

Survey of textile fiber waste

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Abstract: Textile fiber waste in Pakistan is significantly produced; however, studies are needed to direct the reuse or recycling. This study demonstrated the preliminary market-based survey findings in the production of pre-consumer textile fiber waste, its collection, and the possible reuse in developing a new garment. Presently, this waste is mainly disposed of through burning or landfilling, creating an increased environmental footprint. This survey enhances the understanding of textile waste production for collecting, sorting and using in new garment making. The waste is collected from 35 commercial places in Karachi. Collected fabric pieces were used in the garment design by patchwork, and one case is demonstrated. The use of fiber dimensions, type, color, and variety found in the survey was demonstrated through a case study. It was found that the pre-consumer textile waste can be used in garment development through patch or applique designs. Several case studies were performed to apply waste fabric pieces in the design and development of fashion garments. Finally, one case study is demonstrated using patchwork to show the importance of waste fabric in garment making.

Keywords: textile fiber waste; environment; pre-consumer textile waste; survey; yarn; fabric

1. Introduction

A large amount of textile fiber waste is currently generated from the manufacturing of fabric, garments, home textiles, technical and industrial textiles, etc. The textile fiber waste is now a known problem for increasing the environmental footprint, greenhouse gases, and climate change.

The textile fiber waste can be categorized as pre-consumer waste, largely produced at garment manufacturing small and medium enterprises (SME), and post-consumer waste [1], mainly produced by the used fashion garments. Reusing or recycling any of the textile fiber waste can significantly reduce the undesired environmental effects.

The textile circular economy, or reusing and recycling textile waste, is an important research subject worldwide, and several review studies are available [2–6]. It is generally known in the literature to emphasize the post-consumer textile waste; since this waste is apparently generated in increased volume; however, any textile waste can be reused or recycled as a raw material to produce energy [7,8].

There is a significant lack of research studies on the participation of enterprises in the local sector. It can be shown that the commercial and public enterprises are lacking in controlling the textile waste elimination [9]. The real improvement in waste reuse and recycling is dependent upon the participation of the commercial and industrial sectors [10].

Recent market studies have shown a significant lack in the textile fiber waste produced by a large number of small and medium enterprises working in the local market. It can be interesting and useful to study the textile waste production in

enterprises and the commercial sector for determining the possible use of pre- or post-consumer textile waste [11].

The developing countries need to improve the structure for the collection and use of textile waste. This is more demanding in developing countries relative to the USA and Europe, where public policies are supporting the use of textile waste [12].

Pre-consumer textile waste provides the original fiber as raw material for new products. However, it needs significant work in developing countries for its management and utilization. Determining the key places and the fabric waste characteristics is important [13]. A review of pre-consumer textile waste to indicate the recent development for sustainable solutions through using this waste in products and projects was provided [14].

The diversity of fiber type makes the waste collection, sorting, and separating a complex process [15]. A survey study to appreciate the generation of textile fiber waste can be a useful source for managing and reusing the waste. The management of textile fiber waste is important in meeting the milestone of zero waste [7].

The idea of zero waste is based on using the waste as a resource or raw material for making another product. Globally, March 30, 2022, is celebrated as International Day of Zero Waste. It was 14 December 2022 when the United Nations General Assembly, in its 77th session, passed this day. Türkiye, with 105 countries, placed this resolution.

Survey studies are useful in enhancing the sorting and management of fiber waste. Semi-structured interviews conducted with eleven senior representatives from textile sorting and fiber recycling organizations, working in the US, were discussed [16]. To sort out the huge volume of textile fiber waste, an automated waste sorting system was suggested [17,18].

Pre-consumer fabric waste pieces from apparel manufacturers and tailoring units can be used in making fashion products [19]. Building a recycling system for post-consumer textile waste can also be important [20].

Most pre-consumer and post-consumer textile fiber waste in Pakistan contains cotton fibers. Cotton fiber is at the backbone of Pakistan's textile sector. Most textile waste contains cotton fibers (68 percent), and Pakistan was noted as the top third country exporting cotton fiber waste (estimated at \$59.29 million). Moreover, Pakistan is estimated to produce annually 887 kilotons of pre-consumer textile waste [21].

A cluster study on pre-consumer textile waste is important in producing data for directing textile waste management. The apparel industry is one of the major sources of producing the pre-consumer fiber waste [22].

In Brazil, the survey and interview study found useful to produce important information for the identification and characteristics of post-consumer textile waste, to develop the process of collection, sorting, and reinsertion of garment items in the production chain [23]. Collecting the textile waste separately in the municipality can help in the reuse of textiles and save the environment [24].

It is therefore obvious that the requirements for managing the textile waste can be country-specific [25]. The survey studies on textile waste can provide the foundation for managing the waste [26,27]. The textile waste survey can also be made using qualitative or quantitative analysis [28–31]. When damping properties are desired in garments, high-damping rubber isolators (HDRBs) can be useful [32].

In a developing region where textile waste collection, sorting, and reuse are not established, the market survey study can generate information for the reuse of pre-consumer textile waste. Such a survey study can be the basis for waste utilization, business opportunity, and employability.

The preliminary survey study of textile fiber waste in the local market can provide the fiber waste characteristics, places generating the waste, and making the disposal of this waste more environment-friendly. The knowledge of waste fabric pieces, size, color, and fiber variety can be useful in reusing them in new garment development.

There is a large number of small enterprises working across the country in stitching and manufacturing of ladies', gentlemen's, and children's clothing. All these small enterprises are mainly producing fashion and party wear. Knowing the nature of fiber waste, including the size or mass, can help in addressing the reuse of the waste. Five different type of waste producing places were visited and shown in Table 1. The popular tailoring shops were covered in this study, and the selected areas are shown in **Table 2**. The tailoring houses are over a thousand, actively producing the virgin fabric waste. Some useful contact details can be seen here in the List of Tailors in Karachi Branches (<https://branches.pk/branches/Tailors-in-Karachi>).

The design, determination, and control approach in the textile fiber waste survey study is presented in **Figure 1**. Using the fabric waste produced in designing the new garments can eliminate the waste going to landfills and avoid burning. It may significantly reduce the environmental pollution footprint of textiles.

Therefore, this study is a survey of textile fiber waste produced at various places, including tailor houses, fabric-selling shops, and boutiques. This was mainly pre-consumer waste, and its usefulness is presented through case studies to demonstrate application in making new garments (Section 6).

This was a survey study addressing the waste collection of small fabric pieces; however, it can be estimated that up to 129 kg per week of waste can be saved from going to landfill and creating the pollution problem.

This is an interdisciplinary study that involves an understanding of applying fiber science and the garment designing process. Therefore, detailing each step and each garment design development makes a very large manuscript. The garment development process involves the stages of making a product research board, motif and design composition development, material research, and product layouts. One representative garment is presented here to demonstrate the suitability of fabric waste utilization.

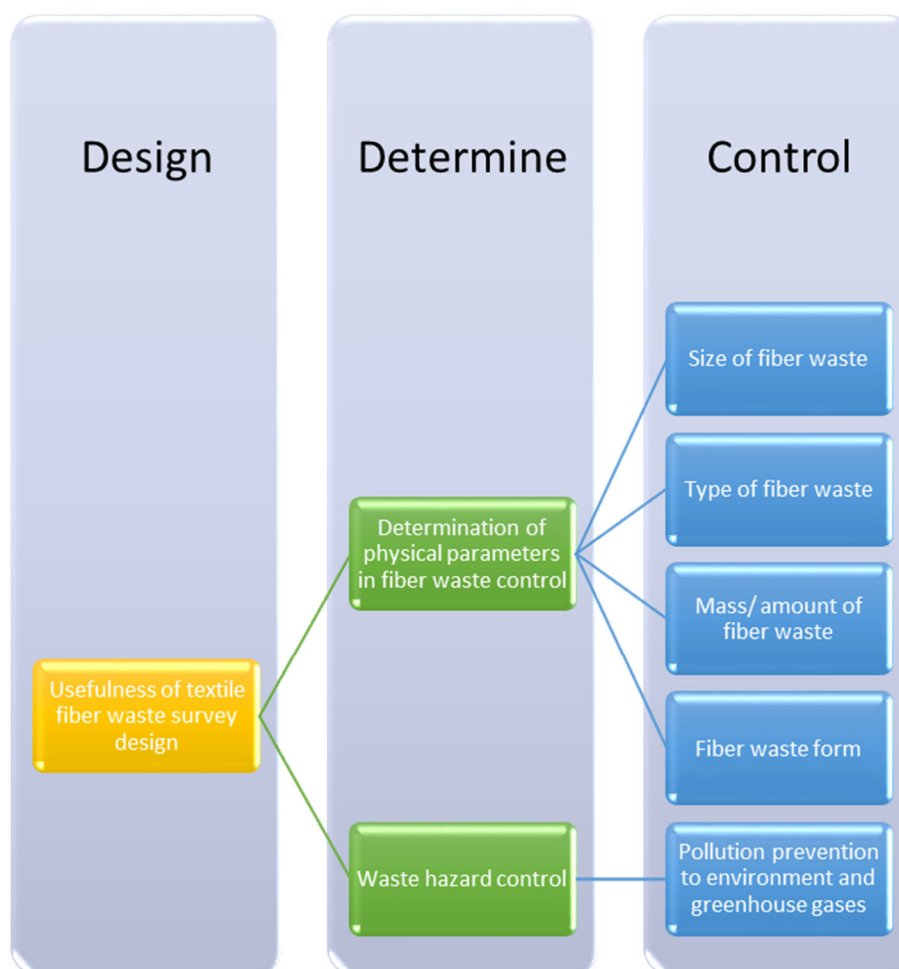


Figure 1. The design, determine and control approach in the textile fiber waste survey study.

2. Methodology

2.1. Focus of survey

This survey study has focused on generating an understanding of the following practices demonstrated by the small and medium enterprises in the local market:

1. Type and size of fabric pieces produced as waste
2. Where is the disposal of waste fabric made?
3. Use of the pre-consumer textile fiber waste in making garments.

Fiber, dyestuff, finish, and weave identification were not considered since it significantly increases the cost of making a garment, and the textile fabric waste pieces can be used in making garments without such identification.

2.2. Survey questionnaire

The survey form had the following sections, each of which was completed after visiting the site where fiber waste was produced. These sections are:

- i. Name of place visited- the name of the enterprise, and the name of the area. Most of the places visited were located in the areas inhabited by middle-class or lower-middle-class people.

- ii. Type of fiber waste- any information on fiber and fabric waste type. Generally, the fiber types were cotton and polyester. The fabric was cotton or a cotton and polyester blend.
- iii. Dimensions of waste type produced- length and width of waste fabric pieces were noted in cm. Since a variety of garments and structures were produced at the shops, the dimensions of waste fabric pieces were significantly diverse. The dimension indicated by the shop manager as most frequent, with the variation $\pm 5-7\%$ were noted.
- iv. Disposal- how the fabric waste is disposed of in routine on a regular basis. This was to know where the fabric waste was disposed of, including landfilling, burning, and selling.
- v. Any use of waste- to find out if the fabric waste was used for any purpose. This is to decide whether fabric waste can be used in appliqué or patchwork, based on its size
- vi. Selling price- to find out the price if the fabric waste was on sale. In some cases, the larger fabric waste pieces were on sale.

All the sites visited were at least 3 years old, and the person assisting with the survey information provision was at least the shop manager or proprietor.

2.3. Selection of city: Karachi

Karachi is a cosmopolitan city in Pakistan. It is the provincial capital with a population of over 30 million. It is a city with rapid urbanization, creating a major source of pre- and post- consumer textile fiber waste.

The city is a business hub of the country with a large number of garment and textile manufacturing and processing units. Globally reputed textile brands and processing industries, including Gul Ahmed, Al-Karam, Artistic Milliner, and Effroze 88 are working in Karachi. A large number of garment manufacturing units and tailor houses are releasing the pre-consumer textile waste.

2.4. Selection of places

The selection of places for the assessment of pre-consumer textile waste production in the city based on the small and medium enterprises producing fashion garments and furnishing. Tailor houses were working all the calendar months and were higher in number. Since most of the places are the tailor houses producing the pre-consumer textile fabric pieces on a daily basis, these were explored in high numbers. Some other places, including home, boutique shop, fabric selling shop, and technical textile shop, were included to know if they are producing any significant amount of pre-consumer textile waste.

2.5. Selection of areas in the city

The population of the city spreads from rich to poor consumers. Since most of the families approaching the customized fashion garment tailor houses were in the upper and lower middle class, the areas selected are those where such families are in the majority. The names of the city areas are provided (**Table 2**).

2.6. Type of places surveyed

There were five types of places selected in the survey study, including a tailor's house, a home, a fabric-selling shop, a boutique, and a technical textile shop. The total number of places surveyed was 35. Home was the only place where post-consumer textile fiber waste was generated. All the remaining places were generating the pre-consumer waste. These residential areas visited were mainly populated with the lower- and upper-middle-class families. **Figure 2** shows the types of places that were visited in this survey for the study of textile fiber waste. Five different types of places were visited in this survey. Except for the home, all the places visited were producing pre-consumer textile waste. Tailor houses were producing an increased fabric waste.

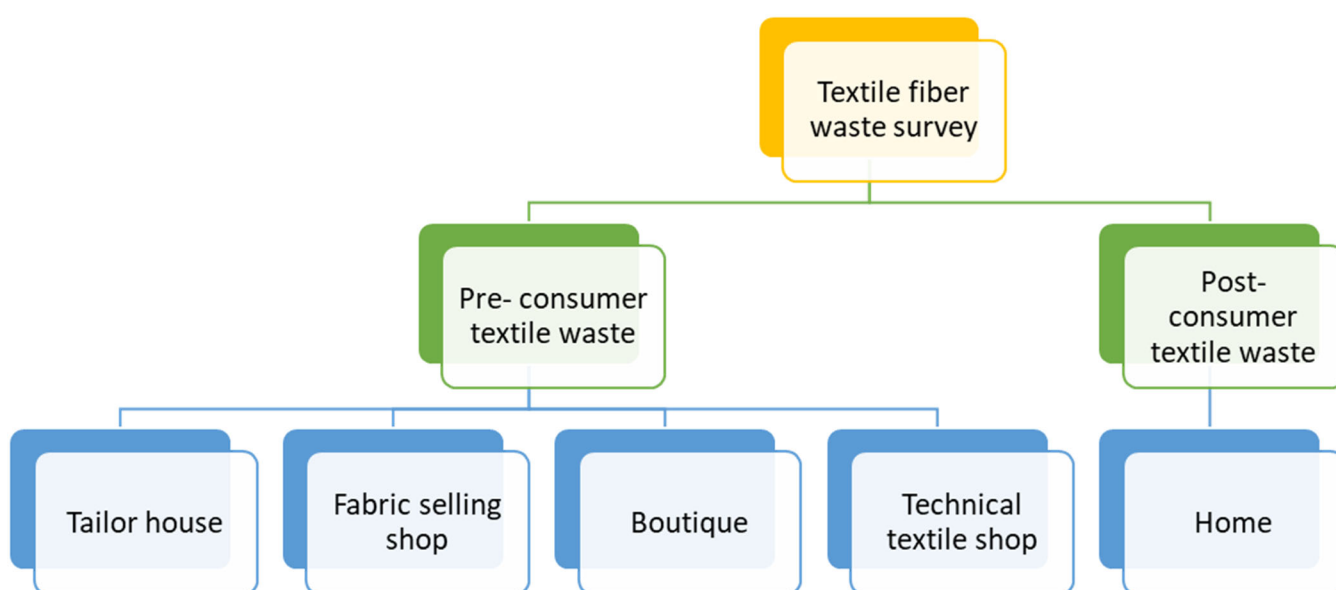


Figure 2. Textile fiber waste type and places studied in the survey.

The tailor houses provide the commercial service to design, cut, and stitch the desired suits and garments. The tailor houses were found to be the largest source of generating the pre-consumer textile waste out of all the places studied in this work (**Figure 3**). There were 21 tailor houses, a number of homes, fabric selling shops, and a boutique, respectively 6, 4, and 3. A large number of tailors' houses are working across the city and producing fabric waste in all the fashion seasons. Garment manufacturing at the tailor house is highly customized work, leading to an increased generation of pre-consumer fabric waste. Fabric pieces selling shops and boutiques were smaller in number and less involved in producing the fabric waste. The work of these tailor houses involved the production of a significant amount of pre-consumer textile fiber waste. Therefore, the highest number of tailor houses was visited in the different areas of the city. All the tailor houses were generating the pre-consumer textile fiber waste. The type of place and the number of places visited are shown in **Table 1**.

Table 1. Number of places visited and the type of fiber waste generated.

S. no	Name of the place	Place coding	Number of places visited	Type of fiber waste produced
1	Tailor house	T	21	Pre-consumer
2	Home	H	6	Post- consumer
3	Fabric-selling shop	FS	4	Pre-consumer
4	Boutique	B	3	Pre-consumer
5	Technical textile shop	TTS	1	Pre-consumer
Total places			35	

Table 2. Places and areas covered in the textile fiber waste study.

S. no	Name of place	Place code	Name of city area
1	Tailor house	T	KDA market, Gulshan-e-Iqbal, Kamran Market, F. B. Area, Sadder, DHA Phase V, Gulf, North Karachi, Ameer Khusro Road, PECHS, Clifton, Tariq Road
2	Home	H	Gulshan-e-Iqbal
3	Fabric-selling shop	FS	Nursery
4	Boutique	B	DHA (Golden Tower), Gulshan-e-Iqbal, Bahadurabad
5	Technical textile shop	TTS	Zone area

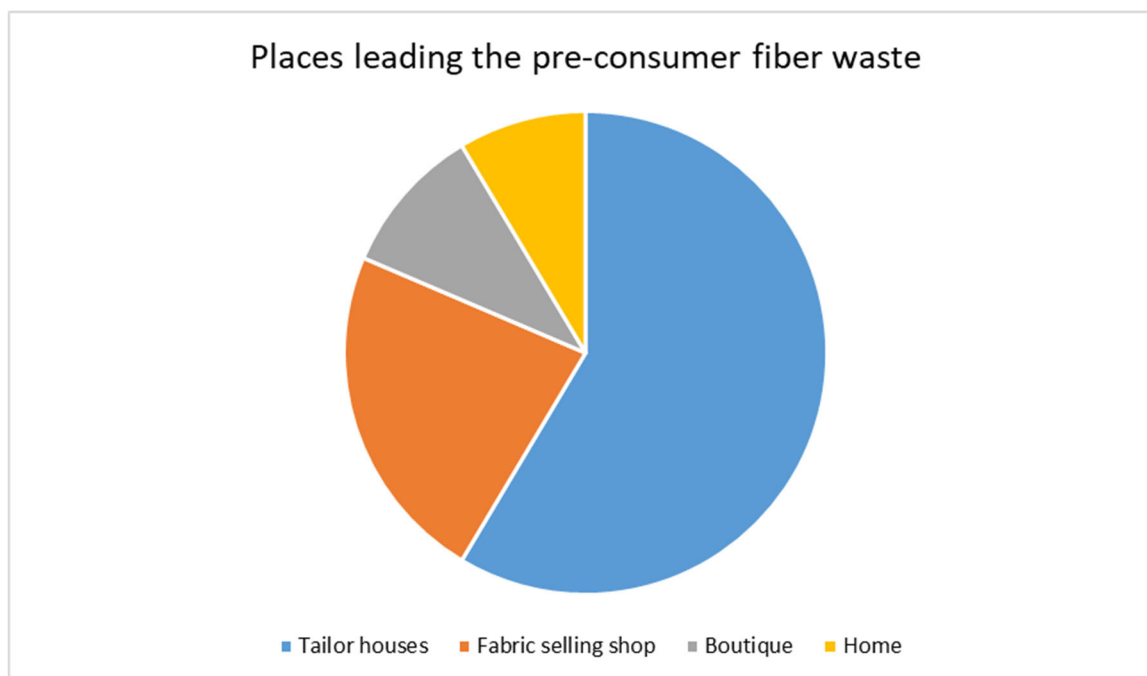


Figure 3. Important places leading the pre-consumer textile fiber waste.

2.7. Characteristics of pre-consumer textile fabric studied

There are several characteristics of pre-consumer textile fabric waste. However, an economical, profitable application of this waste based on the local ease, skills and technique was using these waste fabric pieces in applique and patchwork.

Therefore, this study mainly focused on the size of these waste fabric pieces in designing and developing the new garments acceptable in the local market. The color of the waste fabric pieces was adjustable when designing the new garments. The weight of the pre-consumer textile waste produced was found not to affect the garment development, since it was within acceptable limits.

2.8. Disposal of pre-consumer textile waste

Disposal of pre-consumer textile waste at the surveyed places is reported since it indicates the availability of the waste material at no cost or at a minimal price. An easy and inexpensive availability, depending upon the collection and transportation management for the waste, is possible. It indicated the garment production at a smaller material cost. In most of the case studies performed for making new garments using the waste, the profit was estimated 100%.

2.9. Case studies

There was a variety of garments produced using the waste fabric pieces to confirm the utilization for entrepreneurship. Innovative and traditional garment development is possible using the waste fabric pieces.

The garment manufacturing work using these pieces was systematically performed through the standard procedure based on theme selection, garment product research, design of the garment using the waste fabric pieces, and commissioning for the manufacturing of the garment.

Several case studies were performed; however, one representative case study, which largely represented the whole process (Section 6), is included in this article. The detailing of the case study is beyond the scope of this study, since this study aims to demonstrate the effectiveness and use of pre-consumer textile waste in the local market, and the making of new garments.

3. Results and discussion

3.1. Pre-consumer textile waste at the tailor house

A large number of tailor houses are operating in the city, Karachi. Perhaps, the highest amount of small-sized pre-consumer textile fiber waste is generated by tailor houses across the country. However, there is no significant design mechanism for collecting, sorting, managing, identifying, and utilizing such fabric waste.

The tailor houses are functioning as small and medium enterprises, and producing fashion garments for ladies, children, and gentlemen on a daily basis. A smaller number is also producing furnishings for the interior decoration.

Pre-consumer textile fiber waste is a significant mass generated at places associated with the processing of home textiles, technical textiles, and shops selling fabrics and clothing articles. However, tailor houses are generating a large amount of pre-consumer waste across the city. The number of these tailor houses is in several thousands in the city. A small tailor house was generating 3-7 kg of pre-consumer textile waste per week.

Currently, most of the tailor houses are disposing of the pre-consumer textile waste through burning and land filling. There are a couple of exceptions that sell this waste or voluntarily pass the pre-consumer fiber waste for filling purposes in furnishing manufacturing.

There were 21 tailor houses surveyed in this study. These tailor houses are labeled as T1, T2, T3T21. The nature of textile fiber waste, its dimension (size), disposal and any usage and selling price are described in **Table 3**.

The maximum size of pre-consumer textile fabric waste produced at the surveyed tailor houses is 90 cm by 40 cm, and the minimum size is 3 cm by 2 cm. The tailors who house T1, T2, T9, and T19 produced the textile waste that can be directed for reusing in applique and patchwork, filling in sofa furnishing, cushions, etc. However, the remaining tailor houses were disposed of through burning or landfilling.

Since the pre-consumer fiber waste produced at these tailor houses contains the virgin fiber, the waste of each fiber type can be explored to find more applications. The column 'Any possible use' is showing the suggested use.

There were a few tailor houses that managed to sell their pre-consumer textile fiber waste. T2 was selling the fiber waste to a furnishing house at the rate of Rs 250 per kg to use the waste as filling in making cushions.

The size of fiber waste produced by T2 was 25 cm by 17 cm. Some other tailor houses, including T15, T16, and 20, managed to sell pre-consumer scrap fabric pieces at relatively smaller prices.

All these tailor houses are producing waste fabric pieces on a daily basis, and there are thousands of such shops across the city. If a fabric piece collection center is established, a significant amount of pre-consumer waste can be managed, suitable for applique, patchwork, or obtaining virgin fiber for making yarn and fabric.

Importantly, a large amount of this pre-consumer textile waste can be obtained from designated tailor houses without any price, and saving the environment.

Collecting the said textile waste and consuming it in another product-making process can significantly reduce the environmental footprint and greenhouse gas production.

3.2. Pre-consumer textile waste at the fabric-selling shop

There were four fabric-selling shops (FS) surveyed in this study. The details of these shops are shown in **Table 4**. Fabric shops are selling the dyed/printed/finished textile fabric for suiting. The small colored fabric pieces are the source of innovative designs on the surface of the garment through appliqué.

The larger fabric waste pieces can be used in developing the garments through patchwork can also be applied. The case study presented in Section 6 is based on using such a waste type. Customers bought such fabric in the desired size. Therefore, it is possible to generate small fabric pieces ranging from 1 m or less.

Table 3. Characteristics of textile fiber waste and disposal by tailor houses.

Tailor house code	Area	Nature of textile fiber waste	Size of fiber waste (width–length)	Disposal	Any possible use	Any Selling price
T1	KDA	Cut-off fabric	22 cm–50 cm	Dustbin	Applique/ patch work	Nil
T2	Gulshan-e-Iqbal	Cut-off fabric	17 cm–25 cm	Sell to sofa maker	Filling in cushion	Rs. 250 per Kg
T3	Kamal Market	Cut-off fabric	No regular fabric waste size was possible	Dustbin	Making duster	Nil
T4	F. B. Area	Cut-off fabric	No regular fabric waste size was possible	Burn	Making button	Nil
T5	Saddar	Cloth pieces	No regular fabric waste size was possible	Dustbin	Patchwork	Nil
T6	DHA Phase V	Cloth pieces	15 cm–25 cm	Sell to furniture maker	Applique work	Rs. 150 per Kg
T7	Gulf	Cloth pieces	No regular fabric waste size was possible	Sell to furniture maker	Landfilling/ burning	-
T8	DHA Phase V	Cloth pieces	10 cm–15 cm	Dustbin	Landfilling/ burning	Nil
T9	KDA Market	Scrap fabric	5 cm–6 cm	Dustbin	Applique	Nil
T10	North Karachi	Scrap pieces	No regular fabric waste size was possible	Dustbin/ burning	Buttons/ Furnishing	Nil
T11	Gulshan-e-Iqbal	Lace or fabric pieces	2 cm–3 cm	Dustbin	Furnishing	Nil
T12	North Karachi	Scrap fabric	3 cm–5 cm	Burning	Filling	Nil
T13	Ameer Khusro Road	Laces and fabric pieces	16 cm–14 cm	Dustbin/ burning	Applique/ patchwork	Nil
T14	-	Fabric pieces and thread	10 cm–5 cm	Dustbin/ burning	Applique	Nil
T15	-	Fabric pieces	24 cm–40 cm	Dustbin	Patchwork	Sold at various prices depending upon the waste fabric size
T16	-	Fabric pieces	10 cm–21 cm	Dustbin	Filling	Sold at various prices depending upon the waste fabric size
T17	PECHS	Lawn and cotton	10 cm–36 cm	Dustbin/ burning	Applique	Nil
T18	Gulshan-e-Iqbal	Georgette and chiffon	90 cm–40 cm	Reuse	For dress finishing and belting	-
T19	Clifton	Lawn and cotton	40 cm–20 cm	Dustbin/ burning	Patchwork	Nil
T20	Tariq Road	Fabric and laces	12 cm–8 cm	Dustbin	Doll clothing	Sold at various prices depending upon the waste fabric size
T21	Tariq Road (Kurta Gali)	Fabric pieces	12 cm–8 cm	Dustbin/ burning	Applique	Nil

Table 4. Pre-consumer textile waste is found at the fabric-selling shops.

Fabric selling shop code	Nature of waste	Size of fabric waste (width–length)	Disposal	Selling price (if any)
FS1	Banarsi and plain cotton	1 m–1 m	Sell out to small garment companies	Depending upon fabric type and size
FS2	Fabric pieces	0.457 m–0.457 m	Sell out to small garment companies	Rs. 100 per piece
FS3	Fabric pieces	0.914 m–0.914 m	Sell out to small garment companies	Rs. 120 per piece
FS4	Fabric pieces	20.5 cm–18 cm	Sell or burning	Selling 40 to 60 % discount

The larger pieces of fabric are sold to customers. However, the smaller fabric pieces are burnt or landfilled.

3.3. Textile fiber waste at home

A variety of textile waste can be generated at home, including pre-consumer and post-consumer textile fiber waste. The focus of this study was mainly the commercial places and pre-consumer textile fiber waste; therefore, a few houses were surveyed to see if there is any pre-consumer waste. The characteristics of textile waste produced at home are described in **Table 5**.

The residential houses are found to significantly produce post-consumer textile fabric waste, and is a subject of another study. This study is mainly limited to developing garments using the pre-consumer textile waste.

Table 5. Textile fiber waste production and disposal at home.

Home code	Nature of waste	Size (length–width)	Disposal	Any possible use	Possible selling price
H1	Cut-off fabric pieces	12 cm–5 cm	Dustbin	Patchwork or shredding	Nil
H2	Towel	80 cm–70 cm	Reuse	Making mop	Nil
H3	Garments	70 cm–49 cm	Reuse/ dustbin	Making mop	Nil
H4	Blanket	165 cm–127 cm	Reuse/ dustbin	Reuse	Nil
H5	Fabric pieces	30 cm–10 cm	Dustbin	Patchwork	Nil
H6	Garments	98 cm–49 cm	Reuse/ dustbin	Second-hand clothing	Nil

A variety of small and large fabric pieces, such as pre-consumer or post-consumer textile waste, may be generated at home. However, an important trend seen at home-based fabric waste was the reuse in other applications (or second-hand clothing use), therefore, delaying the textile article from going into the dustbin or landfill. Collection of fabric pieces or used textiles prior to sending them to the dustbin may result in the fabric waste utilization in a second application, for example, making a mop.

Generally, the fabric pieces and garments at home, after the first usage, are consumed in one more application, followed by throwing them in the dustbin. This type of fiber waste needs to develop uses in composite, and partly mixing it with the virgin fibers to produce yarn and fabric.

3.4. Textile waste at the boutique

The three different boutiques visited for the textile fiber waste survey are summarized in **Table 6**. The fabric waste produced at the boutique shop was significantly higher in size; however, it was generally not further utilized and disposed of through burning or landfilling. The amount of textile waste produced at the boutique is relatively small and after an extended time or occasionally compared to the tailor houses. The type of textile waste produced was pre-consumer.

Table 6. Textile waste produced at boutiques.

Boutique code	Area	Nature of waste	Size (length-width)	Disposal	Any possible use	Selling price
B1	Bahadurabad	Fabric (cotton lawn)	30 cm- 16 cm	Dustbin or burning	Applique	Nil
B2	Gulshan-e-Iqbal	Cotton, net, georgette, chiffon	90 cm- 45 cm	Reuse	Dress finishing, belting	Nil
B3	DHA- Golden Tower	Fabric (cotton lawn)	40 cm- 18 cm	Dustbin or burning	Applique	Nil

3.5. Technical textile fiber waste

There are several types of technical textile articles used in industrial applications. There are not many shops known to deal with the technical textile business in the city's residential areas. However, a specific and detailed structure is required to comprehend the waste type, collection and separation followed by recycling and reuse. The current survey was mainly focused on the study of waste production in the manufacturing or use of home textiles and garments.

One shop found in this study was selling protective gloves (technical textile). The gloves were made of nylon and polyester grade fibers. The waste consisted of defective protection gloves with a center width of 22.5 cm and a length of 19 cm. The disposal of gloves was through burning or selling them at a reduced price. The price of defective gloves was 60–70% less than the original. The production of this type of waste was relatively smaller in amount and was occasionally generated.

Textile fiber types and techniques used in the technical textile formation are of special characteristics; therefore, the waste fibers require a detailed study for possible reuse.

4. Work feasibility and economy

For any developing work study, it is important to know the methods, skills, tools, and technologies available in the local market. This study is based on using the textile waste fabric pieces in the design and development of garments using the patchwork and appliqué. Importantly, the human resources, skills, equipment, and operating methods are already established in the local market. Therefore, the feasibility can be supported with local resources.

Most of the case studies in making the garments using the fabric waste in this study were found to produce 100% profit after deducting the cost of material, energy, labor, and manufacturing overheads. Therefore, the economy of the work for setting up a business is attractive.

5. Technical pathways for the business

The fundamental requirement, to set a garment-making business using the pre-consumer textile waste from the tailor houses working in the city, is more related primarily to the management and structuring of the waste collection, sorting, and then directing it for the utilization in the product development.

When the management and the system structure are achievable, and the fabric waste is defined for the particular garment product development, the business can flourish.

A large number of tailor houses across the city, Karachi, are continuously generating fabric waste pieces that are obtainable at minimal to no cost. A small tailor house can produce ± 5 kg of pre-consumer textile waste per week on a regular basis at zero to minimal price. The main cost will be the collection of fabric waste and transportation to a central control place for sorting and directing it to produce the defined garment.

A business route can be identified starting from the collection of textile waste fabric pieces to the new garment manufacturing, and is shown in **Figure 4**. All these activities are manageable in the local market using the available facilities and provide an attractive and profitable business setting.

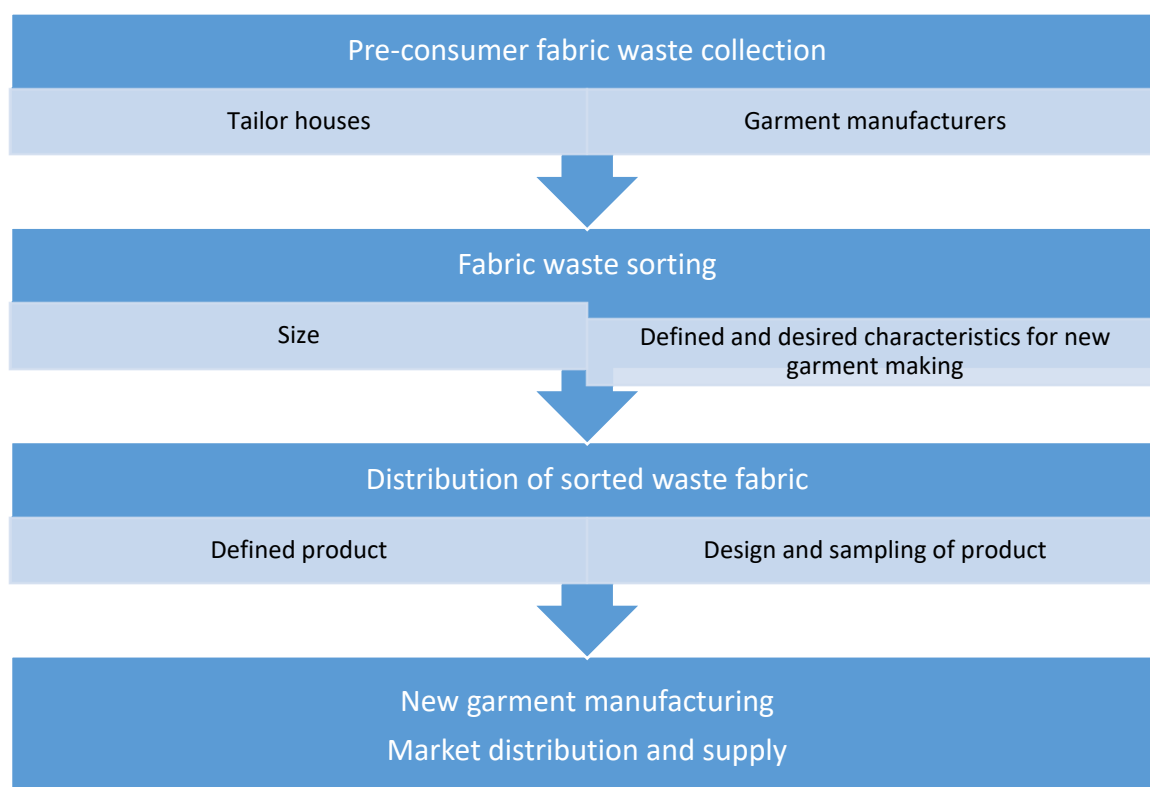


Figure 4. The pathways from pre-consumer waste collection to new garment manufacturing for the proposed business.

6. Product development case study

To demonstrate the effectiveness of the survey, the use of the pre-consumer waste fabric pieces was studied in the design and manufacturing of fashion garments.

Several case studies were performed in producing the garment using waste fabric in patchwork or appliqué. The garment produced in the presented case study here is based on the commissioned patchwork, following the garment design and sketches development.

A variety of garments were produced using the waste fabric pieces to confirm the economy of the work. This garment manufacturing work was systematically performed using theme selection, garment research, and design of the garment using the waste fabric. However, part of this work in stitching was externally commissioned. One representative garment development produced through patchwork is shown here in **Figures 5–9**.

The variety of designs can be produced using a product research board (**Figure 5**), product board (**Figure 6**), and then creating the sketches (**Figure 7a–c**) for possible product design (**Figure 7a–c**), color ways (**Figure 8**), and the final product (**Figure 9**).

The case study demonstrated the effectiveness of using the pre-consumer textile waste in product development, and significantly encouraged the direction for a profitable business since the low-value textile waste can be consumed in new product making.

The research board showed a variety of possible textile garments that can be designed and manufactured using the pre-consumer textile waste fabric pieces (**Figure 5**), and the product board showed the selected garment product that was opted to design and manufacture (**Figure 6**).

The sketches produced demonstrate the variety of pre-consumer textile waste fabric placement in the design of garments to be produced (**Figure 7a–c**). The final garment produced in this case study was made using patchwork. The final sketch selected to produce the patched garment is shown in **Figure 7c**. When working for a particular market and customization, the design can be tailored accordingly.

The obvious advantages observed in this case study include reducing the fashion waste footprint on the environment, opportunity for employment and entrepreneurship, business development, etc.

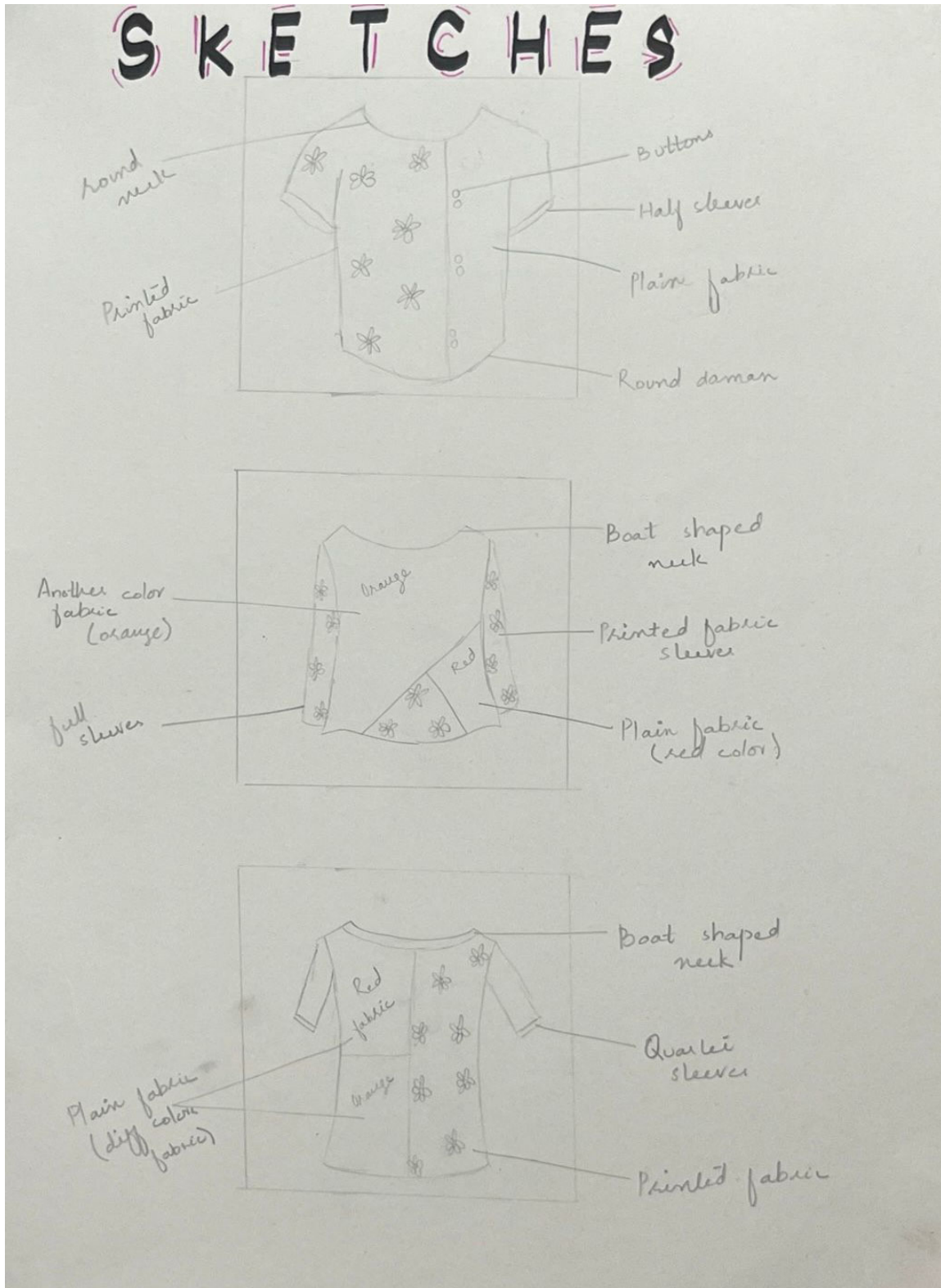
The new garments developed in this study using the fabric waste were estimated for a cost analysis. The production cost was based on labor, material, energy, and utilities, making the price of the product visible to the market shops for having an idea of the selling price. Interestingly, the price offered by the market-experienced salesperson was 100% higher than the total production cost.



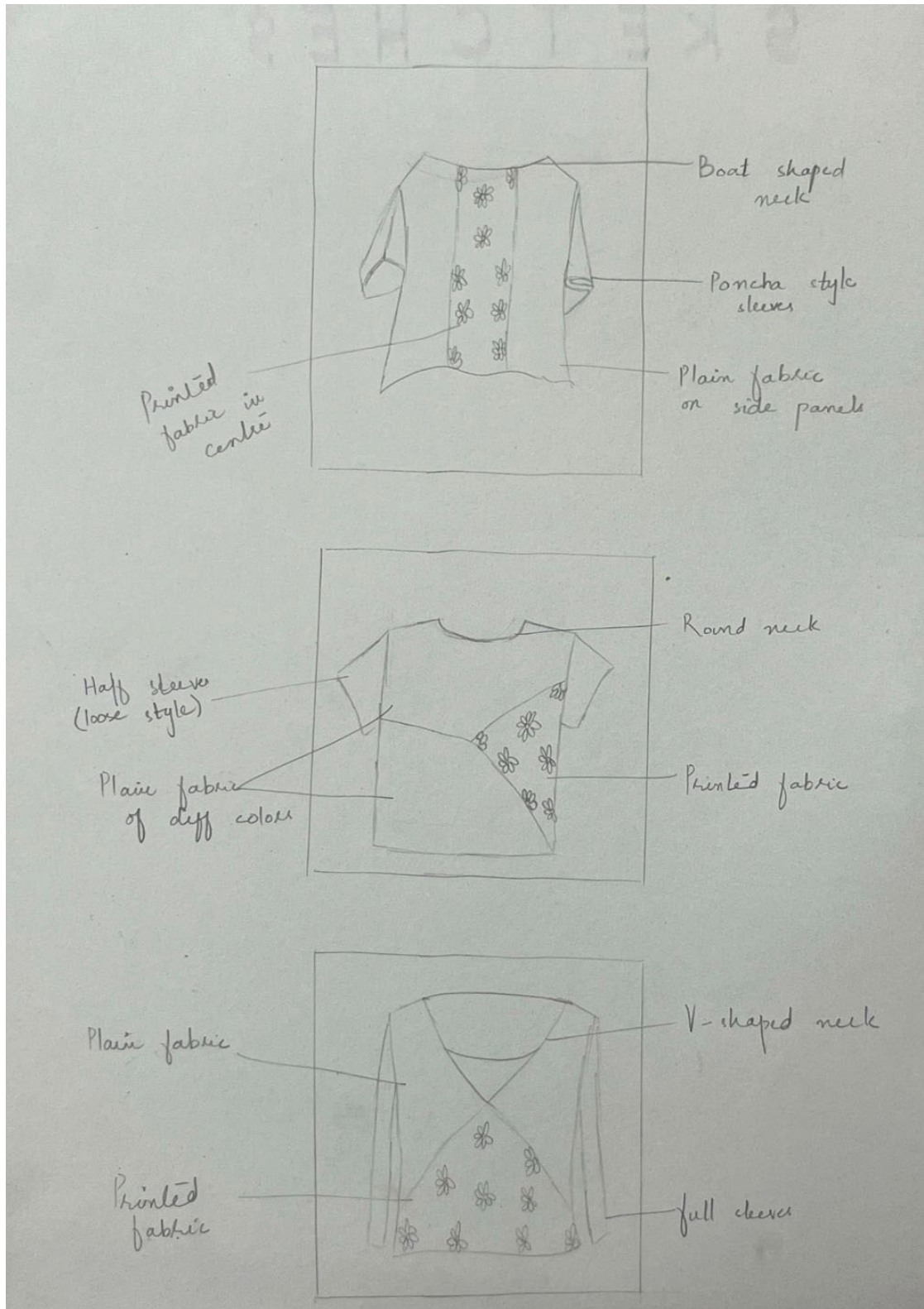
Figure 5. Product research board for designing the possible new garments using the pre-consumer textile waste.



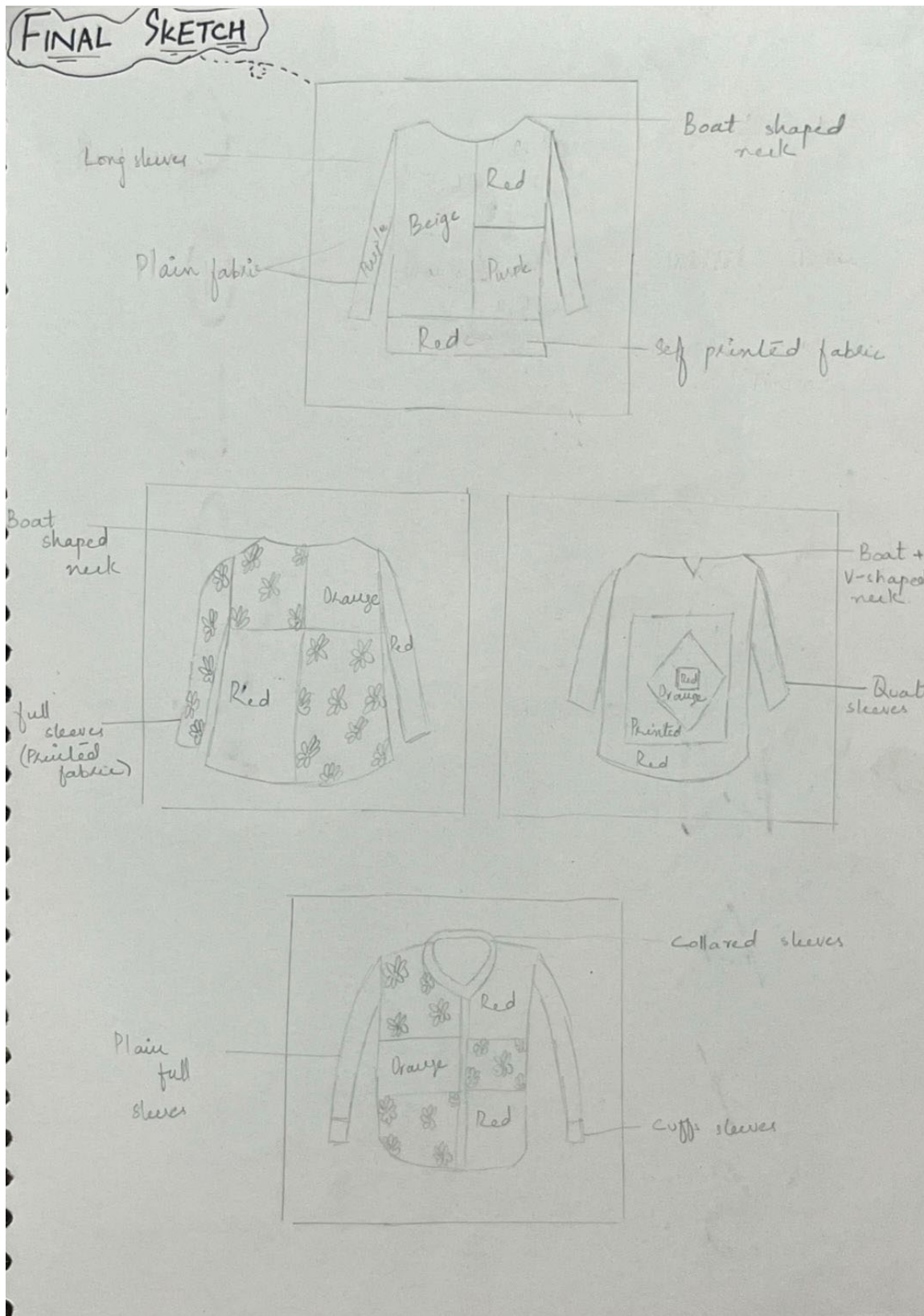
Figure 6. Product board for designing the new garment using the pre-consumer textile waste.



(a)



(b)



(c)

Figure 7. (a-c) Sketches produced for product design using the pre-consumer textile waste.

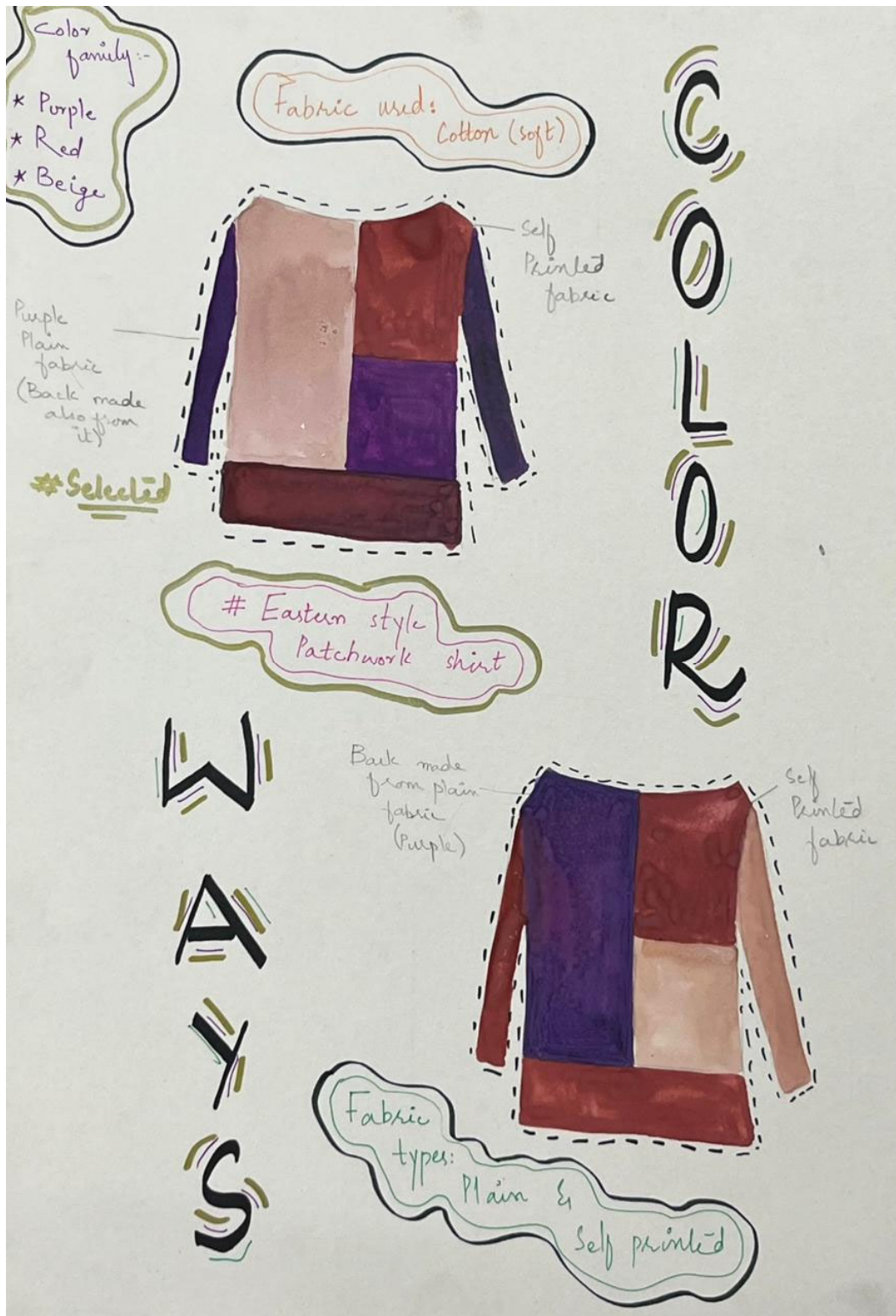


Figure 8. The color ways for the new product design using textile pre-consumer waste.



Figure 9. Final product developed using the pre-consumer textile waste.

7. Conclusion

The reuse and recycling of textile fabric waste is currently needed for environmental and climate sustainability. There are thousands of small and medium enterprises in Karachi. These enterprises are producing the pre-consumer textile waste daily. These textile fabric waste pieces are generally smaller in size and sold at a

minimal price, or disposed of through landfilling or burning, creating an environmental footprint.

Out of these small and medium enterprises, fashion tailor houses are leading the textile waste by fashion garment manufacturing for ladies, kids, and gentlemen. The purpose of this study was to demonstrate the use of the pre-consumer fabric waste pieces in the making of a new garment using the patchwork.

A survey study was designed to explore the availability of pre-consumer textile waste from 35 different enterprises, mainly comprising the fashion tailor houses working across the city in areas inhabited by the middle class or lower middle class. The use of available fabric waste pieces is studied in patchwork, where the size of the fabric waste is useful.

Case studies, utilizing the pre-consumer textile fabric waste pieces, were performed to confirm the development of other garments through patchwork. Employment, profitable business and entrepreneurship are possible through such activity. A profit of 100% was estimated, generally following the manufacturing and production of new garments.

This study showed the development work based on using the local know-how, skills, and equipment. Therefore, it can be applied in real development work, provided the system is structured for collection, sorting, and directing the defined use. Future study needs to address the mechanism and cost determination for executing the collection, sorting, and distribution of pre-consumer waste for utilization. The data analysis for waste fabric characteristics, including color, chemical finishes, mass, and fiber type, may also be the subject of a target development in future studies.

There are several studies addressing the textile waste reuse, including those in India, Bangladesh, etc.; however, the current study is covering the market survey starting from pre-consumer waste from fashion producers and leading to the production of design and development of new garments using the patchwork specifically.

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