machine Idle Time	2.73 minutes	1.50 minutes	45%

To better understanding the improvement made by using lean tools in inventory management system the data of table 6 is graphically shown in figure 7 below.

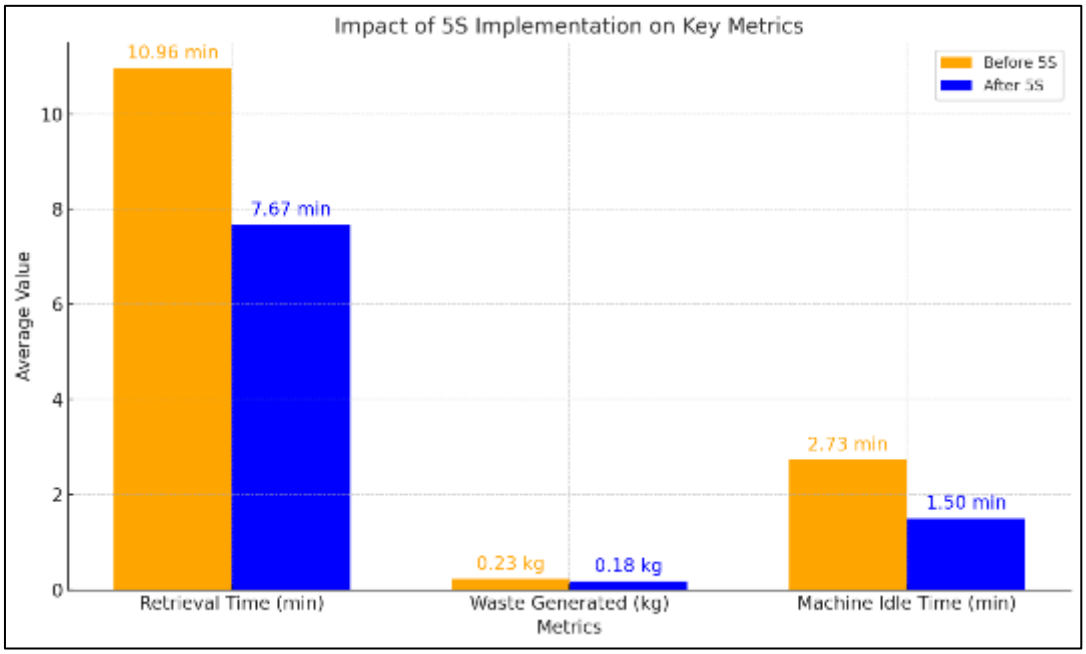

Figure 7 Comparison of key metrics before and after lean tools implementation

5. Discussion

The 5S method has helped the garments sector maintain better track of its inventory. It has made things go more easily, made more goods, and cut down on waste. Before the implementations of lean tools, it took an average retrieval time of 10.96 minutes, which means they took a long time to get. But it took 7.67 minutes less time, or 30% less time, to get everything back after following the 5S criteria. The 'Set in Order' and 'Shine' components of 5S helped make this better by cleaning up and arranging the workplace. This made it easier to get to the fabric rolls. The average amount of waste from each roll of cloth was also 0.23 kg. This was primarily because of bad inventory management and the necessity to re-knit. After 5S was put into place, each roll of cloth only made about 0.18 kg of waste. The 'Sort' and 'Standardize' concepts worked quite effectively in this case. They tossed away fabric rolls that they didn't need, which made it easier to keep track of stocks and helped cut down on fabric waste.

It was also evident that getting fabric and scheduling machines weren't working correctly because machines were sitting around for 2.73 minutes before 5S was put in place. Once 5S was put in place, machines were not working for 45% less time. That's just one minute and fifty seconds. This progress was achievable because people who bought fabric and individuals who ran machines communicated to one other more and made better plans. This meant that machines didn't have to wait as long for what they required. These adjustments indicate that 5S principles may help a production work a lot better by making things more structured, cutting down on waste, and making things run more smoothly.

6. Conclusion

The implementation of 5S in garments factory has led to remarkable improvements in KPI (key performance metrics) of the factory. To me mentioned, retrieval time was down by 30% as well as amount of waste and machine idle time also reduced by 25 % and 45% respectively. This results proves the effectiveness of lean tools implementation in increased productivity and reducing loss of the company. The outcomes suggest that proper inventory management, optimal scheduling and organized and cleaner workplace are important for increasing factory performance.

The company needs to keep working on arranging the fabric rolls so that the most critical ones are easy to find. Regularly checking your stockpiles can help you preserve the improvements in waste formation and get rid of additional fabrics that you don't use as often. There should also be better techniques to plan when machines will operate so that they don't have to stop as often and more work is done. You can teach your workers how to apply 5S, host Kaizen events on a regular basis, and use visual management tools to make sure that the changes are always followed.

The study's results show that textile makers might be able to keep better track of their stocks by employing the lean tools. Learning more about Value Stream Mapping (VSM) and other lean methods could help you uncover more ways to make the supply chain and operations better. We can also learn more about the greater benefits of 5S by looking at how it helps keep things in good shape and saves money over time. The factory ran better with the 5S guidelines, and it was easy to keep track of small chores. The study's results demonstrate that textile companies may use 5S to speed up production, cut down on waste, and make their manufacturing processes more efficient without spending a lot of money.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] I. S. Swazan and D. Das, “Bangladesh’s Emergence as a Ready-Made Garment Export Leader: An Examination of the Competitive Advantages of the Garment Industry,” International Journal of Global Business and Competitiveness 2022 17:2, vol. 17, no. 2, pp. 162–174, Feb. 2022, doi: 10.1007/S42943-022-00049-9.

[2] M. Rock, “Globalisation and bangladesh: The case of export-oriented garment manufacture,” South Asia: Journal of South Asia Studies, vol. 24, no. 1, pp. 201–225, 2001, doi: 10.1080/00856400108723430.

[3] N. Islam and A. S. Bari Chowdhuri, “Socio-Economic Factors of Readymade Garments Workers in Bangladesh,” SSRN Electronic Journal, Oct. 2016, doi: 10.2139/SSRN.2851802.

[4] M. S. Islam, “Ready-made garments exports earning and its contribution to economic growth in Bangladesh,” GeoJournal, vol. 86, no. 3, pp. 1301–1309, Jun. 2021, doi: 10.1007/S10708-019-10131-0/METRICS.

[5] “An Overview of the Ready-made Garment (RMG) Sector of Bangladesh: From Origin to the Current State of Pinnacle - 九大コレクション | 九州大学附属図書館.” Accessed: Jul. 16, 2025. [Online]. Available: https://catalog.lib.kyushu-u.ac.jp/opac_detail_md/?lang=0&amode=MD100000&bibid=4067129

[6] J. K. Hayakreevan, S. Kirthick, C. Vishwarudhresh, M. Jagannath, D. Vydeki, and G. Velmathi, “IoT-Based Garment Inventory Management System,” Proceedings of the 2024 3rd Edition of IEEE Delhi Section Flagship Conference, DELCON 2024, 2024, doi: 10.1109/DELCON64804.2024.10866340.

[7] B. Shen, H. L. Chan, P. S. Chow, and K. A. T. Barletta, “Inventory management research for the fashion industry,” International Journal of Inventory Research, vol. 3, no. 4, p. 297, 2016, doi: 10.1504/IJIR.2016.082325.

[8] R. Chauhan and S. Ghosh, "Knitted fabric production," Textile Calculation: Fibre to Finished Garment, pp. 237–254, Jan. 2023, doi: 10.1016/B978-0-323-99041-7.00004-7.

[9] M. Chowdhury et al., "A feasibility study to analyze the behavior of heat settings on the cleaner production of knitted fabrics," Clean Eng Technol, vol. 7, p. 100429, Apr. 2022, doi: 10.1016/J.CLET.2022.100429.

[10] L. Ozsen, M. S. Daskin, and C. R. Coullard, "Facility location modeling and inventory management with multisourcing," Transportation Science, vol. 43, no. 4, pp. 455–472, Sep. 2009, doi: 10.1287/TRSC.1090.0268;WEBSITE:WEBSITE:INFORMS-SITE.

[11] V. Jayaraman, "Transportation, facility location and inventory issues in distribution network design: An investigation," International Journal of Operations and Production Management, vol. 18, no. 5, pp. 471–494, 1998, doi: 10.1108/01443579810206299/FULL/XML.

[12] P. A. Miranda and R. A. Garrido, "A simultaneous inventory control and facility location model with stochastic capacity constraints," Netw Spat Econ, vol. 6, no. 1, pp. 39–53, Mar. 2006, doi: 10.1007/S11067-006-7684-5/METRICS.

[13] M. P. Vance and D. M. Lambert, "Implementing an Effective Inventory Management System," International Journal of Physical Distribution & Logistics Management, vol. 20, no. 9, pp. 17–23, Sep. 1990, doi: 10.1108/EUM0000000000376/FULL/XML.

[14] R. Grmek, Y. Khmelevsky, and D. Syrotovsky, "Automated inventory tracking system prototype in cloud," Proceedings of the 2011 International Conference on High Performance Computing and Simulation, HPCS 2011, pp. 435–441, 2011, doi: 10.1109/HPCSIM.2011.5999857.

[15] A. B. and A. Hattangady, "Inventory Tracking System," Senior Design Project For Engineers, Dec. 2024, Accessed: Jul. 16, 2025. [Online]. Available: https://digitalcommons.kennesaw.edu/egr_srdsn/107

[16] M. Afizi Mohd Shukran et al., "Low-Cost Asset Tracking and Inventory Management System (ATIM)," J Phys Conf Ser, vol. 2007, no. 1, p. 012072, Aug. 2021, doi: 10.1088/1742-6596/2007/1/012072.

[17] G. M. and economic cybernetics studies and and undefined 2009, "Inventory management optimization as part of operational risk management," papers.ssrn.com, Accessed: Jul. 16, 2025. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1562699

[18] S. Muhr, "Inventory Level Visibility: Reasons Causing Lack in Service Field Operations," 2020, Accessed: Jul. 16, 2025. [Online]. Available: https://www.diva-portal.org/smash/record.jsf?pid=diva2:1461298

[19] K. Michael, L. M.-I. C. on Mobile, and undefined 2005, "The pros and cons of RFID in supply chain management," ieeexplore.ieee.org, Accessed: Jul. 16, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/1493672/

[20] A. Elsharydah, M. A. Michaelis, and N. Rajan, "Lean management: inventory, waste management," Springer, pp. 113–118, Jan. 2019, doi: 10.1007/978-3-030-19171-9_8.

[21] S. L. B. França, D. F. Dias, A. E. B. Freitag, O. L. G. Quelhas, and M. J. Meiriño, "Lean manufacturing application analysis in the inventory management of a furniture industry," Springer, vol. 280, pp. 207–219, 2019, doi: 10.1007/978-3-030-14969-7_18.

[22] R. Moori, … H. K.-… J. of M., and undefined 2017, "A lean inventory management model as a competitive strategy analysis tool: implications for sustainability," inderscienceonline.com, vol. 3, no. 4, p. 310, 2017, doi: 10.1504/LAJMSD.2017.089372.

[23] Md Bahar Uddin, Md. Hossain, and Suman Das, "Advancing manufacturing sustainability with industry 4.0 technologies," International Journal of Science and Research Archive, vol. 6, no. 1, pp. 358–366, Jun. 2022, doi: 10.30574/ijsra.2022.6.1.0099.

[24] A. Anđelković, M. Radosavljević, D. S.-E. themes, and undefined 2016, "Effects of lean tools in achieving lean warehousing," sciendo.com, vol. 54, no. 4, pp. 517–534, Dec. 2016, doi: 10.1515/ETHEMES-2016-0026.

[25] L. Yik, J. C.-I. C. S. M. S. and, and undefined 2019, "Application of 5S and visual management to improve shipment preparation of finished goods," iopscience.iop.org, doi: 10.1088/1757-899X/530/1/012039/META.

[26] M. Guendi et al., "5s methodology applied to inventory management," journalindustrial.com, vol. ISSNe, no. 1, pp. 2961–211, 2021, doi: 10.47422/jstri.v2i1.9.

[27] H. P. Hsu, C. N. Wang, T. T. B. C. Vo, and N. T. Nguyen, "Enhancing productivity and inventory management in aquatic processing through a comprehensive lean manufacturing framework," emerald.com, 2025, doi: 10.1108/IJQRM-05-2024-0134/FULL/HTML.

[28] P. Ritthaisong, N. K.- F1000Research, and undefined 2025, "Application of value stream mapping to design and develop an inventory management system in a hospital," f1000research.com, Accessed: Jul. 16, 2025. [Online]. Available: https://f1000research.com/articles/14-365

[29] P. Abhishek, … M. P. B. and M., and undefined 2020, "Achieving lean warehousing through value stream mapping," journals.sagepub.com, vol. 9, no. 3, pp. 387–401, Dec. 2020, doi: 10.1177/2277977920958551.

[30] H. Ravinder, R. M.-A. journal of business, and undefined 2014, "ABC analysis for inventory management: Bridging the gap between research and classroom," digitalcommons.montclair.edu, 2014, Accessed: Jul. 16, 2025. [Online]. Available: https://digitalcommons.montclair.edu/management-facpubs/2/

[31] C. Chu, G. Liang, C. L.-C. & I. Engineering, and undefined 2008, "Controlling inventory by combining ABC analysis and fuzzy classification," Elsevier, Accessed: Jul. 16, 2025. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0360835208000612

[32] M. Hamid and S. D.-J. O. B. ADMINISTRATION, "Factors Influencing Effective Inventory Management In The Textile Industries of Bangladesh," cu.ac.bd, Accessed: Jul. 16, 2025. [Online]. Available: https://cu.ac.bd/1/CUJBA%20(Vol.-33)-1-1.pdf#page=300

[33] M. Alam, O. Thakur, F. I.-R. management journal, and undefined 2024, "Inventory management systems of small and medium enterprises in Bangladesh," emerald.com, vol. 18, no. 1, pp. 8–19, Jan. 2024, doi: 10.1108/RAMJ-09-2022-0145/FULL/HTML.

[34] R. Rahman, M. Rahman, … S. A. S.-… in A. I. of, and undefined 2025, "Importance of ERP System in Increasing the Inventory Management Productivity in Apparel Industry of Bangladesh," papers.ssrn.com, Accessed: Jul. 16, 2025. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5113910

[35] A. Basak, M. Seddiqe, … M. I.-… : A. A. and, and undefined 2014, "Supply chain management in garments industry," academia.edu, Accessed: Jul. 16, 2025. [Online]. Available: https://www.academia.edu/download/55861892/4-Supply-Chain-Management-in-Garments.pdf

[36] T. C. Nguyen, T. Fishman, A. Miatto, and H. Tanikawa, "Estimating the material stock of roads: the Vietnamese case study," Wiley Online Library, vol. 23, no. 3, pp. 663–673, Jun. 2019, doi: 10.1111/JIEC.12773.

[37] A. C. Yao and J. G. Carlson, "The impact of real-time data communication on inventory management," Int J Prod Econ, vol. 59, no. 1–3, pp. 213–219, Mar. 1999, doi: 10.1016/S0925-5273(98)00234-5.

[38] Md. K. Alam, O. A. Thakur, and F. T. Islam, "Inventory management systems of small and medium enterprises in Bangladesh," Rajagiri Management Journal, vol. 18, no. 1, pp. 8–19, Jan. 2023, doi: 10.1108/RAMJ-09-2022-0145.

[39] J. B. Jr, … J. C. S. B. M., and undefined 1985, "Inventory management techniques," search.proquest.com, Accessed: Jul. 16, 2025. [Online]. Available: https://search.proquest.com/openview/ac6bf546ed3b3043c2576de541863194/1?pq-origsite=gscholar&cbl=49243

[40] H. Inegbedion, S. Eze, … A. A.-T. J. of S., and undefined 2019, "Inventory management and organisational efficiency," eprints.lmu.edu.ng, Accessed: Jul. 16, 2025. [Online]. Available: http://eprints.lmu.edu.ng/2302/

[41] M. R. Hoque, S. R. Tushar, M. A. S. Shafil, M. M. Bappy, and M. G. S. Rayhan, "An integrated VSM 4.0 and interval-valued q-Rung orthopair fuzzy approach to sustainable process development in the apparel manufacturing industry," International Journal of Industrial Engineering and Operations Management, vol. ahead-of-print, no. ahead-of-print, 2025, doi: 10.1108/IJIEOM-12-2024-0094/FULL/PDF.

[42] M. Samad, J. Abdullah, M. R.-A. J. of E. and, and undefined 2023, "Reduction of Manufacturing Lead Time by Value Stream Mapping of a Selected RMG Factory in Bangladesh," ajeat.com, vol. ISSN, no. 1, pp. 10–17, 2023, doi: 10.51983/ajeat-2023.12.1.3578.

[43] M. Habib, R. Rizvan, S. A.-R. in Engineering, and undefined 2023, "Implementing lean manufacturing for improvement of operational performance in a labeling and packaging plant: A case study in Bangladesh," Elsevier, Accessed: Jul. 16, 2025. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2590123022004881

[44] A. Chowdhury, S. Shahriar, … T. H.-A. M. and, and undefined 2017, "Reduction of process lead time using lean tool-value stream mapping (VSM)," Trans Tech Publ, Accessed: Jul. 16, 2025. [Online]. Available: https://www.scientific.net/AMM.860.74

[45] V. S.-I. R. J. of E. and and undefined 2019, "The Study of various Tools and Techniques of Inventory Management and Experiment with use of ABC Analysis," academia.edu, Accessed: Jul. 16, 2025. [Online]. Available: https://www.academia.edu/download/59737092/IRJET-V6I47720190615-15181-cqgl3e.pdf

[46] Y. Chen, K. Li, S. L.-2008 I. I. C. on, and undefined 2008, "A comparative study on multicriteria ABC analysis in inventory management," ieeexplore.ieee.org, Accessed: Jul. 16, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/4811802/