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Fashion Circularity: Potential of Reusing and Recycling Remnant Fabric to Create Sustainable Products

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Abstract: The textile and fashion industry produce a significant amount of solid waste annually. Most of this waste is either disposed of or burned; very little is reused. This research investigates the potential of reusing and recycling remnant fabric to create sustainable luxury fashion products in a circular economy. Focusing on three factories namely Factory A, Factory B, and Factory C, this study analyzes product diversification, capacity, capital investment, supply chain dynamics, and manufacturing operations. A qualitative approach with semi-structured interviews with industry practitioners from the case factories was employed. Data from purchasing orders, production reports, inventory reports, and monthly invoices were analyzed. The factories manufactured a range of sustainable products, emphasizing floor mats, ladies' handbags, and bedding items (pillow covers). The analysis revealed that each factory achieved a 30–40% profit margin on their monthly sales. Notably, approximately 95% of the remnant fabric was recycled in the production process, with merely 5% being discarded and resold for further use. These findings indicate local employment opportunities and substantial contributions to socio-economic advancement. This study recommends adopting a circular economy model to generate new business opportunities and income streams from remnant fabric. It encourages new financial investment and technical innovations to promote growth in this sector and benefit wider stakeholders.

Keywords: sustainability; circularity; remnant; fashion products

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Academic Editor: Giovanni De Feo

Received: 30 December 2024
Revised: 17 February 2025
Accepted: 19 February 2025
Published: 26 February 2025

Citation: Shamsuzzaman, M.; Al. Mamun, M.A.; Hasan, H.M.R.U.; Hassan, R.; Zulkernine, A.; Atik, M.A.R.; Islam, M. Fashion Circularity: Potential of Reusing and Recycling Remnant Fabric to Create Sustainable Products. *Sustainability* **2025**, *17*, 2010. https://doi.org/10.3390/su17052010

1. Introduction

Due to the fast fashion demand, the production of garments/apparel has increased significantly, amounting to 80–150 billion pieces per year, employing over 300 million people [1,2]. The manufacturing of this large quantity of garments consumes huge amounts of water, energy, and raw materials, including fibers, dyes, chemicals, etc., that have a notorious environmental impact. Around 92 million tons of textile waste is generated every year, including fibers, fabrics, garments, dyes, and chemicals. Moreover, products have become more disposable with shorter lifespans, while the demand for new items continues to grow in the Western world. This rapid acceleration in production and consumption cycles is leading to higher environmental impacts and increased waste generation [3].

Approximately 10% of global carbon dioxide (CO_2) emissions and 20% of greenhouse gases come from this sector, making it the second-largest polluter after the oil industry [4].

Textile and garment waste can occur at various stages of production and consumption process, including manufacturing, distribution, retail, and end-of-life disposal. Significant waste is generated due to the large volume of textile and apparel production and consumption, coupled with shorter usage lifespans [5,6]. Approximately 30–40% of fabric waste generated during manufacturing is valuable, recyclable, and reusable, with 70–80% sold as remnant fabric. A significant amount of in-process fabric waste is generated from the cutting sections in the garment industry [7,8]; more than 85% of waste is disposed of in landfills or incinerated, and only 15% is collected for repurposing. In 2018, the United States produced 17.03 million tons of textile waste, with 18.9% incinerated for energy recovery, 66.4% landfilled, and only 14.7% recycled. Currently, the industry produces 92 million tons of textile waste annually, with 75–80% being solid fabric waste [9]. Projections indicate that by 2030, around 148 million tons of textile waste will be generated annually, and by 2050, over 150 million tons of clothing will be incinerated or landfilled [10,11]. To mitigate these global challenges, sustainable textile production is becoming an integral part of textile waste management. It reduces environmental effects, conserves natural resources, and assures ethical labor practices, while remaining economically viable. To produce textiles with a lower carbon footprint, it uses eco-friendly materials, resource-efficient procedures, waste reduction, and circular economy principles. Sustainable textile production entails a variety of tactics, such as employing organic or recycled fibers, using water- and energy-efficient dyeing and finishing techniques, and reducing the use of hazardous chemicals. It also encourages ethical labor practices, such as fair wages and safe working conditions. Bio-based materials, digital printing, and closed-loop recycling systems are among the innovations that contribute to sustainability. The ultimate goal is to build a responsible supply chain that balances economic, environmental, and social concerns, while addressing customer desires for eco-conscious fashion and textiles. Effective methods, including reuse, recycling and/or repurposing, must be incorporated into the fashion supply chain [12].

The recycling of fabric/garment waste and circularity practices have gained significant momentum in recent years, focusing on various factors, which include green consumerism, waste disposal costs, and numerous legislative initiatives and mandates [13]. These processes allow for the recovery and repurposing of resources and material circulation to create useful items, reducing environmental impacts [14,15]. Along with environmental benefits, recycling and circularity practices help preserve the cultural heritage and contribute significantly to the economy by creating new value-added products. The practice of recycling leftover fabric is becoming increasingly popular in leading countries like Bangladesh [8,16].

The global fashion industry is now reflecting a significant trend towards sustainability, driven by rising environmental concerns and consumer demand for eco-friendly products [17,18]. Manufacturing sustainable items from leftover fabric is gaining importance when the materials are back in their supply stream [18], promoting circularity. Many governments and major fashion firms are investing in advanced recycling technologies to convert textile waste into high-quality, marketable products [19,20]. Europe and North America are at the forefront, enacting stringent legislation and policies to promote recycling and the circular economy. Countries like Germany and Sweden have developed efficient waste management systems for collecting and processing textile leftovers. Major textile manufacturers in Asia, including China, India, and Bangladesh, are also adopting sustainable and circular practices, though at a slower pace due to economic and infrastructure challenges [21]. Global efforts and collaborations, such as the Sustainable Apparel Coalition (SAC) and the Ellen MacArthur Foundation's circular economy programs, encourage best practices and technological advancements in fabric recycling. Despite these efforts, scalability, affordability, and consumer acceptance remain significant challenges. However, the global outlook on recycling leftover textiles is improving, with notable progress toward integrating sustainability and circularity into the textile industry's core practices [22,23].

Despite increasing awareness and efforts to promote sustainable practices in the textile sector, significant research gaps exist in producing sustainable goods from recycled remnant materials. Current studies have focused on the environmental benefits and overall feasibility of textile recycling but have lacked detailed information on the economic viability and market acceptance of products made from leftover fabrics [24,25]. Additionally, the technological challenges of converting various types of leftover textiles into high-quality, durable luxury fashion goods are not well addressed [10]. There is also limited research on supply chain logistics and the scalability of these sustainable practices (e.g., eco-friendly materials, manufacturing, products) to meet large-scale industrial demand [26–28]. Furthermore, consumer perceptions and their willingness to pay a premium for sustainable items made from recycled materials have not been explored well [17,29]. Addressing these gaps should help to develop effective strategies to increase the adoption of sustainable manufacturing practices in the textile industry, support a circular economy, and reduce environmental impacts.

In this research, three small and medium enterprise (SME) factories, namely A, B, and C, were selected from Bangladesh for the case study. The manufacturing operations of various luxury fashion products, including floor mats, handbags, and bedding items, were investigated, with multiple research questions highlighting remnant fabric sourcing, pricing, the manufacturing costs of each product, profits, etc. The uniqueness of remnant-based stylish luxury product development research stems from its revolutionary approach to sustainability, circular economy integration, and luxury market adaptability. This study investigates how fashion firms might utilize textile remnants and production waste in luxury products, while maintaining quality, aesthetics, and exclusivity. It focuses on advanced upcycling processes, material innovation, and the perception of luxury derived from sustainable sources. It also investigates commercial approaches that promote leftover utilization, such as limited edition collections and co-creation initiatives. By linking sustainability with luxury, this study offers a fresh viewpoint on waste valorization, while also harmonizing with changing customer expectations for ethical fashion.

We formulate, three specific research objectives as follows:

i. To explore the feasibility and utilization of remnants to manufacture sustainable luxury fashion product from recycling remnant fabric;
ii. To analyze the manufacturing process of floor mats, ladies' handbags, and bedding items by using remnant fabric;
iii. To analyze the costing, pricing, and profits of recycled remnant fabric-based luxury fashion items created by the case factories

The remainder of this paper is organized as follows: the key literature and theoretical background on recycling remnant fabric, an exploratory case study methodology, results and discussion, a summary of key findings, research implications, and conclusions.

2. Literature Review

2.1. Present Scenario of Remnant Fabric Collection, Processing, and Distribution

Around 92 million tons of textile waste is generated in different scenarios, which is estimated to rise to 134 million tons by 2030 [30]. The greatest producers of textile waste are China and the United States, with 20 million and 17 million tonnes, respectively [30]. Globally, apparel manufacturing generates approximately 60 billion square meters of cut-and-sew fabric waste annually [31,32]. In Bangladesh, over 550 tons of remnant fabric is being generated every day by the Bangladeshi textile industry, serving as a major source of raw material for small and medium enterprises (SMEs) engaged in sustainable fashion production [25,33]. Moreover, most of the garments are thrown away into the environment after only being used a few times; among them 50% are reusable, and 50% are recyclable. Unfortunately, 66% are landfilled, 19% are incinerated, and only 15% are collected for recycling and repurposing [30]. This is leading to a higher carbon footprint and energy and raw material losses [9,13,34].

These wastes predominantly consist of pure cotton, which can be recycled into new fibers and garments. Several SMEs in this country directly produce sustainable fashion products from remnant fabric [23,35]. Approximately 30–35% of the waste is recycled domestically in Bangladesh to produce items such as baby clothes, bedding, bags, pillows, car seat covers, blankets, mattresses, and other products [36]. Approximately, 20,000 to 22,000 traders are involved in the 'jhut' business, employing approximately 0.6 million workers, particularly women, and indirectly supporting around 1.0 million people in the apparel sub-sector [37]. In Bangladesh, a few locally developed methods are employed to recycle leftover fabric, aiming to minimize textile waste and create value from recovered materials [36,38]. These local industries and technologies are supporting the Government of Bangladesh's commitment to achieving sustainable management and efficient use of natural resources, aiming to substantially reduce waste generation through prevention, reduction, recycling, and reuse by 2030 [3].

2.2. Sources of Remnant Fabric

Remnant fabric is sourced primarily from two categories: pre-consumer waste and post-consumer waste. Pre-consumer waste is typically generated by textile factories and other production facilities. Pre-consumer waste that is not used or consumed by the intended user is called production waste. The textile and apparel industries produce this kind of waste as a by-product or solid waste. It is mainly caused by errors in design communication, poor craftsmanship, errors in fabric knitting or weaving, an incorrect color or shade, substandard materials, machine malfunctions, incorrect patterns, overproduction, and other factors. The fibers, both natural and synthetic, as well as finished yarns and textiles, technical textiles, nonwovens, clothing, and footwear, including off-cuts, selvages, shearing, rejected materials, and B-grade clothing, that result in production waste are shown in Table 1 [39,40].

Table 1. Manufacturing stages and types of garment solid wastes.

Manufacturing Stages	Types of Solid Wastes
Storage	Defected fabric, end rolls.
Cutting	Cut pieces during fabric laying and after cutting.
Printing	Different sizes of cut panels, thread, oily fabric.
Sampling	Fabric leftover from sample development.
Dyeing	Dyeing fault, rejected body.
Finishing	Rejected body.

There is a substantial amount of waste generated in the garment industry that originates from the cutting room. This waste can result from a variety of sources, including marker utilization, cutting waste, and roll remnants. One of the primary sources of waste in this area is the excessive cutting of fabrics into various sizes. The details can be found in Figure 1 [39,40].

Post-consumer waste refers to the waste generated by consumers after the product made of textiles has been used and discarded. It includes items like old clothing, household textiles, and other textile products that are no longer in use. Post-consumer waste is commonly found in landfills, creating environmental issues [41]. Wearable materials end up in the second-hand clothing industry. The vast majority of Western-style clothing is offered in emerging nations. Non-wearable textiles, depending on the type of fabric, are converted into fibers, also known as crappy, using two primary methods, including mechanical and chemical processes [42].

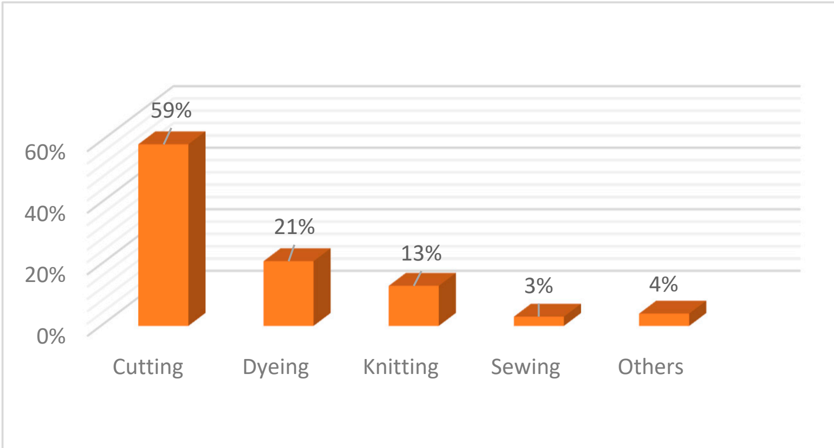

Figure 1. Percentage of fabric waste from garments' production stages.

2.3. Processing Methods of Remnant Fabric

The 10R strategies extend the traditional 3R strategies to the circular economy. These include refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recovery. These can be prioritized according to their levels of circularity [28]. The hierarchy of circular solutions relevant to the textiles and clothing market segments is presented in Figure 2, which was built on this 10R strategy [43]. Common textile fabric recycling methods include remanufacturing garments from wastage fabric, the mechanical or chemical recycling of wastage fabric to fiber, and repurposing as the upcycling of fabric to a different product. These methods are in the lower levels of the circularity hierarchy in Figure 2.

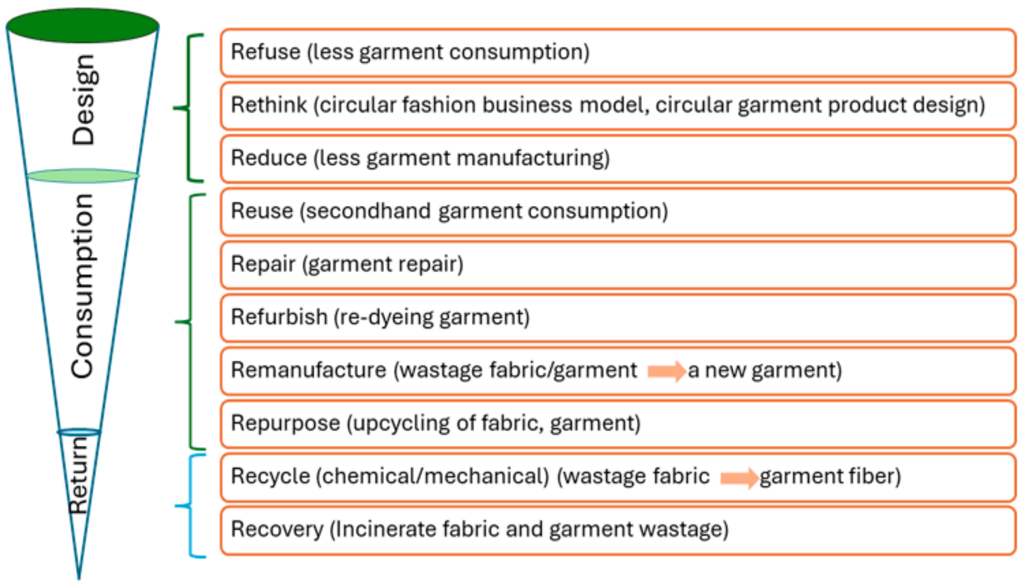

Figure 2. Textile and fashion circularity hierarchy.

Mechanical/physical recycling is the best way to eliminate textile waste. Here, either recoveries or a commingled waste treatment policy is implemented, where defective or worn-out garments are transformed into fibers and yarns. These can be used to make carpets, nonwovens, materials for insulation and filtration, geotextiles, and more. As the new product is produced without a complete change of the material's origin (reclamation), this technique is environmentally friendly, cheaper, and easier [44]. Physical or mechanical recycling methods including (i) Shredding and Re-Spinning, (ii) fabric recycling, (iii) Nonwoven Textile Recycling, (iv) Mechanical Fiber Blending, (v) Downcycling, (vi) Pulverization for Composite Materials, and (vii) Fiber Recovery from Denim. In chemical recycling, synthetic fibers are processed through polymerization reactions where synthetic fibers are dissolved and spun to form new ones. In addition, acid and alkali Hydrolysis can remove dust from the waste fibers [29,44]. Chemical recycling includes (i) Depolymerization, (ii) Solvent-Based Recycling, (iii) Hydrolysis, (iv) Glycolysis, (v) Enzymatic Recycling, and (vi) Chemical Fiber-to-Fiber Recycling. Thermal recycling processes mainly use heat or electricity to break down fiber molecules into smaller ones through Pyrolysis processes. This breakdown occurs at 450 °C and 700 °C, where cloth loses 74% of its original weight [21]. Thermal recycling methods include (i) Incineration with Energy recovery, (ii) Pyrolysis processes, (iii) Gasification, (iv) Thermal Depolymerization, (v) Thermochemical Conversion for Blended Materials, and (vi) Melting and Reforming.

Considering Bangladeshi SME factories, the most suitable and widely used recycling technique is mechanical/physical recycling, where the remnant waste is collected and reshaped into new luxury products with a minor modification/addition of other components.

3. Materials and Methods

This study examined the implications of remnant-based sustainable fashion products made by three small and medium size enterprises (SMEs) namely factories A, B, and C in Dhaka, Bangladesh. The facilities were selected based on their workforce, annual turnover, and sustainable product items (Table 2). The research employed a multiple-case, semi-structured survey questionnaires (Appendix A), direct observation, and analysis of reports as fundamental methods. The remnant based waste fabrics were collected from different locally developed sourcing or supply chain strategies from various garment industries to utilize as raw materials for manufacturing of selected luxury product items including floor mats, ladies' handbags, and bedding items (pillow cover). This study analyzed the incorporated reusing and recycling process for manufacturing luxury products, cost of manufacturing from raw materials sourcing to sell, and profit margins. A qualitative research method was utilized to systematically report the observed facts and ideas, providing a clear perspective on the collected data. Throughout the analysis, the considered case factories were identified, with the physical or mechanical reusing and recycling processes to manufacture the selected luxury product items. Figure 3 displaying the potential research plan.

Table 2. Factory description.

Factory Name	Yearly Turnover	No. of Employees	Product Produces
Factory A	USD 600,000	110	Kids items, floor mats, carpets, handbags, bedding items
Factory B	USD 350,000	85	Kids items, floor mats, carpets, handbags, bedding items
Factory C	USD 200,000	55	Kids items, floor mats, carpets, handbags, bedding items

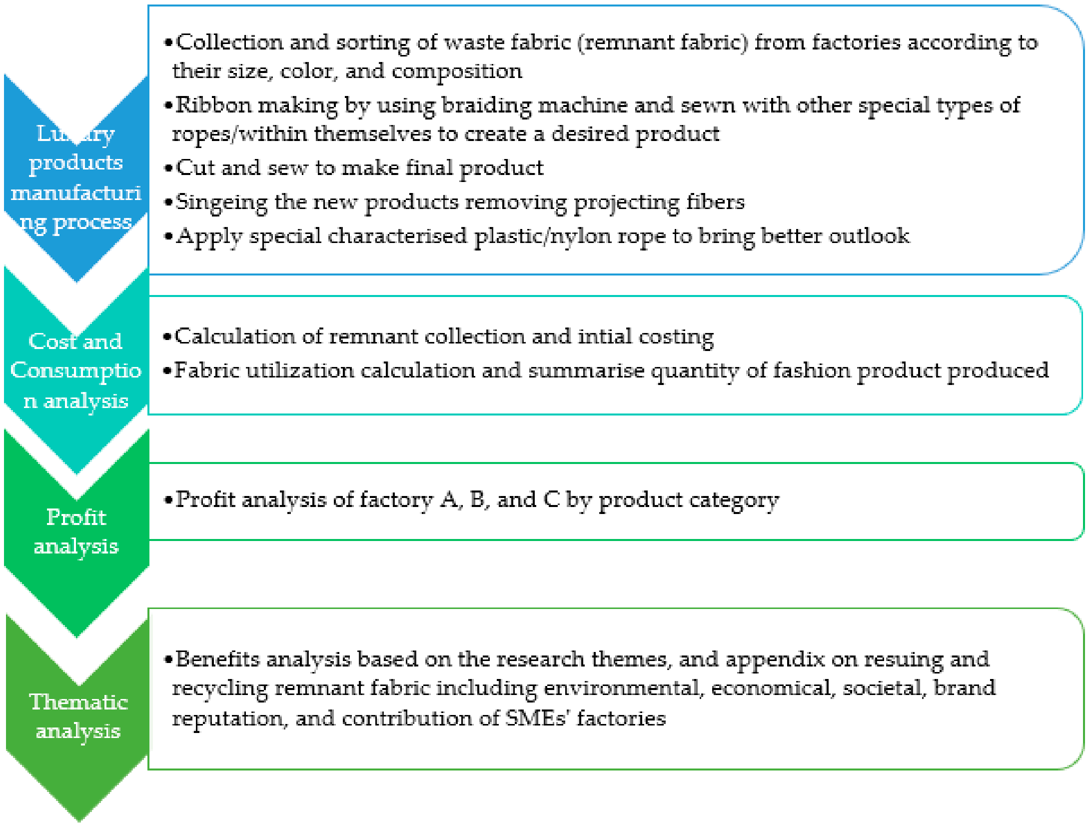

Figure 3. Research plan (research flow chart).

3.1. Factory Specification

To conduct this case study on remnant fabric utilization, the researchers considered three small and medium-sized local enterprises from Dhaka city, Bangladesh. The factory details are as follows (Table 2).

3.2. Research Plan

In this section, we have depicted out potential research plan for this work (Figure 3). The analysis is organized into four sections: (i) the luxury products manufacturing process; (ii) cost and consumption analysis; (iii) profit analysis, and (iv) thematic analysis and implications. In the first stage, a detailed analysis of luxury fashion product manufacturing steps, such as remnant collection, sorting, processing, and finishing, will be covered for the chosen product categories. Later, the use of remnant fabric, product quantity computation, and prospective production costs will be explored. In the third stage, a profit analysis of the SMEs (A, B, and C) will be carried out by observation and calculation. In the end, a thematic analysis will be included, analyzing the contribution of remnant fabric's reuse and recycling potential to the well-being of society and the environment.

3.3. Luxury Product Manufacturing Processes

3.3.1. Collection, Sorting, and Distribution of Remnant Fabric

The production of recycled consumer goods from textile waste starts with the collection of fabric scraps (remnants) from garments factories. The manufacturer sort out the collected fabric waste based on its dimensions, fabric types, and colors. The hand sorting procedure involves segregating the fabric pieces according to their dimensions, fabric type, and color. The pieces are categorized into three grades based on their sizes including Grade 1 for pieces ranging from 1 to 4 inches, Grade 2 for pieces ranging from 4 to 8 inches, and Grade 3 for pieces larger than 8 inches (Table 3). This classification aims to facilitate the identification and allocation of the appropriate materials for production. The selected fragments are shredded mechanically or braided to create long fabric ribbons, which are then stitched together using an automated zig-zag stitching. Secondary processing techniques, such as singeing, refine the product's texture by burning protruding fibers. Figure 4 illustrates the percentage of product variations. Floor mat production accounts for 75% of total utilization, followed by ladies' handbag production with 16% and bedding (pillow cover) production with 9%.

Table 3. Remnant fabric grading.

Size Intervals by Grade (in Inches)
$1 \leq$ Grade 1 ≤ 4
$4 <$ Grade 2 ≤ 8
$8 <$ Grade 3

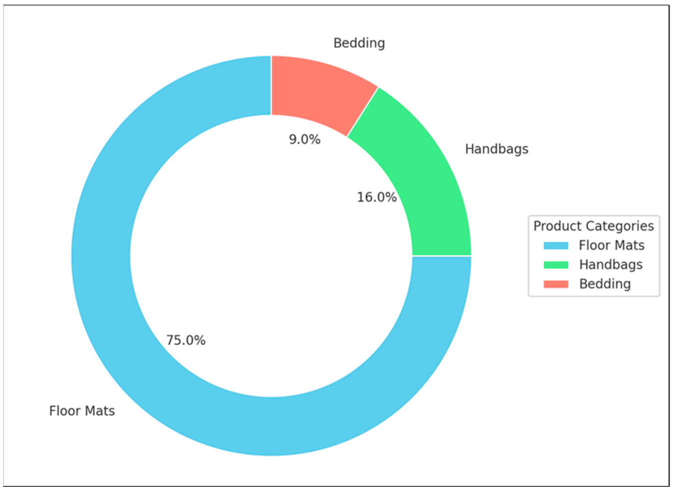

Figure 4. Remnant fabric utilization percentage by item.

3.3.2. Manufacturing Methods of Selected Sustainable Fashion Products

Ribbon-Making Process

Ribbon making is the first process of manufacturing sustainable floor mats, handbags and bedding items. For this, the graded remnant fabric is passed through a braiding machine to make a continuous length of ribbon. Generally, remnant fabric is passed surrounding the jute rope to make it a filament and stronger. A locally manufactured braiding machine can produce 15–20 kg of ribbon per hour.

Floor Mat-Making Process

Initially, the design of the floor mat is approved by the buyers before commencing the production process. The floor mat design involves using square shapes with flattened angles, each measuring 25 inches in width and length. After selecting the fabric ribbon and color combination, the waste fabric ribbons are sewn together using a sewing machine. The process is similar to the bag manufacturing process. Approximately 500 g of ribbons is required to produce an average-sized floor mat. Once all the components are sewn together, the floor mat manufacturing process is considered complete. Typically, the singeing process is not incorporated in most cases of floor mat manufacturing.

Handbag, Makeup Bag, and Tote Bag Making Process

To manufacture functional and fashionable handbags, various combination of fabric ribbons derived from remnant fabric are used. After the finalization of the bag design, the ribbons are joined together using a sewing machine and adhesives. Approximately

200–300 gm of ribbons from remnant fabric is needed. The fabric is then sewn together following a specific pattern, allowing the joints to flow in a horizontal rhythm. The bag is then assembled, which includes attaching hardware, any required accessories, and trimmings. A rigorous focus is maintained on detailed quality control throughout the process. Two zippers are sourced from two end-of-use garments and creatively matched in one bag. The bags are sewn on a zigzag machine with white dual-duty cotton thread. Quality control is also achieved through the singeing process, which removes any floating fibers from the surface of the fabric by burning, resulting in a smoother texture, increased luster, and reduced pilling.

Bedding Item-Making Process

Bedding items may include cushions, bed covers, pillow covers, and other decorative items. To manufacture these items, manufacturers generally select the appropriate design and initiate production. One of the bedding items is pillow covers, which need a similar sewing process as the previous items.

3.4. Materials and Machineries

Materials include jute rope, lining (polyester based), a zipper, sewing thread, and buttons. The machinery includes a zigzag stitching machine, a rope-making braiding machine, and a sewing machine.

3.4.1. Braiding Machine

The braiding machine interlaces four strands of yarn wire, three fabric bobbins, and one jute rope bobbin to create a long ribbon. The braiding machine is manufactured locally, and the specification is as Table 4.

Table 4. Specifications of braiding machine.

Name	Details
Braiding machine	4-Spindle braiding machine
Place of origin	Bangladesh
Weight (KG)	160 kg
Power	0.55 kw
Bobbin Size	100 × 330 mm
Certification	ISO 9001: 2015 CE [45]
Number of stands	4
Rope size range	1–8 mm
Speed	330 rpm
Voltage	380 V

3.4.2. Zigzag Stitching Machine

A zigzag stitching machine is used for edge stitching to attach elastic, tape, and braid. Sometimes it is used for decorative topstitching. Table 5 presents the specification of the stitching machine.

Table 5. Specification of Zigzag stitching machine.

Name of m/c	Zig-Zag Stitching Machine
Origin	China
Model	20U
Needle	1
Stitch type	Lock stitch
Motor type	Servo motor
Rpm	400–4000

4. Results

The research captures valuable insights into the potential of reusing and recycling remnant fabric to create sustainable luxury fashion products in a circular economy. The results have been organized in the following three ways: (i) cost and consumption analysis, (iii) profit analysis, and (iii) thematic analysis.

4.1. Cost and Consumption Analysis

4.1.1. Fabric Utilization and Costing

The researchers considered three luxury fashion products manufactured from reusing and recycling remnant fabrics. The researchers observed the whole manufacturing process and tried to gather information and identified the amount of waste collection, processing cost, selling prices, and profit margin.

The total amounts of remnant fabric purchased were 66,070 kg, 50,015 kg, and 33,600 kg by Factory A, B, and C, respectively, from various sources. This amounts to 44.2%, 33.4%, and 22.4% by Factory A, B, and C, respectively. In addition, the cost of the collected remnant fabric was USD 26,437, USD 20,050, and USD 13,459, respectively (Figure 5). Therefore, the per kg cost of remnant fabric was USD 0.40 across all the factories.

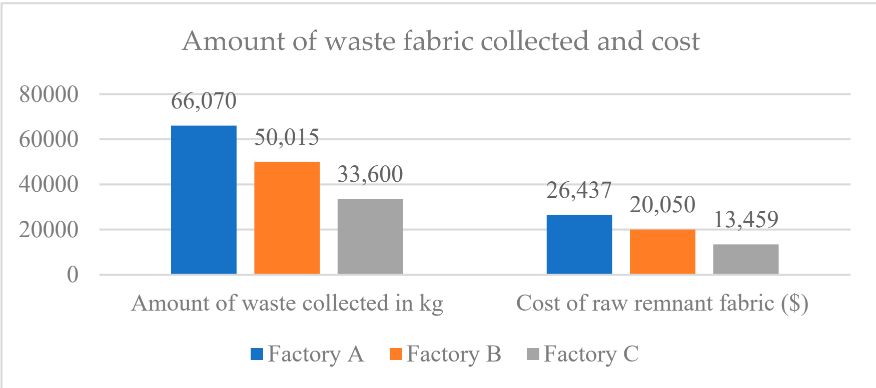

Figure 5. Summary of remnant fabric collection.

Table 6 depicts the amount and cost of remnant fabric for each of the factories across three product categories: floor mats, ladies' handbags, and bedding (pillow covers). All the factories distributed the largest amount of collected waste fabric to floor mats (75%), then ladies' handbags (16%) and bedding items (pillow covers) (9%) combined. A higher proportion of material allocation to floor mats than the other two items might indicate a higher suitability of remnant fabric's quality for this type of product. Figure 6 presents the material allocation percentage per product category, with Figure 7 displaying the distribution of remnant fabric.

Table 6. Distribution of collected remnant fabric and initial cost.

Items	Factory A		Factory B		Factory C	
	Quantity (kg)	Collection Cost (USD)	Quantity (kg)	Collection Cost (USD)	Quantity (kg)	Collection Cost (USD)
Floor Mat	49,500	19,823	37,500	15,026	25,200	10,097
Ladies' Handbag	10,660	4264	8050	3225	5400	2160
Bedding (Pillow Cover)	5910	2350	4465	1799	3000	1202
Total	66,070	26,437	50,015	20,050	33,600	13,459

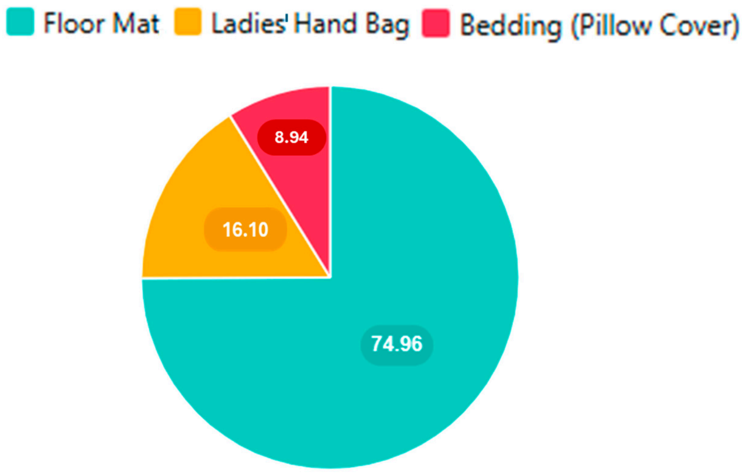

Figure 6. Material allocation percentage per product category.

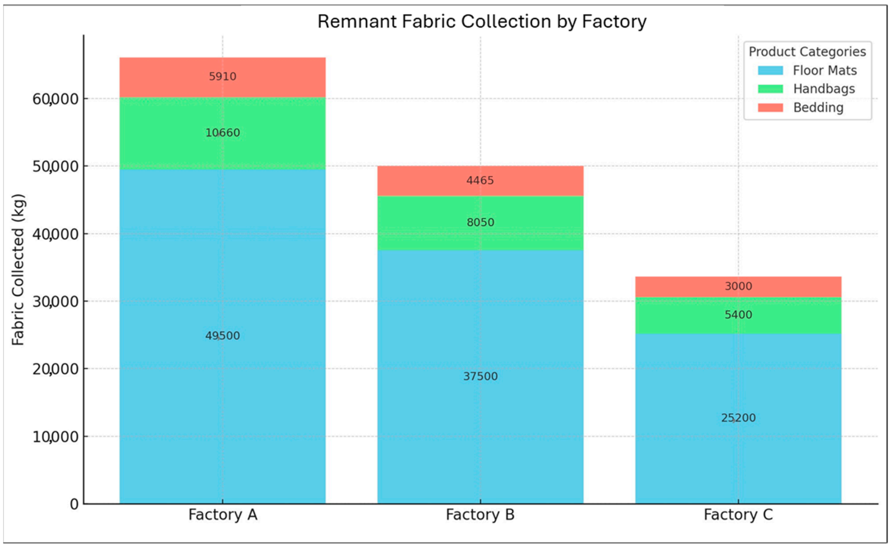

Figure 7. Distribution of collected remnant fabric.

4.1.2. Quantity of Sustainable Products

After primary processing (ribbon making), the facilities were heading toward the manufacturing of floor mats, ladies' handbags and bedding items. Following, Figure 8 shows the monthly production quantity for each factory.

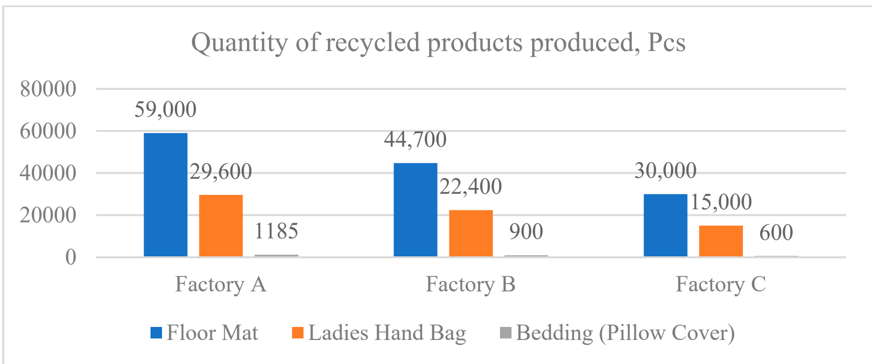

Figure 8. Total quantity of recycled remnant-based fashion products per month.

Figure 8 reveals that Factory A produced the most floor mats (59,000 pieces), indicating a strong emphasis or superior efficiency in this area. It also produced a large number of ladies' handbags, 29,600 in total, the most of any of the three companies producing this item. However, the output of bedding (pillow covers) was noticeably low at 1185 pieces, indicating either decreased demand or production complexity for this product. Factory B ranked second in overall output, producing 44,700 floor mats, which was less than Factory A but more than Factory C. For ladies' handbags, Factory B produced 22,400 items, keeping a competitive advantage but lagging behind Factory A. The production of bedding (pillow covers) was 900 pieces, which was somewhat less than Factory A's output but more than Factory C's. Factory C, on the other hand, routinely produced less, indicating capacity limits. It is seen that ladies' handbags are the most efficient product for manufacturing through utilizing remnant fabric. It takes 16% of the remnant fabric, and the output is 33% of the total products. On the other hand, floor mats and bedding pillows take 75% and 9% of the remnant fabric, and the output is 66% and 1% of the total products, respectively. Pillow covers are the most inefficient product among the considered product categorizes

4.1.3. Cost Calculation and Analysis

Table 7 shows the total cost of sustainable product manufacturing. Using equation 1, the following table has been generated for each factory to calculate the total manufacturing cost.

$$\text{Total cost of manufacturing} = \text{Collection cost (cost of remnant fabric)} + \text{Cost of manufacturing} \quad (1)$$

Table 7. Cost of manufacturing.

Items	Factory A			Factory B			Factory C		
	Collection Cost (USD)	Cost of Making (USD)	Total Cost (USD)	Collection Cost (USD)	Cost of Making (USD)	Total Cost (USD)	Collection Cost (USD)	Cost of Making (USD)	Total Cost (USD)
Floor Mat	19,823	23,886.2	43,709.2	15,026	18,126.6	33,152.5	10,097	12,128	22,225
Ladies' Handbag	4264	30,774.7	35,038.7	3225	23,280.8	26,505.8	2160	15,596.1	17,756.1
Bedding (Pillow Cover)	2350	4026.3	6376.3	1799	3043.8	4842.8	1202	2025.5	3228.5

4.2. Profit Analysis

Table 8 presents a financial analysis of the three factories (Factory A, Factory B, and Factory C), focusing on three product categories: floor mats, ladies' handbags, and bedding (pillow covers). Factory A demonstrates the highest profitability across all categories, particularly in floor mats, where it earns USD 25,841 in profit, supported by its substantial production and selling expenses (USD 43,709.2 and USD 69,548.5, respectively). Additionally, Factory A generates USD 18,720.6 in profit from women's purses and USD 2635.3 from bedding. Factory B, although ranking second to Factory A, exhibits significant profitability, especially in floor mats (USD 19,539.3) and women's purses (USD 14,179.9), indicating effective production and sales strategies. Despite operating on a smaller scale, Factory C remains profitable, with the highest earnings from floor mats (USD 13,138.6), followed by women's purses (USD 9486.8) and bedding (USD 1334.3). Figure 9 presents a grouped bar chart comparing the profits for different luxury products across the three factories.

Table 8. Summary of profit analysis.

Items	Factory A			Factory B			Factory C		
	Total Cost (USD)	Selling Cost (USD)	Profit (USD)	Total Cost (USD)	Selling Cost (USD)	Profit (USD)	Total Cost (USD)	Selling Cost (USD)	Profit (USD)
Floor Mat	43,709.2	69,548.5	25,841	33,152.5	52,691.8	19,539.3	22,225	35,363.6	13,138.6
Ladies' Handbag	35,038.7	53,759.3	18,720.6	26,505.8	40,685.7	14,179.9	17,756.1	27,242.9	9,486.8
Bedding (Pillow Cover)	6376.3	9011.5	2635.3	4842.8	6854.2	2011.4	3228.5	4562.8	1334.3

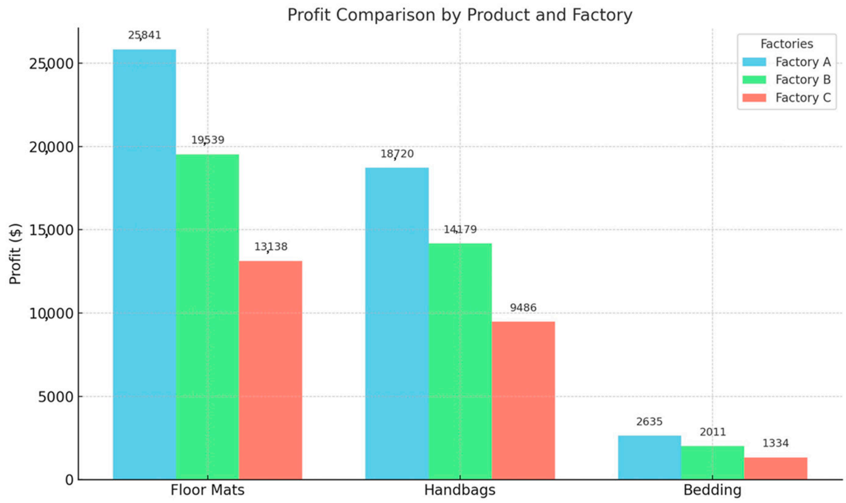

Figure 9. Summary of profit analysis.

4.2.1. Profit Analysis for Factory A

Figure 10 summarizes the financial parameters for three product categories: floor mats, ladies' handbags, and bedding (pillow covers) for Factory A. Floor mats have a manufacturing cost of USD 43,709.2 and a selling price of USD 69,548.5, yielding a significant profit of USD 25,841. This suggests a significant profit margin, most likely owing to efficient manufacturing methods or high market demand. Ladies' handbags have a manufacturing cost of USD 35,038.7 and sell for USD 53,759.3, resulting in a profit of USD 18,720.6. While the profit is lower than that of floor mats, it is still sizable, indicating effective market positioning and price tactics. Bedding (pillow covers) has the lowest manufacturing cost of USD 6376.3, sells for USD 9011.5, and makes a profit of USD 2635.2. Overall, the data demonstrate that all three product categories are profitable, with floor mats leading the way, followed by ladies' handbags and bedding, demonstrating good cost management and pricing strategies across many product lines.

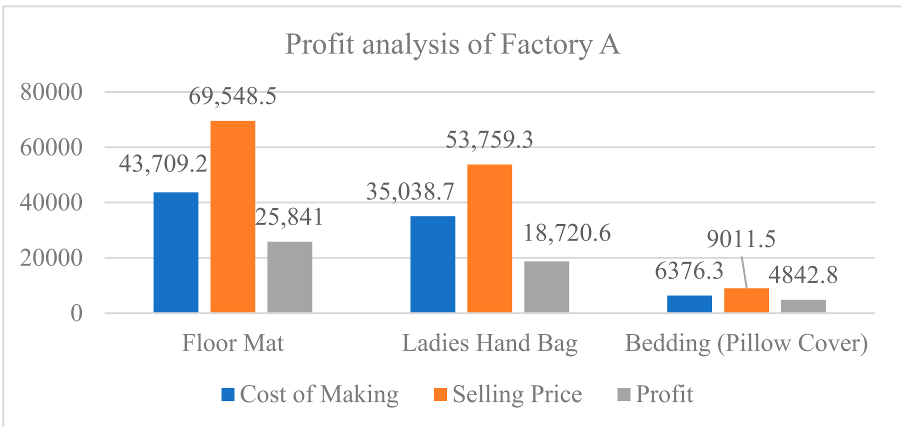

Figure 10. Profit analysis of Factory A (USD).

4.2.2. Profit Analysis for Factory B

Following, Figure 11 describes the total cost of manufacturing, selling cost, and total profit earned by Factory B.

Figure 11 indicates the financial information for three product categories: floor mats, ladies' handbags, and bedding (pillow covers). The cost of producing floor nats is USD 33,152.5, with a selling price of USD 52,691.8, yielding a profit of USD 19,539.3. This suggests a strong profit margin, implying efficient manufacturing and high market demand.

Ladies' handbags have a USD 26,505.8 manufacturing cost and a USD 40,685.7 selling price, for a profit of USD 14,179.9. While the profit is less than that of floor mats, it is still sizable, demonstrating a successful pricing and market strategy. Bedding (pillow covers) has the lowest manufacturing cost of USD 4842.8 and a selling price of USD 6854.2, resulting in a profit of USD 2011.4. Although this profit is the smallest of the three categories, it represents a positive return, most likely due to lower production costs and maybe less complex manufacturing procedures. Overall, all three product categories are profitable, with floor mats leading the way, followed by ladies' handbags and bedding, displaying effective cost control and clever pricing across many product lines.

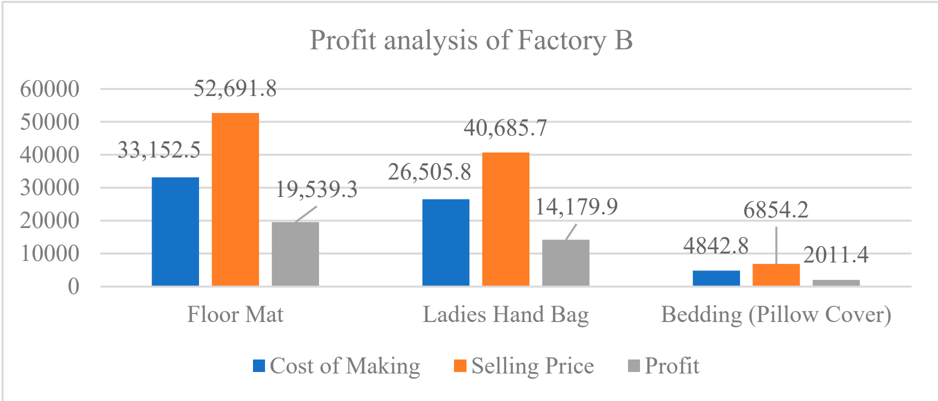

Figure 11. Profit analysis of Factory B (USD).

4.2.3. Profit Analysis for Factory C

Following, Figure 12 describes the total cost of manufacturing, selling cost, and total profit earned by Factory C.

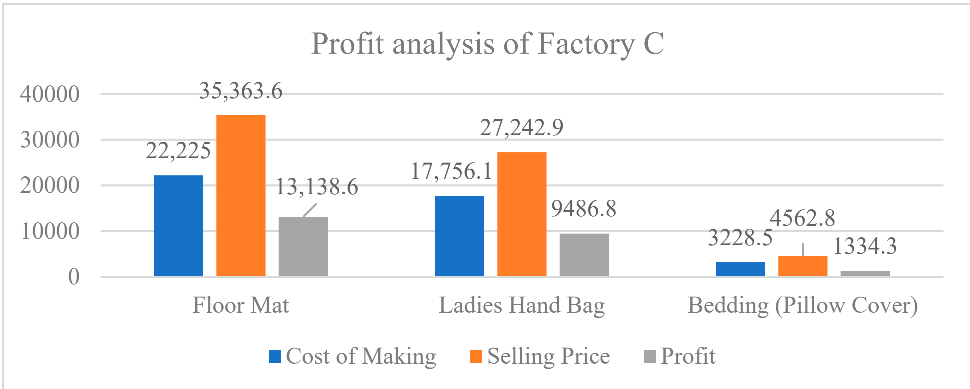

Figure 12. Profit analysis of Factory C (USD).

Figure 12 shows the manufacturing costs, selling prices, and profit for three distinct products: floor mats, ladies' purses, and bedding (particularly pillow coverings) for Factory C. The floor mat has the biggest profit margin of the three, at USD 13,138.6. This indicates either low production costs or a higher selling price than the other items. Bedding (pillow covers) gives the lowest profit margin of USD 1334.3, indicating a reduced production amount. Ladies' handbags lies in the middle, with a profit margin of USD 9486.8. Overall, all three product categories are profitable, with floor mats taking the lead, followed by ladies' handbags and bedding, demonstrating efficient cost control and pricing across multiple product lines.

Figure 13 represents a heat map visualization of profit margins for different products across factories. Darker shades indicate higher profits, and vice versa for the lighter shades.

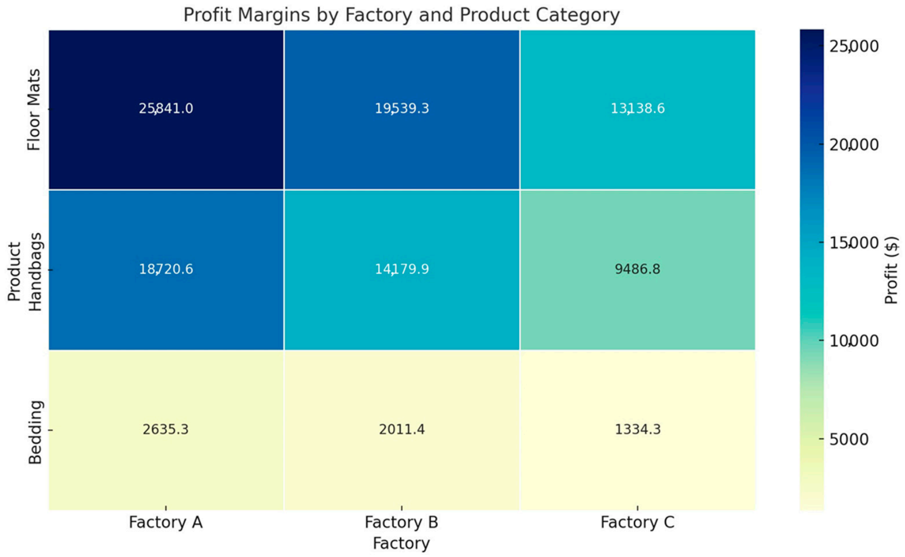

Figure 13. Profit analysis of factories (USD).

4.3. Thematic Analysis

Figure 14 shows a graphical illustration of the benefits of recycling remnant fabrics. Based on the research themes and appendix, thematic discussion is conducted.

Figure 14. Benefits of recycling remnant fabric.

4.3.1. Environmental Benefits of Recycling Remnant Fabric

Recycling leftover fabric for manufacturing sustainable fashion products has significant advantages, as it dramatically decreases the amount of dumping to landfills. It enhances resource efficiency by prolonging material lifecycles, lowering the demand for fresh raw materials and reducing waste [31,32]. It further prevents the discharge of hazardous chemicals and dyes into the environment. This approach minimizes soil and water pollution. The utilization of remnant fabric lessens the need for virgin raw materials for SME factories, therefore conserving natural resources and mitigating the environmental impact of their extraction and production processes. Furthermore, recycling often requires less energy and water than making new textiles, contributing significantly to ecosystem preservation and environmental sustainability by eliminating the need for resource-intensive procedures and greenhouse gas emissions [32,46,47].

4.3.2. Economic Benefits of Recycling Remnant Fabric

Recycling leftover fabric has enormous economic benefits, increasing both the profitability and sustainability of the textile sector. Using recycled materials frequently results in lower prices than purchasing virgin raw materials, i.e., cost savings. For SME factories, this is crucial, as raw material prices can considerably affect profit margins. Furthermore, recycling opens new business prospects and revenue sources. It has been seen that 52–69% of fashion consumers showed interest in sustainable fashion products [48]. As consumer demand for sustainable and eco-friendly products increases, businesses that include recycled fabrics in their offers may capitalize on this growing market, distinguishing themselves from competitors and attracting environmentally concerned clients. It also promotes innovation in product design and production techniques, resulting in the development of high-quality textiles [31,32]. Companies that develop and apply innovative recycling technologies and processes can enhance their operational efficiency and produce high-quality goods that match market standards. This inventiveness not only improves the quality and appeal of recycled textile goods, but it also promotes economic growth in the sector. It introduces new jobs in the local market and positions recycled remnant-based factories in the competitive market [20,49].

4.3.3. Social Benefits of Recycling Remnant Fabric

Recycling leftover fabric has various social advantages, including improving community well-being and developing a culture of sustainability. The recycling process comprises several steps, including collecting, sorting, processing, and manufacturing, all of which create jobs [31,32,50]. These employment opportunities may provide steady incomes and raise living standards. Furthermore, recycling projects frequently encourage fair labor practices and improved working conditions. This emphasis on fair labor standards contributes to less exploitation and a better standard of living for textile workers. Recycling leftover textiles promotes environmental and social responsibility through educational campaigns and community involvement projects. This may empower local communities by directly engaging them in sustainability initiatives, and it can grow a sense of ownership and responsibility for the betterment of the environment [50].

4.3.4. Brand Reputation Benefits of Remnant Fabric Recycling

Recycling leftover fabric improves brand perception by demonstrating a company's dedication to sustainability and environmental responsibility. This approach improves the business's image and aligns the brand with the expanding worldwide emphasis on environmentally friendly projects. By recycling textile waste, a business not only minimizes waste but also conserves resources, which is appealing to customers and stakeholders. This dedication to sustainability develops consumer loyalty and trust, as environmentally concerned customers are more likely to support and stick to businesses that match their beliefs. Furthermore, sustainable practices provide the business with a competitive advantage, setting it apart in a congested market and recruiting a loyal niche of environmentally conscious customers. Improved public perception, greater customer loyalty, and a strong competitive edge contribute to a brand's prestige and respect in the industry, resulting in long-term business success and resilience [51,52].

4.3.5. Contribution of Recycled Remnant-Based SME Factories

Recycled remnant-based small and medium-sized company (SME) manufacturers have enormous development potential in Bangladesh, which is recognized for its thriving garment industry and developing economy. Recycled remnant-based SME industries address environmental concerns by incorporating a waste management policy, resulting in a reduced carbon footprint and lessening the climate change consequences. Thus, these businesses help to establish a more sustainable economy. In addition, recycled remnant-based SME industries contribute significantly to social empowerment and poverty reduction. These businesses frequently employ marginalized groups, such as women and rural people, enabling these people to improve their lives and break the vicious cycle of poverty. Furthermore, the decentralized character of SME manufacturers guarantees that economic advantages are delivered more fairly across regions, minimizing inequities and encouraging inclusive growth [53].

In recent years, there has been an increase in global demand for environmentally friendly and ethically made products. Bangladeshi SMEs that adopt sustainable practices are well positioned to capitalize on this lucrative market niche, increasing their export potential and generating foreign exchange revenues. By emphasizing their environmental credentials, these businesses may stand out in the global economy and attract socially concerned customers. As a result, Bangladesh emerges as a responsible partner in the global supply chain, boosting its reputation and competitiveness in the world market [3,24].

However, despite their various benefits, recycled remnant-based SME manufacturers confront several hurdles that must be overcome to fully realize their potential. Access to financing, technology, and market connections is still a major challenge for many small-scale enterprises. Governments, development agencies, and private sector partners must work together to provide targeted assistance and capacity-building efforts, to allow these businesses to grow and prosper. Additionally, comprehensive regulatory frameworks and quality standards are required to assure the authenticity and safety of recycled products. By tackling these issues comprehensively, Bangladesh can foster long-term growth in its SME sector [27,54].

5. Recommendations and Limitations

To manufacture sustainable luxury fashion product from remnant, collaboration among industry stakeholders, including fashion brands, fashion product manufacturers, textile producers, and recycling facilities is mandatory [3,21]. Such partnerships have the potential to foster innovation in sustainable materials and production processes, while also streamlining supply chains to enhance efficiency. Additionally, governments can play a pivotal role by enacting legislation that promotes sustainable practices and advocates for transparency in labeling and manufacturing processes [3]. Moreover, raising consumer awareness about the environmental impact of fashion consumption and the advantage of utilizing recycled leftover items is essential. This objective can be achieved through educational campaigns, collaborations with influencers, and transparent communication from businesses. Furthermore, investment in research and development to advance recycling technology and environmentally friendly materials is crucial for the long-term success of the sector. Finally, fostering initiatives that promote a circular economy, such as clothing rental services, resale platforms, and upcycling workshops, can contribute to prolonging the lifespan of fashion products and minimizing waste in the fashion sector [5]. By embracing these recommendations, stakeholders can collaborate effectively to expedite the growth of the recycled remnant-based fashion sector, thereby creating a more sustainable and ethical fashion landscape for the future.

This study has several limitations. The qualities of remnant fabrics may limit the options for design and product development, impeding large-scale production, increasing production costs, and preventing quality from being maintained for all goods. Understanding consumer habits and preferences for sustainable products is difficult, because price and functionality frequently take precedence. Overcoming these limits through extensive research and innovation is crucial to advancing sustainable manufacturing.

6. Conclusions

This study explored reusing and recycling pre-consumer textile waste (remnant/waste from cutting department) using a novel manufacturing method and developed high-value luxury products using these fabrics. It has included a comprehensive economic analysis that demonstrates the cost-effectiveness and profitability of remnant-based fashion items. The quality and durability of the items, an entire supply chain investigation, efficient logistics, and scalable techniques were discussed. Approximately 95% of the fabrics were utilized, and the rest were manufacturing waste. The variations in production between the three factories significantly impact their recycled remnant-based fashion products, encompassing floor mats, handbags, and mattresses. These items predominantly rely on sustainable materials and production practices, thereby rendering economic efficiency and environmental stewardship. Across all instances, Factory A and Factory C exhibit more commensurate production costs for the aforementioned items than Factory B. This may indicate leveraging recycled materials in their fabrication. In the context of recycled remnant-based fashion goods, consumers often prioritize sustainability over aesthetics and utility. Therefore, products from Factory A or C may resonate more profoundly with an ecologically mindful clientele by garnering greater appeal in the marketplace.

This research endeavors to encourage small and medium enterprises (SME) to large enterprises to embrace more sustainable production practices, including the utilization of recycled materials and waste reduction strategies and adherence to environmental regulations. Furthermore, these have the potential to stimulate the creation of new markets and employment opportunities within the recycling industry, thereby stimulating economic growth and offering income prospects for individuals.

The recycled remnant-based fashion sector is intricately interconnected with various entities such as textile-recycling facilities, waste management companies, and recycled material suppliers. This collaborative network is essential for ensuring the smooth supply chain management necessary for producing sustainable fashion goods. Additionally, these factories require expertise, efficient advanced technology, and skilled labor to transform waste based raw materials into high-quality fashion products. This sector faces challenges related to logistics and distribution, necessitating collaboration with logistics providers, shipping firms, and e-commerce platforms. Marketing and branding efforts play a vital role in promoting the sector's products and values, attracting customers, and fostering brand loyalty. Overall, the slow progression in the development of sustainable fashion products from remnant fabric can be attributed to a lack of skilled manpower and advanced machinery and inadequate investment.

Author Contributions: Conceptualization, M.S., R.H., A.Z. and M.I.; methodology, M.S., R.H., A.Z. and M.I.; software, M.A.A.M., H.M.R.U.H. and M.I.; validation, M.S. and M.I.; formal analysis, M.S, M.A.R.A. and M.I.; investigation, M.S., R.H., M.A.R.A. and A.Z.; data curation, M.S., R.H., A.Z. and M.I.; writing—original draft preparation, M.S., R.H., A.Z. and M.I.; writing—review and editing, M.A.A.M., H.M.R.U.H., M.A.R.A. and M.I.; visualization, M.A.A.M., H.M.R.U.H. and M.I.; supervision, M.I. and M.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This research will not be submitted to any organization for any degree.

Informed Consent Statement: No findings were related to human health.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: We acknowledge the support of local SME factories in Bangladesh to conduct this research.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Ques. No.	List of Research Questions
1.	What does sustainable luxury fashion product means and how it is produced?
2.	How reusing and recycling remnant fabric contributed to manufacture sustainable luxury products?
3.	Does any types of luxury products can be manufactured while maintaining appropriate quality of that items through ustilising remnant fabrics?
4.	What strategies do you employ to ensure the quality and consistency of your products while using recycled materials?
5.	What are the challenegs and opportuinities for SMEs' in souricng, manufacturing, and marketing sustainable luxury product made from fabrics waste?
6.	What kind of machinery do you use, and are these machines made locally or imported?
7.	What startegies do you follow to current process for product development and waste management?
8.	How do you ensure that your waste management process is efficient and effective?
9.	What are the key challenges that your facility faces in conducting maintenance?
10.	What is the cost of manufacturing, selling price, and how do you make profit for each product?
11.	How do you perceive the current demand for recycled remnant-based fashion products in the market?
12.	What factors influence your decision to purchase recycled remnant-based fashion items?
13.	What policies or regulations do you think are needed to support the growth of the recycled remnant-based fashion sector?
14	How do you engage with consumers to raise awareness about the environmental benefits of recycled remnant-based fashion?

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