## Study of Current Stage of Pre- Consumer Apparel Waste in SM Apparels and Proposing Efficient Solution for Better Management

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**Independent Project** 

## **Social Design**

By

Harshini Saravanan

Submitted to NIFT in partial fulfillment of the requirements for the degree of

**Master of Design** 

**Department of Design Space** 

Faculty Guide: Prof. Biniya Arul Jothi

#### CERTIFICATION

#### NATIONAL INSTITUTE OF FASHION TECHNOLOGY, BENGALURU.



This is to certify that **Ms. Harshini Saravanan** of Design Space Department at National Institute of Fashion Technology, Bengaluru, has been evaluated for her graduation project report titled, **Study of Current Stage of Pre- Consumer Apparel Waste in SM Apparels and Proposing Efficient Solution for Better Management** and have fulfilled the requirements set by the institution and the evaluation jury. Her work has been found satisfactory.

Ms. Biniya Arul Jothi Assistant Professor & Centre Coordinator Master of Design, NIFT Bengaluru

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#### Social Design

Ву

#### Harshini Saravanan

#### M Des

#### Batch 2021-23

Submitted by Ms/ Mr. ... Harshini Saravanan to NIFT in partial fulfilment of the requirements for the degree of Master of Design of the National Institute of Fashion Bengaluru and hereby certify that in the judgment of the following members of jury it is worth of acceptance: -

Name & Date	Institute/ Organization	Signature
-		
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-		
Remarks regarding fulfill	ing further requirements, if any: -	

Signature of CC – Department of Design Space

Date:

#### ABSTRACT

Being the second most polluted industries, the apparel waste has become an alarming challenge for both environmental activist and apparel sector. The effect of exponential growth of waste with long-term decay time, toxic leaching, and methane emissions, is significantly harmful to landfill areas. Designers and product developers are currently being called upon to take greater responsibility for the problems presented by the inefficient and unsustainable systems used to create new fashion items. Clothing which is being a basic necessity since basic evolution of human beings, added with its modern technological revolution and fast fashion evolution, over production and over consumption making its case worser, also apparel waste has also become a significant problem. But practical solutions of consuming the waste back into the production process are not being widely pursued. Upcycling is one such method which not only deducts the amount of waste that gets tossed but it also stops the demand for more production of items that will potentially meet the sustainable target. As a design-based waste solution, upcycled fashion production utilises textile waste to create products with a higher retail value than traditionally recycled goods.

This paper aims at understanding the apparel manufacturing from scratch, analysing the waste in each stage of process, defining the current state of waste management and the core of my project is upcycling as it allows the use of preexisting material and also the final product is of a greater value. The data was obtained via a Semi- structured qualitative type of questionnaire that is dominated by open ended questions distributed to the top managers of a manufacturing unit located in Thirupur, SM Apparels. The primary research also includes field visit to understand the real time system. The analysis showed that the waste stream consisted principally of woven fabrics, predominately cotton and cotton blends, with the presence of lycra. Bearing in mind the waste composition, the most appropriate end use for the pre-consumer waste though a system design is proposed.

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## **1. INTRODUCTION**

### 1.1 About this Project

India faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment and disposal, Current systems in India cannot cope with the volumes of waste generated by an increasing urban population and industrial production, this impacts the environment and also public health. The challenges and barriers are significant, but so are the opportunities.

However, while looking at and analysing other waste streams where possible interventions can be made and solutions charted, I found apparel waste is a huge potential area to look at and apply systems thinking to deliver solution(s) that consistently create a positive impact on our environment.

The issue is due to apparel waste generation are related to over consumption of apparel in western world. The diversion of old apparel for reuse meets the requirements of clothing for 70% of the population in developing countries.

Like other wastes, apparel wastes are also disposed through landfill and incineration is responsible for global warming. Though apparel recycling has old history, today it has become multibillion industry producing innovative products. Many agencies and stakeholders are making efforts to contribute towards the aim for saving in resources of raw materials, energy, water etc. and reducing the impact on environment for sustainable development. In future apparel recycling would be as important industrial activity as apparel manufacturing.

The need for effective apparel waste management is motivated by the increasing cost and decreasing availability of landfill space and the dwindling of natural resources. Apparels are nearly 100% recyclable. So, in the apparel industry nothing should be wasted. If apparel waste can be prevented, it can solve both waste disposal and resource waste problems at the same time. It is essential to address the source of the problem by minimizing the wastage and by maximizing the use virgin apparel materials. Waste can be converted again to resource and hence, bringing down the use of virgin material and lowering the amount apparels ending in the landfill or incineration.

The vast amount of apparel waste within the fashion industry all around the world has resulted in extensive research in the last decade. (Ekstrom and Salomonson, 2014) suggested that both clothing and textile reuse and recycling, are under-researched areas and that more information is needed on how reuse and recycling can be utilised by different stakeholders in society.

With the importance of sustainable and ethical fashion growing by and, the concept of zero waste needs to progress from designers to mass market as a combined approach.

India being the hub of production, we generate tons of apparel wastes which negatively impacts the environment. This research study has been planned to design a platform for managing and mapping of textile waste in Thirupur apparel unit named SM Apparels

Building on the same, system design approach has been taken to design the solutions for waste generated keeping all the stakeholders in system. Where research is focused on understanding the new era of zero waste and where India is taking initial steps in the journey, predicting the next steps that will be impactful of the apparel industry and the stakeholders. Exploring and understanding existing waste minimization strategies followed, gives the brief outlook of current scenario in India.

#### 1.2 Why this study

This opening section will provide an introduction to the background, the environmental impact and identification of the objectives. A discussion of the problem followed by the intent will lead to the presentation of the research objectives that shape the analysis. Limitations of the study will end the introductory part.

The apparel industry is an important sector in India. On the other hand, this massive manufacturing activity of clothing and its supportive industries produce a lot of solid waste. Due to the lack of proper waste management, this waste poses a serious threat on the environment and losing the economical potentiality. This study will find out the impacts of apparel industry on the environment, current scenario of solid waste management in the apparel industry and assess the upcycling of apparel solid waste which is relatively more environmental and economic sustainable way. This study will explain why upcycling, was chosen as an alternative solution, but complementary strategy to durable system design or professional services of repair or upgrading for product lifetime extension. The potential relationship between upcycling and product attachment for product longevity is described.

#### **1.3 About SM Apparels**

SM apparels is a garment manufacturing Unit which is specialised in T- Shirts manufacturing. 99% of their product is exported. Mostly it is exported to the buyers of UAE tagged as "REDTAG".

This company buys undyed yarns as their raw material, knitting process is partnered with nearby knitting unit, and as per their order specification of colour and count they send the fabric for dyeing.

Th design and style of the T-Shirt, colour and extra accessories like buttons are completely with respect to the buyer.

#### 1.3.1 SM Apparels

S M Apparels was established in the year 2010 and has carved a distinct position for itself amongst the dominant names of the industry. It is carrying out our business activities as a partnership company from our office located at Tiruppur, Tamil Nadu (India). They have gained immense appreciation in the field of manufacturing supreme quality assortment of Boys T-Shirt, Boys Plain Pant, Girls Sweatshirt and more. Offered products are designed by using superior quality fabrics and latest techniques.

#### 1.3.2. Infrastructure

The company possess a vast infrastructural unit where all of the business activities are performed in an efficient manner. They have equipped this unit with all the requisite machines and tools that are required for day to day functioning of manufacturing related tasks. They also upgrade the installed amenities from time to time to ensure their smooth performance.

#### 1.3.3. Range of Products

Starting from basic to casual for both masculine and feminine, their product ranges from cotton top, printed top and round neck T-shirt for girls, Hoodie, printed T- Shirt, Round neck T-shirt and full sleeve T- shirt for boys, and Polo T-shirt, Round neck T- shirt, corporate T- shirt and collar T- shirt for men.



Fig 1: SM Apparels Web page

#### 1.3.4. Raw materials and Fabric Management

They manage the yarn bundles. Sending yarns for knitting according to the order requirement, managing sample fabrics, sending the fabric for dyeing and collecting them are also handled by this department.

#### 1.3.5. Sewing and Checking

The people of this department work in twos. One person in every team act as a helper who sort and arrange cut pieces like sleeve, collar, waist part of same serial number. The other is a tailor who stiches them together and overlogging is also done here if required. Then they are sent to group of people of the same department who checks for defects and errors.

#### 1.3.6. Tagging, Cleaning and Iroing

The sewed T- shirts come to this department for labelling. The labelling usually done by one or two people through the rubberised sticker which uses heat and pressure to stick. Then these goes to group 5- 6 people who tags and add extra labels that are required as per the buyer specifications. Then they go for cleaning. Usually, they do oil cleaning method. Then ironing is done and finally T-shirts are sent for packing

#### 1.3.7. Packaging

The final packaging is done here **Auditing-** Who take accounts, orders, stocks and deadlines **CAD-** programming and designing as per the order specifications **Sample creation-** Special group of well- trained tailors whose job is only to create samples **Accessories-** needles, thread, buttons and other accessories are managed by

this department

#### 1.4. Background

The Textile and Apparel industry is one of the largest contributors to India's economy constituting 2% of total GDP, 12% of total exports, 7% of industry output in value terms, while employing over 45 million individuals. India is also one of the largest producers of cotton, jute and silk. Over 25% of the global cotton production comes from India (Fashion for Good's Sorting for Circularity; India Project, July 2022). Due to abundant availability of raw materials and workforce, India is one of the most thriving countries of textile and apparel industry. And the need for this both (Abundant raw materials and workforce) is dumped more by fast fashion. N number of fashion trends are being created and promoted every day and equally many trends are sooner discarded every day. It's very clearly estimated that the span of a trends are immensely decreased in last two decades (Fletcher 2008). This directly proportionated with the waste generation. On the basis of the stage they being generated, these wastes are mainly classified into three types: Pre- consumer wastes, Post- consumer wastes and import wastes.

As the names indicate, pre consumer wastes are wastes generated before reaching consumer hands, post- consumer wastes include discarded apparel by consumers and import wastes are e includes second-hand clothing and mutilated rags imported to India.

Here, pre-consumers wastes are something generated during and post process of manufacturing., It is estimated that nearly 40% of the fabric that goes into production ends up as waste and never reaches the consumer. Even before reaching its utility (Son of a tailor, Autumn 2019). These are technically called as **Virgin fabric Waste**.

These virgin fabric wastes are just disposed. At present, the key disposal methods are **open dumping and incineration** (Dr. Jaymala Dave, Dr. Sudha Babel, October 2020). Open dumping contributes to the formation of leachate as it decomposes, which has the potential to contaminate both surface and groundwater resource. A few waste composition studies in **Tirupur** indicate that unrecovered apparel waste accounts for approximately **4 per cent** of the content of landfills (Darshita Modi, 2013). Up to 7800 kilo tonnes of apparel waste is accumulated in India annually; the largest share of which, an estimated 51%, originates from Indian consumers – post-consumer waste, with factory waste and offcuts – pre-consumer waste amounting to 42%, followed by imported waste that contributes a further 7%. India's apparel waste accounts for 8.5% of the global

total; only 48% of the textile waste in India finds its way back into the apparel industry through reuse and recycling, with a mere fraction making it back into the global supply chain.(Fashion for Good's Sorting for Circularity; India Project, 27 July 2022).

But apparel wastes sent to recycling are not free environmental burden. They also consume enormous amount of energy in the process and also emit greenhouse gas (Gustav Sandin , Greg M. Peters, February 2018).

Hence, these virgin fabric wastes can't be used and also recycling wouldn't be a better option. So, how if one can add value to it, either intellectual, material, emotional or economic value, through a sustainable process, which can also be framed as "Upcycling"

## 1.5. Overview of Indian Apparel Industry

India is second-largest textile and clothing producer in the world. Increased penetration of organized retail, favourable demographics and rising level of income are likely to drive textile demand. The textile and apparel industries can be broadly categorized into two categories-fibre and yarn, and fabrics and apparel production (Indian Textiles and Apparel Industry Analysis, n.d.). The textile and clothing industry in India has strengths across the entire value chain from fibre, yarn, fabric to apparel. It is highly diversified with a wide range of segments from traditional handloom, handicrafts, wool and silk to organized textile industry. The organized textile industry is characterized by the use of capital-intensive technology to mass-produce textile products and includes the production of spinning, weaving, processing and apparel. The potential size of the textile and clothing industry in India is expected to reach \$223 billion by 2021 from \$140.4 billion in 2018. A strong raw material base, a vast pool of skilled and unskilled workers, cheap labour, good export potential are some of the key features of the Indian textile and apparel industry (India - Knitting the future, n.d.) Some other significant features of Indian textiles and apparel industry have been stated below:

- The domestic textiles and apparel industry contributes 2.3% to India's GDP, 7% of the country's manufacturing production and 13% of the country's export earnings.
- The textiles and apparel industry in India is the second-largest employer in the country providing employment to 45 million people. It is expected that this number will increase to 55 million by 2020

- FDI in the textiles and apparel industry has reached up to \$3.4 bn during 2020.
- Exports in the textiles and apparel industry are expected to reach \$300 bn by 2024-25 resulting in a tripling of Indian market share from 5% to 15% (India Knitting the future, n.d.)

India's growing population has been a key driver of the country's growth in textile consumption. The increase in the young population, complemented by an increase in female labour force, has led to changes in tastes, preferences and fashion. Clothing is more related to trends and personal style; therefore, people tend to buy clothing more often than household textile products. The 'National Household Survey 2008 released by The Textiles Committee, Ministry of Textiles, reveals that Indians purchase 22.41 meters of textiles in a year. While the demand for sarees continued unabated, the dhoti market has reduced by 8.59%, selling 11.7 crore pieces. Interestingly, jeans are bought more in the rural areas. (As per 2009 report 'National Household Survey 2009 released by The Textiles Committee, Ministry of Textiles). Wallander stated in study that global data reveals that more than two billion t-shirts and 124 million denim jeans are sold every year (Wallander, 2012).

Thus, the processes of accelerated population growth and continued high levels of consumption translate into a greater volume of textile and apparel waste being generated. As a result, worldwide pressures on the environment issues are steadily increasing.

#### 1.6. Waste Generation

Waste has been defined as any product or substance that has no further use or value for the person or organization that owns it and is, or will be, disposed of. However, what may be discarded by one party may be of value to another. Therefore, the definition of waste should be redefined in order to consider this waste as a potential reusable resource for others. The amount of waste generated and its actual or potential negative effects on the environment are issues of concern to the government, industry and the community. Waste is perceived as a problem for many reasons, but the three most frequently cited reasons are: waste disposal can harm the environment and human health; landfill space is claimed to become scarce as industries strive for zero waste targets; costs are increasing to use existing landfills and replace them. Waste is the end of the apparel lifecycle which causes costly environmental impacts and depletes valuable resources and energy-intensive apparel manufacturing processes and production processes. (S Sakthivel, Dr T Ramachandran, R Vignesh, R Chandhanu, J Padma Priya, 2012) More than 60 per cent of the fabric fibres used by the luxury fashion industry are derived from fossil fuels, according to a report by a leading international newspaper. And they're not biodegradable, and when you recycle them, they end up in a landfill where they emit toxic contaminants and toxins that end up destroying the ecosystem. In fact, the plastic microfibers in these clothes end up in the oceans, lakes and river(Schlossberg, 2019). It has been estimated that every year there are 20 new clothes produced per person and we buy 60 per cent more than we were in 2000. Each clothing is worn less until it is disposed of, and this shorter lifetime means higher relative manufacturing emissions. The fashion industry is one of the most polluting and generates 1.2 billion Tons of CO2 equivalent (CO2e) per annum, which is more emissions than international flights and maritime shipping. More than 60 per cent of textiles are used in the clothing industry and a large proportion of clothing production occurs in China and India, countries that depend on coal-fired power plants, raising the footprint of each garment. It has been said that the apparel industry accounts for about 5 percent of total global emissions (The price of fast fashion, 2018). Globally, 80% of discarded textiles are doomed to landfill or incineration. Currently, just 20 per cent is reused or recycled. The clothing that ends up in landfills will remain there for more than 200 years, and when it decomposes, it releases methane — a more efficient greenhouse gas than oil (McCarthy, 2018). The production of industrial large-scale fashion has material waste rates ranging g from 5 to 20 per cent. When fibre was limited and textile processes were time consuming (e.g. hand-spinning and weaving) the fabric was valued and expensive. It is reported that material was cut as little as possible and clothing was designed in order to avoid waste during cutting (Rissanen, 2013). The scale of production in the clothing industry worldwide is enormous, with the result that a large amount of textile content is being wasted. The fashion and apparel industry has been challenged by environmental issues at all stages of clothing production. Waste is produced mainly in the planning and development of markers and in the cutting processes(Niinimäki, 2013). Traditional textile manufacturing using cut-and-sew techniques yields about 15 percent fabric waste; the amount ranges between 10–20 percent depending on the design of the textile. Therefore, not only at the textile production and processes, but also at the design, pattern cutting and sewing stages, the elimination of fabric waste is required. Current practices in the fashion industry are unsustainable (Rissanen, 2005). Contemporary fashion design and production have been criticized

for the wasteful way in which the fabric is cut compared to, for example, the way in which the fabric is used in traditional dress forms (Rissanen, 2008).

Consumers are reacting to shifts in fashion. Seasonal shifts in fashion mean that clothing can be out-dated very easily, and this enables the replacement and recycling of out-dated, but goodquality clothing(Katkar & Bairgadar, 2010). This results in issues of over-consumption and disposing of discarded clothes contributing to resource challenges around the world. This poses a double-edged sword, in that while improving the economy at the same time, it also generates the increased issue of clothing and garment disposal(Hawley, 2008). The loads of unfashionable, unsuitable, not yet worn out yet no longer stylish clothes are wasted further(Joseph, 2001). Because as a result of the creation and manufacture of clothes or after consumption because 73% of clothes are thrown away ends up in landfills for this fast movement of fashion is accused of not being a healthy habit(Rissanen, 2013). In this way, the entire fashion industry contributes to clothing waste, both preconsumer and post-consumer(Joung & Park-Poaps, 2013)

Depending on their source, textile waste appropriate for fashion design can be classified into three groups: post-consumer, pre-consumer and production waste. For properties, they are distinct from each other and have a particular system of effective management.

## 1.7. Types of Wastes Generated



Infographics 1: Types of apparel waste

#### 1.7.5. Pre- consumer waste

In the age of fast fashion, availability of cheaper raw materials and low wage labour costs, manufacturers always intend to over-produce extra shipments and, as a result, there will be huge leftovers of clothing after final delivery. Often it comes from fail shipment due to poor product or unable to reach the shipping deadline. It also involves leftovers from suppliers and client product creation, faulty returned products, and outsourced clothing shipments that are not withdrawn from customs for different reasons. Pirate product confiscated by customs which would normally be destroyed often forms a part of pre-consumer waste. Pre-consumer waste from the manufacturer end is available on the local market as well as on the black market for branded clothing. And there are a number of options for pre-consumer waste

from sales left over: some stores can sell it to stores, stores or discount stores / websites, donate it to charities or foundations, or up-cycle to design new fashions. There was a dark side left of the retailers. Some clothing retailers had asked their employees to cut holes in unsold clothing and discard it. Employees were prohibited from keeping these clothes or giving them to the poor, as this could damage the reputation of the company (Aus, 2011).



fig:2: pre- consumer waste Aus, 2011).

#### 1.7.6. Post- consumer waste

Post-consumer waste originates predominantly from end use by users. Postconsumer textile waste consists of any clothing or household cloth (such as sheets or towels) that the consumer no longer wants and chooses to dispose of, either

because it is worn out, damaged, outgrown or out of fashion. Generally, this category has been of fair to high quality clothing that can be reclaimed and recycled as second-hand clothing by another person. Third World countries are the main market for secondhand clothes. "The clothes that are unlikely to be worn again are still useful, because they can be recycled into the fibre to be used in items of a similar nature. The majority go on to the landfill. Within the category of post-



fig 3: post- consumer waste

consumer waste, commercial and industrial textile applications often involve waste from assets such as carpets and curtains, hospital refuse besides industrial applications such as filtration, conveyor belting, etc. Industrial textile waste is typically "dirty waste." Problems related to storage and chemical pollution make this group the least likely to recover. A large proportion of these end-of - life products are consigned to landfill (Chavan, 2014).

### **1.8.** Apparel waste Sources

Garments solid waste is typically manufacturing waste, and is often known to be pre-consumer waste. Mainly the cutting section and the sewing section are the two units that create more solid waste. In addition, the textile industry has numerous units that contain solid waste of fabric, which is wholly or partially a by-product of apparel creation and processing of the supply chain.

**Storehouse**: Storehouse is the starting point for the apparel industry. Here all raw materials are processed until the creation and processing of some type begins. Inventory still holds the final items in the warehouse during manufacturing and after shipping. Storehouse is also responsible for monitoring the quality and quantity of raw materials sourced from various suppliers. Mainly faulty materials, end rolls of cloth, unused tissue from the product production stage and various accessories are waste from the storeroom. Such waste is fairly fresh and new than other waste(ADEME, 2016).

**Cutting wastage:** From the cutting table, a significant amount of waste is coming in garments industry. Wastes in the cutting room can come from several sources including marker utilization, cutting waste and roll remnants. Different sizes of the cut pieces of fabrics are main wastage from cutting(Grasso, 1996).

**Cut panel inspection and bundling room**: After cutting the layer of fabric according to the size of the marker, the cut panels have to inspect and numerate the embroidery, printing and sewing before input. Here various faulty cutting panels are isolated by inspection. Because there is no 100 percent inspection, some rejected cut panels that input into the further production process and that would eventually be a waste from the area of production.

**Printing / Embroidery:** Cut panels often need to be submitted in the section of printing and embroidery before sewing. Cut panels here are rejected due to misprinting, shading, colour spot, misplace, needle cut, misuse of the thread, shrinkage after embroidery and so on. There, too, panels cut in various sizes are the biggest waste.

**Stitching:** Stitching is a crucial process during the manufacturing phase of clothes. Machine operators may find out the faulty cutting panels in the cutting area which were wrongly generated in the sewing floor. Unless the faulty cut panel cannot be checked again, it would be a waste product. Various sewing faults, which may be

minor or vital, may lead to a waste garment. Any important sewing faults are torn stitches, skip stitches, incorrect threads, needle cuts, irregular seam lines, oil stains, etc. There the key waste is broken panels and a whole body which is left over or refused due to various issues

**Dyeing and washing:** After stitching, certain garments have to be dyed and cleaned. Because of shade variance, machine problem, workmanship problem some clothing gets a big or essential fault, and that's known as waste clothing. The biggest wastage here is full body clothing.

**Finishing:** Finishing and packing is the final step in the clothing industry. Here the waste comes from ironing, iron spot, measuring variance, scissor cutting the loose thread of fabric, etc. There, too, the biggest loss is full body wear.

## 1.9. Waste Hierarchy Model

The waste hierarchy classifies waste management options according to the the best environmental results, taking account of material Lifecycle. A material's lifecycle is an environmental measurement of all aspects of a product's life from cradle



fig 4: water hierarchy model

to grave(DEFRA, 2011).

## 1.10. Steps of Wastes Hierarchy Model

**Prevention** - The most preferably step in the waste hierarchy is avoidance or prevention. The aim of waste management is on enhancing the processing system and preventing waste from occurring in the textile and garment manufacturing sector(Directive 2008/98/EC on waste (Waste Framework Directive), 2014).

**Re-use** - This is the second step in the hierarchy of waste, after reducing the amount of waste generated. If people don't want their clothing they can keep it, throw it in the garbage, sell it or give it away.

**Recycling** - The recycling rates are usually very small. Because recycling is not economically beneficial and technologically limited, this is why not many companies

are working with textile fibre recycling. Even so, the process of recycling textile waste has previously existed in the industry (Fletcher & Tham, 2014).

**Disposal** - This is the last step and the worst situation in the waste hierarchy. The disposal is the most common way to treat textile waste after being submitted to charity. Disposal involves mainly energy recovery by incineration, burning the textiles at disposal and generating energy in this process (Palm, 2011).

The waste hierarchy therefore gives top priority to waste prevention, and lowest priority to disposal. When waste is created, preparing it for reuse, then recycling, then further recovery and last of all disposal is given priority.

In addition to the above-mentioned general waste management techniques, there is another technique which has been highlighted in recent literature, namely: zero waste management techniques.

## 1.11. Waste Management

Waste management practices may differ for developed and developing countries, urban and rural areas, and for residential and industrial producers. Management of non-hazardous residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management of non-hazardous commercial and industrial waste is usually the responsibility of the generator under the responsibility of local, national or international authorities. As there is a very limited and more green technology for textile recycling, more waste flows into wipes, rags or is used as insulation in different industries. The residual traces are either landfilled or incinerated. Furthermore, manufacturer and customer awareness decide what happens to a clothing waste at the end.

#### 1.11.1. Landfill

Minimum preferred strategy for the treatment of solid waste. By means of a landfill, the last destination of the waste in or on the land is controlled or uncontrolled according to different sanitary, environmental and other safety requirements. Due to the lower price and lower quality value of second-hand clothing, a huge amount of waste of clothing ends up in landfills.

Each year 80 billion tons of clothing are manufactured worldwide, producing 1.3 billion tons of fabric waste (Mishra, 2019). At least 50 percent of the textiles one throws away are recyclable, but only 25 percent of the material is recycled in operation. An outlook on the future textile market says India is projected to rise about 3-5 per cent in the area of disposal, and sequentially this will increase landfill

disposal (Saravanan, 2011). Approximately 5% of municipal waste produced is textile waste due to ever-changing trends in fashion and increased demand for clothing in both developing and developed countries (Mishra, 2019).

The ecosystem is heavily contaminated through greenhouse gas emissions through the direct contribution of waste from landfilling garments. Through landfills, this waste contains hazardous contaminants to cause carbon emissions to soil and pollutants to groundwater. "The emissions of carbon dioxide from natural fibres may be considered part of the normal cycle of biogenic carbon dioxide emissions. Cotton landfilling however releases approximately 0.2 kg CH4 (5 kg CO2-eq.). Once incinerated, a pure polyester fibre emits about 2.3 kg of carbon CO2 per kg of cloth but very little when landfilled (Fletcher & Tham, 2014)

#### 1.11.2. Energy Recovery

Incineration with energy recovery is the dominant technology for waste treatment in many countries. Incineration can be achieved with or without recovery of the energy. The textiles may also be cut into parts, compacted, pelletized and used as boiler fuels or used in the production of ethanol or biogas. Textile waste collected from bins and sacks is sent along with other urban waste collected to incineration. The heat and power recovered would theoretically replace other energy sources (Palm, 2011).

The environmental impact of incineration on the energy recovery of textile waste is of minor importance compared to the production of new textiles. Incinerator chimneys, however, emit organic substances such as dioxins, heavy metals, acid gasses and dust particles, all of which are potentially harmful to both humans and the environment. There is also a problem with the disposal of residual ash, which is likely to contain a concentration of toxic material (Katkar & Bairgadar, 2010).

#### 1.11.3. Recycling

Recycling is concerned with providing the manufacturer with reprocessed raw materials to be used as inputs for the production of new goods. Recycling is defined by EU Directive 2008/98 / EC as any recycling activity by which waste materials are reprocessed into goods, materials or substances, whether for original or other purposes. Material recycling saves money, and typically requires less energy than new material processing (Aus, 2011). There are several technologies available or upcoming for recycling textile and garments solid waste. After collection, the process

of recycling starts with sorting, this is done by the colour, type and size of fabric. There are two ways for recycling: mechanical and chemical.

**Mechanical recycling**: Mechanical recycling is processing fabrics and yarns from recycled pieces of cloth. First, the waste is cut into small bits, then passed through a revolving drum and processed into fibres. Due to the mixed colour of the fibres and the different fibre lengths the physical properties and quality of the fibres produced using this method are low. Since of the inhomogeneous nature of the materials, recycling of blended fabrics poses a major challenge. The collected fibre can also only be used in filling upholstery, underlay carpets, sound and heat insulating fabrics, disposable diapers, napkins and tampons. One way to improve the quality of this product is to mix these fibres with virgin fibres and to blend them into yarns. Since the properties of such yarns depend on the quality of textiles, they are mostly used in the production of woven filtration systems or geotextiles (Palm et al., 2014)

**Chemical recycling**: Chemical recycling methods may, in principle, be applied to synthetic fibres (polyester, nylon or polypropylene) or mixtures of natural and synthetic fibres. The fibres are chemically isolated during chemical processing operations, and degraded to the molecular level. The synthetic feedstock is then repolymerized into new fibres (Palm et al., 2014).

Recycling allows the material to have longer life, in addition to reducing resource consumption and eliminating the expense of disposal. Transportation and processing add to the expense of final recycled items making it more costly compared to the new materials. Material recycling saves money, and typically requires less energy than new material development.

#### 1.11.4. Downcycling

The most common way of handling mechanical solid waste is to cut and shred the fabric into small pieces that can be used as filling in mattresses or upholstery, as insulation, or as underlay for carpets. Usually, when reprocessed, the consistency of the material is reduced, and therefore this method called downcycling seeks to use waste materials, reduce fresh raw material use, and has less environmental effects(Zamani, 2014).

The environmental effect is much less resource intensive and polluting than the processes involved in making textiles from virgin fiber when recycled and downcycled raw materials replace virgin textiles. But they still contain the same matter which consumes energy and emits pollutants by breaking the waste through the mechanical and chemical process while recovering raw materials.

#### 1.11.5. Reuse

This could be described as any process where products or components are again used for the same purpose (Gharfalker et al., 2015). This stops the commodity from ending up as waste and will help the environment by making it available to customers who were not in a position to afford it first. Reuse the waste handles of the garments with goods in a manner comparable to recycling and resale. Waste recovery involves re-use of a commodity in its original form. Reuse would also mean using the product as something new which serves another purpose. The largest quantity of products is being processed for the markets for second-hand clothes. Charity stores are getting more donations than they can actually pass on. Whilst retail markets are full of cheap clothes, the second-hand markets for reused garments are also saturated (Niinimäki, 2013). Consumers in the UK use 35 kg of garment per person every year, one-eighth of which is sent by charities for re-use and the rest is discarded. Reusing can also produce profit: in 2000 alone, the secondhand market in the United States was worth more than a billion dollars (Allwood et al., 2006). Over 70% of the world's population uses second-hand clothes; this would equate to 4.2 billion people (Fraser, 2009).

Though it is classified separately in the waste hierarchy, reuse of the product can be connected to a method of waste management, as both aim to minimize the amount of waste that needs processing. The reuse of textiles decreases the volume of waste stream and thus decreases the harmful environmental content. Reusing garments greatly helps reduce the harmful effects that fashion textiles have on the climate (Vats, 2015).

#### 1.11.6. Prevention

Waste prevention is a preferred option for waste management. In addition, waste reduction gets more attention as of late because of the enormous deformities of modern pollution control as the best step in the waste management process. However, it also brings significant side effects when reducing contaminants, such as the issue of secondary emissions, the increased expenditure for the treatment facility, etc. On the basis of the EU Waste Directive, prevention shall mean measures taken before a substance, material or product has become a waste that may reduce: the quantity of waste, including through the re-use of products or the extensive life span of products; the adverse environmental and human health impacts of waste

generated; the content of harmful substances in materials and products.'(Directive 2008/98/EC on waste (Waste Framework Directive), 2014).

Waste prevention is always the best way to achieve the maximum output and the least negative impact on the environment. Prevention of waste reduces production costs and thus helps the industry to make more profit. It also reduces the amount of waste disposal and material consumption. Preventive tactics can sometimes become innovative, opening up opportunities for lean manufacturing. Although waste prevention can not address the whole issue of waste disposal, it offers a cost-effective way to minimize the amount of waste that can ultimately be best practice for an organization or a nation.

#### 1.11.7. Upcycling

Upcycling refers to the re-use of leftovers treated as waste and the quality of the final product remains the same or improved by creativity. Recently, the most sustainable development in the textile fashion industry has been called upcycling. As part of the sustainable design and recreation plan, up-cycling offers a designer flexibility with the ability to reassess the true value of waste. This concept was developed by using waste as a new product without any recycle or down-cycle process. It is the beginning of a cycle in which materials already manufactured are not discarded, but re-used in an innovative manner to provide new, high-quality goods. The upcycling method, or upward re-processing, is defined as returning waste to the consumption chain through design by placing it in the chain higher than it used to be – this includes environmental, commercial and aesthetic value – while also taking into account the future of the product (McDonough & BraungarT, 2002).

#### 1.11.8. Upcycling- A solution to Post Production Waste

Up-cycling is a process of transforming discarded or obsolete goods into new materials or items of equivalent or better quality or a higher environmental value. When producing something new it removes waste and retains or increases its efficiency. The purpose of upcycling is to prevent the wasting of potentially usable materials using existing ones (Smusiak, 2010).

Up-cycle textiles are not merely the preservation of the resources that have gone into the production of a particular material, but the addition of the value embodied in them by the application of knowledge in the course of their recirculation (Murray, 2002). The Up-cycling process involves four stages as illustrated in figure:



Infographics 2: upcycling basic flow

As a sustainable design strategy, up-cycling gives designers the opportunity to reassess the true value and value of waste materials through the design and manufacture of new products. Rather than recycling, which may result in the downgrading of the up-cycled material, the aim is to further prolong the life and value of the product and material.

The up-cycle process is more than just using old and raw materials. This kind of re-use increases the raw material to an object of higher status than the original object. It's about upgrading the used material and making it more desirable than it was at the beginning (Gwilt & Rissanen, 2011). Through allowing new value to be added to the greatest possible amount of textile waste, up-cycling will address the problems associated with textile waste in fashion and could be an important step towards achieving zero waste (Zero Waste International Alliance, 2010).

## 1.12. Title

Study of current state of pre- consumer apparel waste in Thirupur and propose an efficient solution for better management

## 1.13. Objectives

To understand the different stages of apparel manufacturing and analyse the different wastes emitted by apparel industries during the manufacturing.

To trace the virgin fabric wastage generated during manufacturing and to determine the scope for reutilising them within circular economy.

To develop more ethical, circular and transparent system/ model to convert fabric virgin wastes or pre consumer wastes into utilitarian product.

The primary aims of this study are: to understand nature of different pre industrial textile wastes and test different techniques of upcycling and to analyse ways to bring these fabric wastes into production.

## 1.14. Significance of the project

Usually, the fabric wastes are not given any attention and once the garment is finished and out of the manufacturing process, these fabrics just end up in dump yards. Implementation of this project is an attempt to make a slight alteration in this process. Instead of ending them into the dump yards, they can be recovered as potential raw materials for a new market.

## 1.15. Need of the Project

**First need:** Virgin fabric waste is not a familiar term to many because, unlike plastic, this waste cannot be commonly sighted in public spaces. But the waste generated is enormous. Out of 7800 kilo tonnes of total textile waste in India annually, about 48% are fresh fabric waste. These fabrics are not at all wastes. In fact, they are virgin fabric, albeit in scrap form. By throwing or dumping these fabrics, we are just throwing and dumping new resource.

**Second need:** Globally we are knowing the importance of sustainability and trying our best to move from linear economy to circular economy to achieve it. Implementing upcycling, which is one of the great principles of circular economy, that too in the textile industry, which own its ever thriving demand, it would be a great opportunity to incorporate sustainability without any loss but establishing a new profitable market

## 2 Review of Literature

The fashion and textile industry is one of the world's most polluting industries, mainly because its volume of production dwarfs most other industries. Textiles production requires a lot of land for crops and uses a lot of water, energy, chemicals and other resources leaving often untreated pollution behind and has a highly negative environmental, economic and social footprint (Fletcher, 2008; GFA & BCG, 2017; Hiller Connell & Kozar, 2017; Leal et al., 2019; Remy et al., 2016). Today's conventional fashion and garment industry is linear by nature and in addition to the impact that raw material extraction for newly produced fibre production has, textile waste has become a major problem in the sector. If a business-as-usual scenario prevails in the coming years – meaning that no action is taken to reduce fast fashion waste – the industry's global emissions will likely double by the end of the decade.

(Ellen MacArthur, 2013, 2017).

#### 2.1 Life Cycle of a Garment

The life cycle of a clothing item consists of several key stages which start from raw material extraction and proceed to fabric manufacturing, clothing manufacturing, retailing, use and end of life stages (P. Munasinghe et al., 2021).



Infographics 3: Life Cycle Inventory of Clothing

# 2.2 Overview of the wastes generated in different stages of clothing

Considering the entire life cycle of clothing, the waste generated in different stages is broadly classified as Pre- consumer wastes, post- consumer wastes and imported wastes.

**Pre-consumer waste** is generated during and post-manufacturing across Cut-Make-Trim (CMT) units, fabric mills and spinning; domestic **post-consumer waste** includes garments/ textiles discarded by domestic consumers. While **Imported waste** includes second-hand clothing and mutilated rags imported to India (fashion for good sorting for circularity: India, July 2022).

Wastes generated during the process of raw material extractions, Fibre manufacturing, yarn manufacturing, dyeing process, fabric manufacturing and clothing manufacturing are categorised under pre- consumer textile waste. They are

named so because they never reach consumers, in fact, consumer never get aware of these wastes. Pre- consumer wastes comprises 42% of total textile wastes produced.

Wastes generated during the process of usable life of a cloth, washing, drying, dry cleaning and ironing are categorised under post- consumer wastes. They are named so because the main cause of this type of waste is the consumer. Post-consumer wastes comprise 51% of total textile wastes produced.

Imported textile waste forms 7% of total textile waste and falls within two categories- Mutilated Rags and Second-Hand Clothing. Used clothing with signs of mutilation and wear and tear also fall under Mutilated Rags. According to import policies, the used clothing category is a restricted trade in India and its import is only allowed in the Kandla Special Economic Zone (KASEZ). The KASEZ has 16 units which were set up to sort and grade imported used clothing and re-export them to other countries. The import of mutilated rags, on the other hand, is a free trade allowed at all ports of India.



Fig 5: Total clothing wastes generated in India,

## 2.3 Wastes generated by Textiles and Apparel Industry in India

Global textiles waste is estimated to increase 60% each year between 2015 and 2030, generating an additional 57 million tons of waste every year, and reaching a total of 148 million tons annually (Niinimamp et al., 2020; Shirvanimoghaddam et al., 2020).

Over one million tonnes of textiles are scrapped every year in India, according to industry estimates. Textile waste is third largest source of municipal solid waste in India. This issue is a major contributor to environmental distress, but there are untapped opportunities to bring about a change (BussinessWorld article, March 13 2023).

## 2.4 Pre- Consumer wastes

Pre-consumer waste, also called post-industrial waste, is **obtained from leftover raw materials generated in the textile material and garment production process**. They are also referred

as **virgin fabric waste**. It also accounts for 3265 k tons annually, spinning waste forms the largest share, followed by Mill Waste and Ready-Made Garments (RMG) waste.

With the expansion of the fashion industry the quantity of industrial preconsumer textile waste has increased. It is estimated that approximately 10-20% of textiles are wasted during garment manufacture (Yuk-Ian Lau, November 2015). It includes scraps, damaged or defective materials samples, fabric selvages, left over fabric from the cutting process (Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020).

## 2.5 Different Types of Pre- Consumer Wastes

Textile wastage produce in every phase of the distinctive textile manufacturing departments like spinning, weaving, dyeing, finishing, garments manufacturing and even from the consumer end. We can classify them as,

Soft waste: Waste from Combing, Drawing and Spinning are called Soft waste.

Hard waste: Waste delivered after Spinning and Twisting, Weaving and Knitting is called hard waste (Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020).

2.5.1. Spinning waste: The fibres from the spinning industry has various other materials like seeds, twigs, dead insects and dust(Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020). This forms 46% of total pre- consumer wastes. Spinning waste is generated during yarn production. 75% of yarn production in India is cotton and cotton blends. The cotton spinning waste further consists of six types of waste- blow room waste, carding waste, comber noils, pneumafil waste, yarn waste and sweep waste. Hence, cotton spinning waste forms 94% of the total spinning waste in India. In man-made fibre spinning processes, waste generation is limited and forms only ~6% of the total spinning waste in India (fashion for good sorting for circularity: India, July 2022).

**2.5.2. Mill Waste:** Mill wastes contributes 612.2 kTons, which is 18% of the total preconsumer wastes generated. This includes defect fabric rolls, yarn waste and other smaller cutting waste. Yarn waste forms 18% of the mill waste, while rejected and deadstock fabrics only form 6% of the mill waste. The remaining 76% consists of smaller cuttings, fabric and selvedge waste generated during the weaving, knitting and fabric finishing processes India (fashion for good sorting for circularity: India, July 2022). The wastes under each process are as follows:

Weaving waste: The yarns that are left on the cone after warping, are weaving waste. In the warping creel section, there will always be a little amount of yarn left on the cones. Sizing waste is another kind of waste in a weaving factory. After sizing wastage, comes the knotting wastage. Knotting is done to ensure all the warp ends of two beams are available for attaching together. Beam residual wastage is another kind of weaving wastage. When a weaver beam is finished, a small amount of warp yarn remains unused on the weavers beam and it is not possible to finish yet. Auxiliary selvage wastage is also a common weaving wastage. Auxiliary selvage is a fake selvage used to hold the weft yarn during loom beat up period(Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020).

**Knitting waste:** The art of knitting is either handmade or machine made. The complicated process and any fault in the technique of loop creation result in wastage. On acquiring an order, the merchandiser makes a sample, which is run for trials and to check the proximity, this resulting in waste samples. Different kinds of knitted defects like stains, barriness, thick and thin yarns, stripes, hole, slub add to the knitted wastes from industry(Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020).

**Dyeing waste:** The batches with shade variation, crease marks in dyed fabric, difference in shade from selvage to selvage are usually thrown as waste in the dyeing industry (Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020)..

**Other processing waste:** The different processing like cutting, bundling, sewing, finishing, printing, embroidery result in scrap waste. Among all, cutting section produces the maximum waste. Solid Waste: The majority of this waste originates from other sources during operations like transportation, bale openings, servicing process, housekeeping etc., the waste under this category includes,

Tubes – Pallets, Cones - Containers/drums Plastic wrap - Corrugated card-board Seam waste - Paper waste Bags - Shipping cartons (Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020). **RMG waste:** Ready- Made Garment waste ot cutting waste generated at the stage of garment production and forms a total of 792.2 ktons, that contributes 24% of total pre- consumer waste generated. It consists of both smaller cut pieces (referred to as 'katran/chindi' in local languages), bigger cut panels and end rolls (referred to as 'marbet/thapki/patti'). A majority of the cutting waste consists of smaller cut pieces as opposed to larger cut panels (Fashion for good sorting for circularity: India, July 2022).

**2.5.3. Fabric deadstock:** This waste is generated due to extra fabric orders, rejected fabric rolls, faulty construction/finishing defects, or order cancellation. This waste has high economic value. This contributes 6% of total pre- consumer wastes (Fashion for good sorting for circularity: India, July 2022).

**2.5.4. Unsold inventory and rejects:** Contributing 5% of total pre- consumer waste, this category consists of clothing that is discarded during apparel quality checks, sampling, export surplus at manufacturer's end, or unsold inventory. This category has high economic value and utility (Fashion for good sorting for circularity: India, July 2022).



Fig 6: Different wastes that are categorised under pre- consumer wastes



Fig 7: Different streams of pre- consumer wastes and quantities of each with respect to India

## 2.6 Statistics of pre- consumer wastes produced

- 1. The pre-consumer, domestic post consumer and imported waste results in the generation of 7793 k tons of textile waste in India annually, forming 8.5% of global textile waste.
- 2. Out of the total waste generated, 59% is reused or recycled. However, out of this share, only 10-40% returns to the global supply chains. 43% of domestic post-consumer waste ends up in landfills as compared to 15% of pre-consumer and imported textile waste.
- 3. At present, nearly 61% of the total pr- consumer waste generated in India is cotton-rich material. However, there has been a considerable increase in the quantity of synthetic textile (especially polyester) waste over the last five years.
- 4. Panipat and Amroha serve as key recycling clusters for pre-consumer waste generated in Northern parts of the country and imported second hand clothing waste.

Most of the waste generated in South India is transported to the Tirupur-Coimbatore- Erode recycling belt(Fashion for good sorting for circularity: India, July 2022).

## 2.7 Causes of excessive apparel wastes

i) Attitude towards textiles: Indians have a rich tradition of using textiles and reusing them to the maximum possible extent. A sari turned into a curtain, then into rags, used as a lamp wig and then as an ash for protecting the eye (kaajal). There was

always a sensible approach to textiles. Post modernisation, lifestyle has been totally influenced by various civilisations. The Western lifestyle is a significant contributor to landfill waste. Not only products are consumed at a high level, but also Western goods are often over-packaged, contributing to even more to the waste stream.

ii) Fast fashion: In the last ten years, the toxic culture of fast fashion has replaced slow fashion. Handmade drawings are replaced by machine-made replicates that cut down time and cost. The recreation of designer clothing at the lowest possible price for mass production is possible only with the use of synthetic and harmful dyes. This fast fashion culture ultimately churns out massive amount of clothes, accelerating carbon emissions and global warming. Low-quality materials soon end up in landfills that turn a menace to handle.

iii) Frequency of shopping: The number of items purchased has increased tremendously, mainly due to price drops. Global 'fast fashion' suppliers offer low-priced clothing with a short life span. It has been calculated that in the last ten years, shopping levels of women have doubled.

iv) Lack of awareness on sustainability: In the life cycle of any textile product, consumer disposal behaviour and their awareness about environment plays a crucial role in reducing waste. At the end-of-life stage, instead of sending it to landfill, if consumers become more open to reusing the product and forwarding the product for recycling rather than to landfill, it will certainly reduce textile wastes to an appreciable level.

v) Lack of eco-friendly practices: Fibre production results in wastes that are not recycled effectively. There is lack of awareness to handle fibre wastes that are of natural origin; as a result they are thrown out in huge numbers. The dark shades of textile are associated with more dye powder, and more toxic textile waste water. There is no method used for treating the waste water generated from using more dyes; yet most people wear dark coloured clothes. Toxic materials like lead, chlorine, formaldehyde are expelled into water bodies from the textile industry.

vi) No strict government policies: Developed countries are working in the direction of streamlining flow of waste, proper disposal of waste, consumer awareness and strict norms. But in developing countries like India, environment legislation is stringent but poorly enforced. Trading of second-hand clothing is not properly worked out. Therefore, government's initiatives and strict policies for trading of second-hand clothes, disposal of waste and awareness camps can be of great help to save the environment.

vii) Lack of quality materials: Clothing companies with mass production capability usually have confidence in their own internal knowledge about product development and design. The fashion information is often received from trend forecasting companies, fashion shows and media. Sizing and fitting of clothing is tested on fit models and graded to other sizes, and not necessarily tested on other bodies before production, thereby causing problems with fit, especially in larger size groups. If physical durability, comfort and ease of maintenance, aesthetics, etc. are addressed correctly during the design stage, then the clothes often remain useful for a longer duration and even resist fashion change over time.

viii) Less popular second-hand clothing: Second-hand clothing is generally considered for low economy countries and low-income groups. It is not appreciated as a good substitute of virgin clothes that have a direct impact on the environment. Second-hand clothing markets and shops are not widely spread and are not popularly known. So these are not easily accessible to the masses at large.

ix) Consumers' lack of knowledge on textile care and maintenance: The commonly used style for washing garments is by using water and other chemicals like detergents, bleaches, etc. Often low-quality domestic products are freely traded without any eco labels. For proper maintenance of clothing, laboratory-based test results are important and should be mentioned clearly on labels.

x) Industrialisation: Various qualities of textiles are available in abundance to target different consumer groups leading to more pre-consumer and post-consumer textile wastes. Fashion due to its ever-changing nature, is a big reason for pollution. Consumers have to be well aware of the choices they make while purchasing (Dr. S. Aishwariya and Mrs. J. Jaisri, July 2020).

#### 2.8 Current system of textile waste management

#### 2.8.1 What is waste management

The methods and actions required to manage garbage from its beginning to the end are referred to as waste management. This encompasses waste collection, transportation, treatment, and disposal, as well as waste management process monitoring and control, as well as waste-related laws, technologies, and economic systems (waste management methods in the textile industry by Textile value chain, September 2022).

#### 2.8.2 Waste management Practices



Fig 8: Ways of managing wastes

## 2.9 Global steps and suggestions to manage apparel waste

#### Suggestions European's report of circular Economy Action Plan

applying the new sustainable product framework as set out in section 2 to textiles, including developing eco- design measures to ensure that textile products are fit for circularity, ensuring the uptake of secondary raw materials, tackling the presence of hazardous chemicals, and empowering business and private consumers to choose sustainable textiles and have easy access to reuse and repair services;

improving the business and regulatory environment for sustainable and circular textiles in the EU, in particular by providing incentives and support to product-asservice models, circular materials and production processes, and increasing transparency through international cooperation;

providing guidance to achieve high levels of separate collection of textile waste, which Member States have to ensure by 2025;

boosting the sorting, re-use and recycling of textiles, including through innovation, encouraging industrial applications and regulatory measures such as extended producer responsibility.

## 2.10 Pre- consumer waste management in India

Of the total pre-consumer waste, only mill waste and overproduction waste is being reused, while cutting waste appears to have multiple applications depending on its quality.

#### 2.10.1 Recycling and reusing

The movement of textile waste between two locations is dependent on the type of waste available at source areas and the demand from the industry at the

destination area that recycles or reuses it. Most of the cutting waste from Delhi-NCR, Uttar Pradesh, Punjab and Haryana is transported to Panipat and Amroha, given the capacities and capabilities of the recycling industry in these locations to deal with cotton, acrylic and wool waste. However, Panipat's recycling is preferred over Amroha, as Amroha's industry consists of shredding and garnetting infrastructure while Panipat has open-end spinning facilities as well. Due to the enhanced infrastructure, Panipat attracts high quality and high value waste and provides better recycler outputs. Panipat also has additional capacities to deal with polyester waste. Tirupur belt, on the other hand, recycles cotton rich waste. Cotton waste is transported from key manufacturing locations in Karnataka and Tamil Nadu, which are known for high production of textiles and garments made out of cotton due to increasing consumption of cotton in hot climatic conditions.

Most of the cutting waste generated in Gujarat, Maharashtra, Rajasthan and Madhya Pradesh is processed within the respective states by mediumto-small-scale recycling and downcycling players. Samana, in Punjab, is emerging as a new recycling hub processing locally produced cotton-rich fibre waste, cutting and mill waste (Fashion for good sorting for circularity: India, July 2022).



Fig 9: Textile wastes flow within India

#### 2.10.2 Punjab as recycling hub

Panipat has emerged as a major recycling hub dealing with both pre-consumer and imported waste. The region started working with wool waste in the 1980s, which is used by smaller recyclers or 'shoddy mills', as they are called in the industry, to make coarser recycled yarns. This was because virgin wool became unaffordable for the industry and the demand for recycled wool yarns increased. Over the years, Panipat has found various use cases for all types of materials and their blends, with an industry consisting of multiple units generating recycled yarns and garments for exports(Fashion for good sorting for circularity: India, July 2022).



#### Fig 10: Current recycling process

Sorting is performed manually by workers through touch and feel, based on specifications from recyclers on size, colour and composition of waste. Two to three levels of sorters and aggregators exist in the value chain and the role of the last level aggregator is not only to sort the waste but also to store the waste until adequate demand comes in.

However, due to the unorganised nature of the value chain, transparency and communication on availability and requirement of waste becomes challenging, leading to leakage or under-utilisation of waste(Fashion for good sorting for circularity: India, July 2022).

There is no problem in demand and supply of textile waste in India except the lack of communication between stakeholders in the value chain due to absence of common platforms and systems. For example, a recycler in Panipat today does not know how and where to get rayon waste from.



Founder of a waste collection and sorting startup, present in key apparel

Fig 11: Challenge in managing textile wates in India

#### 2.10.3 Value Chain

Value chain is the progression of process or activities adapted in the system in order to add value, here value is added to the wastes generated

#### 2.10.4 Overview of textile waste value chain in India

India has a well-integrated, albeit unorganised industry to deal with textile waste leading to informality and difficulties in traceability of waste



Fig 12: Textile value chain

#### 2.10.5 Pre- consumer wastes supply chain

Two parallel value chains exist for pre-consumer waste in India; fibre and yarn waste generated during spinning and mill processes travel through the fibre waste value chain, while the fabric waste generated during mill and apparel production travel through the cutting waste value chain(Fashion for good sorting for circularity: India, July 2022).











Fig 15: Cutting waste value chain

		Pro-consumer waste stream					
Category	Parameters	Fibre waste	Cuttin	g waste	Fabric Deadstock	Apparel Overproduc- tion	
		Recy	/cle		Reuse / Repair		
Waste Characterstics	Size	Not relevant	Smaller pieces with no reuse value move to recycle and downcycle	Bigger prices have wider use case and hence higher valued	Longer rolls of fabric have a higher utility	Not relevant	
	Colour and prints	Depends on the quality of raw fibre and is visually inspected while buying. In polyester, dope dyed fibres produce lower quality waste than whites.	Prints reduce the recyclability of materials. In colours as well, plain white and pastels are high valued	Solid colours and prints based on fashion trends have high reusability	Determined by the trends and market requirements	Determined by the trends and market requirements	
	Contamination rates*	Trash % is visually inspected and is dependent on the raw fibre and machinery	Higher contamination levels (soiled/ stained) are not suitable for recycling and get downcycled	Higher contamination levels (soiled/stained) are not suitable for reuse	Deadstock with stains might not be accepted	Apparel overproduction with stains is usually not easily acceptable.	
	Material composition	Not relevant	Cotton material has high recyclability into yarn and other industries as well	Not relevant	Not relevant	Not relevant	
	Fabric construction	Not relevant	Knits are easier to recycle. Garnetting of woven damages the fibre more, leading to low quality yarn	Not relevant	Not relevant	Not relevant	
	Condition of Clothing	Not relevant	Not relevant	Not relevant	If there are defects, the material is less acceptable	If there are defects, the material is less acceptable	

## 2.11 Factors affecting the value chain of pre- consumer waste

Table 1: factors determining use of pre- consumer waste

	Parameters	Pro-consumer waste stream				
Category		Fibre waste	Cuttin	g waste	Fabric Dead- stock	Apparel Overproduc- tion
		Recy	ycle	Reuse / Repair		
Characteristics of the virgin production process	Quality of machine	Newer and better quality machines have less damaged fibres as waste	Not relevant	Not relevant	Not relevant	Not relevant
	Strength and staple length of the fibre	Checked manually by stretching the fibres	Not relevant	Not relevant	Not relevant	Not relevant
	Stage of generation	Combing stage waste is considered best quality as the fibre is refined till that stage	Overlock waste generated at sewing stage is low value as it is mixed with thread	Not relevant	Not relevant	Not relevant
	Quality of the virgin yarn being produced	60s and 80s Ne count yarn usually give the best by- product/ waste	Not relevant	Not relevant	Not relevant	Not relevant
	Quality of fabric	Not relevant	Fineness of the original fabric determines the quality of recycled fabric	Not relevant	Not relevant	Not relevant
External factors	Fashion trends	Not relevant	Not relevant	Not relevant	Determine the acceptability for reuse	Determine the acceptability for reuse

 Table 2: factors determining use of pre- consumer waste(cont.)
 Image: consumer waste(cont.)

## 3 Methodology

## 3.1. Secondary Research

Review of literature holds the understanding apparel wastes, its types and current scenario and statistics related. First gone through the theoretical study of different steps carried out in the manufacturing unit, wastes generated through each process and nature of them. The study attempts to understand and analyse different types of apparel wastes, properties and current collection and disposal methodologies. The secondary research is carried out on the basis of thorough go through of reading materials from different sources mainly academic literature, research articles, research journals, reports by research bodies and government bodies and Master's and doctoral thesis and dissertations.

## 3.2. Primary Research

### Non participatory observation:

The main objective of the observation is to understand apparel production process and apparel waste generated in each step.

### Qualitative research:

The aim of this part of research is to understand apparel waste flow in the SM Apparels and this part is carried out through informal discussions. The flow of the primary research is aimed to understand:

- 1. Types of wastes generated and its composition
- 2. Fabric nature of the waste, fibre content and lycra content
- 3. Waste packaging Techniques
- 4. Current waste management strategies
- 5. How much is recycled and how that is collected
- 6. The attitude and awareness towards sustainability
- 7. Scope of upcycling to enter into this process

## **4** Research Findings

# **1.** To understand the different stages of apparel manufacturing and analyse the different wastes emitted by apparel industries during the manufacturing

Field visit

- Understand the theoretical process of manufacturing with the help of secondary research
- Visit to the SM Apparels industry to understand real time process
- Study the ratio of production to the wastage in SM Apparels

# 2. To trace the virgin fabric wastage generated during manufacturing and to determine the scope for reutilising them within circular economy.

- Analyse the nature of the waste generated from each process and find which process generate maximum amount of waste
- Study the flow of the waste in SM Apparels
- Find how much of these production waste just dumped as junk

## **5** Analysis

## 5.1 Manufacturing process followed I SM Apparels

#### 5.1.1. Raw materials section

In SM Apparels, the cotton yarns are bought from Sky Cotex India Pvt Ltd. Then they send the yarns for knitting to their partnered knitting unit as per the buyer requirements. Again, the knitted fabrics are sent for dyeing in accordance to the buyer specifications.



Fig 16





Fig 16: yarn stored in the store house; fig 17: yarn specification; fig 18: fabric stored in store house

This also has its other small sub cabinet kind of area where accessories like buttons, zip, needles, elastics and other accessories are stored

#### 5.1.2. Sampling Section

According to the buyer requirement, Design and pattern are compiled through CAD, then cutting and sewing are done to finish the samples. Then they are sent to the buyers for the approval. Generally, the quality of samples would be bit higher than the rest The set of threads, needles, accessories and everything are separate for sample preparation



Fig 19



fig 20

## 5.1.3. Cutting Techniques

Here, they follow two kinds of cutting, Sem-i automatic and manual cutting. The fabrics are marked and cut as per the pattern designed with respect to the buyer requirement. To avoid confusions, after cutting group of women paste temporary sticker in each piece, which is removed after sewing.



Fig 21



fig 22



fig 23

fig 21: manual cutting machine; fig 22: semi- automatic cutting machine; fig 23: temporary stickers pasted to prevent confusions in matching the pieces

#### 5.1.4. Printing Section

An empty screen and a film with the required design is selected and the design is exposed to the screen. The entire printing process consume one and half to two hours. After the fabric fed to the machine, it applies a gel kind of substance on the fabric, then dyed and then fabric is exposed to heat for drying. After printing, the fabrics are sent for curing. It's done to long- last the life of print ad its done under 180 degree Celsius.





Fig 24 Fig 24 & 25: printing section

fig 25

#### 5.1.5. Sewing Section

In SM apparels, 4 section of sewing is available. Attaching the cut pieces, overlocking and checking is done here.



Fig 26

Fig 26 & 27: Sewing section



fig 27

#### 5.1.6. Finishing Section

If the cloth has any strain, its cleaned here using a special chemical. Then finally they are ironed



fig 28



Fig 31



fig 29



fig 32



fig 30



fig33

*Fig 28: tagging; fig 29: metal detector; fig 30: oil cleaner; fig 31: cleaning area; fig 32:* ironing section; fig 33: tagging section

#### 5.2 Waste generation

The wastes generated during this process are mainly:

i. Cutting wastes

- ii. Sewing Wastes
- iii. Finishing wastes
- iv. Excess fabrics of apparel and other

#### 5.2.1 Cutting Waste

The cutting section is the main section to produce wastage in a clothing factory. Due to several roles and marker utilization, a huge number of wastages produce in the cutting section. After cutting all the body parts are inspected and then shorted and bundled. For this reason, some faulty pieces may remain in this section as wastage.



Fig 34 Fig 34, 35 & 36: cutting wastes



fig 35



fig 36

#### 5.2.2 Sewing and Printing Waste

In the sewing section, if a worker finds any faulty piece, he rejects it. Due to this reason wastage is generated in the sewing section. Excluding this, overlocking wastes, excess threads, broken needles, some accessories like damaged buttons, zip, excess elastics are also added in this section of wastage. But here, in SM apparels, broken needles are submitted in the accessories store house in the exchange of new needles. This is followed to prevent human hazards. In the printing section, if any print doesn't match the standard, the garment piece will be a waste.



Fig 37: sewing waste

#### 5.2.3 Finishing Waste

The finishing is the waste is very minimal. This includes excess and damaged labels, tags, etc.

## 5.3 Primary Data Analysis

The targeted profile was SM Apparels which is a large sized company with over **1500** employees.

Results of the research confirmed that **Cutting wastes** are the main apparel waste generated with the composition of 91.1% with just 8.9% of sewing and finishing waste.

The materials employed were further analysed according to the type of fabrics, fibre content and presence of lycra. In general, the analysis showed that the waste stream consisted principally of knitted fabrics, predominately cotton and cotton blends, with the presence of lycra.

Considering their present waste management system, 17% of there get a chance to stay I the life cycle either through down- cycling or recycling techniques. The fabric type, fibre content and presence of lycra determine the procedures for the further treatment of apparel waste recycling.

It also found that at present, most of the recycling units existing in Thirupur prefer mechanical way of recycling. Mechanical method is preferred by all recycling units due to their cost efficiency. (Other two methods of recycling are chemical and thermic)

Here SM Apparels, as it's a complete T Shirt manufacturer, the unit uses only woven fabrics.

The type of material used according to the fibre content is analysed. Pure cotton and cotton blends are the core raw materials. And in the case of lycra content, it varies from 2% to 30%. It varies with respect to the specifications of buyer. And respectively fibre content varies from 98% to 70%.

Then the waste is classified on the basis of the process where it generated: Cutting waste, sewing wastes and others. These others include excess labels, tags, damaged accessories, etc. And then their respective composition was analysed. The maximum contributing waste is of cutting waste. On an average, 8500 kgs of cutting waste is produced per week, then comes the sewing waste with the average contribution of 550kgs per week, then lastly other wastes with an average 250 kgs per week. So,

nearly 91% of pre- consumer apparel industry waste is from cutting waste, then 6% of sewing waste and 2.9% of other wastes.

Furthermore, the methods of apparel waste management within the company was analysed, including methods of packing the waste, the presence of impurities, waste disposal practices and costs. The wastes are usually dumped and packed in plastic polythene bags. They follow this because this remain to be most easy way. Though bailing is the most sustainable and preferred method of experts, packing in plastic bags make them more dust resistant. But the sad part is, these bags are just used once, they are not reused.

Apparel wastes which are packed to send them for recycling are usually clean but sometimes, un- noticeable small materials like cardboard pieces, buttons get into them. Dominant non-textile impurities were cardboard and paper – 16.28%, as well as buttons and reels - 16.28%. With 9.3% of companies, mixed impurities - cardboards, metal parts, buttons, and reels were present in the waste.

#### 5.3.1 Flow of waste in SM Apparels

Then finally current waste management strategies were analysed. So, in SM Apparels, 17 % of their waste is recycled. These wastes are packed in plastic bags. There are mediators who come and collect them once in every week. These wastes are distributed to the local households most commonly women. These women segregate these wastes on the basis of colour and also prints. These people are paid Rs. 15 per kg for this segregation. Then these segregated wastes are again collected by the same mediators and sold to the local recycling units. Most of the recycling units in Thirupur follow mechanical way of recycling. Here, the fabrics are finely grinded till they reach the consistency of fibre, and the cycle continues.

The others are mostly collected by Municipal solid Waste and subsequently disposed of in landfills, where it was combusted. In some cases, mainly with excess accessories, labels and tags, they are stored to poke them into the Life Cycle. But in some case, where the buyer specifies the accessories or he labels shouldn't be reused for any other produce, they are burnt by the company itself.

## 6 System Design

To develop more ethical, circular and transparent system/ model to convert fabric virgin wastes or pre consumer wastes into utilitarian product.

## 6.1 Journey map of apparel waste in SM Apparels



Infographics 4: flow of apparel waste in SM Apparels

## 6.2 Journey map analysis

Main components of wastes end up in combustion



Infographics 5: components of pre- consumer apparel waste

But challenges to upcycle these wastes are:



inconsistency of the waste





Too much diversity in the waste



Uncertain probability of audience welcoming this

Difficulty in getting skilled people who can give life to these wastes

Infographics 6: challenges faced

## 6.3 Mapping of existing model



#### Infographics 7: existing model

The **FOCUS AREAS** are converged into the wastes that end up in landfills and combustion, awareness of the problem with manufacturer and keeping the wastes accountable, traceable and increase positive impact with profitable solution.

## 6.4 Main streaming circular economy

In last five years, government has made considerable effort in scaling out solution for the incredible waste disposed by Thirupur apparel industries. Though people in SM Apparels are not much aware of sustainability, they are still concerned about wastes up to some extent.

This learning and experience now bring the confidence to bring new approach from being a niche player into the mainstream.

The new approach would be inspired by circular economy where nature, people and technology will work together. In circular economy, all materials in the end are puled back into the system by giving utility. So, resource recovery will play a vital role in circular economy.

Apparel waste management as an area is increasingly gaining attraction and focus at a global level on how to systematically move towards sustainable value chains, India, being a country with a vibrant informal economy around repurposing and redirecting apparel waste to some degree, Circular Textiles project can be efficiently implemented.

## 6.5 Solutions and Model

- A platform that can connect apparel waste generators/ apparel manufacturing units with entities that have a complete infra and man- power to upcycle the apparel waste
- 2. Waste from manufacturing units used as resource or raw materials for conversion to second life or zero waste products by the partnered upcyclers that can be retailed directly
- 3. The wastes can be conducted from the manufacturing units, and a workshop can be organised. Interested tailors/ artisans/ anyone with interest in crafts can participate the 1 month workshop conducted where a pile of waste is given as open source for the participants.

The participants can select the pieces they want for their work.

There are many things that can be made from these fabrics and accessories like dolls, key chain, accessories, home decors, tec.,

At the end of participant can display their work in stalls and sell the same.

The price of the products can be decided through discussion of facilitators and the person, who made it. The price should decided in such a way, where either 1% or 2% profit is shared by facilitators.

#### 6.5.1 Waste generation segregation and possible management ideation

**Segregation:** This would be done on the basis of size, colour, shape and material type of the fabric. Here colour and material type sorting are done just for grouping. This has no role to affect the upcycling system. But shape of the fabric and the size can directly affect and influence the new upcycling approach.



Infographics 8: process and end product of segragation

#### Different techniques of attaching

- Kantha
- Patchwork
- Crochet
- Pintucks
- Hand tucks
- Layer stitch
- Pleating
- Table top
- Weaving
- Selvedge
- Weaving

#### Kantha

Kantha is a centuries-old tradition of stitching patchwork cloth from rags, which evolved from the thrift of rural women in the Bengali region of the subcontinent - today the eastern Indian states of West Bengal and Orissa, and Bangladesh.



Fig 38: kantha

#### Patchwork

Patchwork is a technique of sewing small pieces of shaped fabrics, of mixed patterns, colours and texture, all together to create larger geometric designs.



Fig 39: Patchwork

#### Crochet

Crochet is a process of creating fabric from yarn or thread. The word is derived from the Middle French word croc or crochet, meaning hook. Crocheting, similar to knitting, consists of pulling loops of yarn through other loops.



Fig 40: Crochet

#### Pintucks

Pintucks are added to the fabric to give a texture to the fabric by adding it in different ways. They are often used in multiple rows and at different widths to create different directional effects. It is created by folding 1-2mm and sewing the fabric from the edges.



Fig 41: pintuck



fig 42: handtuck

#### Layer- Stitch- Slash

Slashing is a process that involves layering up fabric, stitching usually in parallel channels and then cutting through to the base layer. This can then be brushed to fray it, exposing the layers below and producing velvet



fig43: layer stitch

like texture.

#### Pleating

Pleats are a fold or doubling of fabric that is pressed, ironed or creased into place. (Pleats that are sewn into place are called tucks). There are many varieties, but the side and box pleat are the most common, although they can be accordion, cartridge, circular, curtain, draped, fluted, Fortuny or French.



Fig 47: pleating

#### **Table- top Weaving**





#### Slevedge weaving

sel·vage 'sel-vij. variants or selvedge. Synonyms of selvage. : the edge on either side of a woven or flatknitted fabric so finished as to prevent raveling. specifically : a narrow border often of different or heavier threads than the fabric and sometimes in a different weave.



Fig 49: sleavedge

#### 6.5.2 Product Development Guide

A creative catalogue can be given for the artisans as a helping guide to enhance their creativity in making these products. Also allowing them to come up with products according to what are already working into and implementing apparel waste into it.

## 7 Conclusion

Apparel waste management as an area is increasingly gaining attraction and focus at a global level on how to systematically move towards sustainable value chains. In India, with a vibrant informal economy around repurposing and redirecting apparel waste to some degree, this Circular Textiles project needs to effectively work towards management of apparel waste on a holistic level, traceable and transparent reports presented to industries and consumers.

Thus, ideally system design is proposed to be started in Thirupur to manage apparel waste, pre- consumer waste to close the loop with sustainable value chains.

To conclude, the dissertation helped to understand current scenario of apparel waste in Thirupur, and identify the gap in the system for the apparel waste management and with help of SM Apparels, understanding the possibility of creating a platform where waste from industry is source of income for communities. Use of waste as available resources to create something new, without losing the essence of the material.

## 7.1 Future research Scope

- Proper route of pre- consumer apparel wastes in India, should be traced and documented, which will spread the knowledge about the concepts like apparel recycling and upcycling, circular economy and why is it important.
- In India philanthropic study about the prevailing and motivating factors among the Indian populations is important to know their attitude towards environmentalism, as well as and products from recycling and upcycling of waste.
- Collection of some facts and valuable data regarding wastes generated by different production setups especially unorganised sector like roadside tailors and other small production houses is very important to trace the lifecycle of apparel waste in that sector.
- Various experiments with the pre- consumer wastes, there upcycling and recycling is very challenging way to help circular recycling and to overcome the problem of apparel wastes.

#### Thoughts of people:

"This is a good idea. If this gets successful in implementation, then we can really prevent lot of fabrics those are wasted. And I think this would be welcomed by audience also"

Miss. Mayuri, tailor

"Sounds workable. As designer, this would be a good opportunity to minimise textile industry waste and also make appaels as better sustainable one"

Madhumisha, Fashion Designer

" The way of ideation is nice. I think the point where we miss sustainability in fashion is affordability. There is standard image that sustainable fashion goods are often expensive. This is the place where we unconsciously support fast fashion. If this idea implemented and break this image, that would be a good achievement towards sustainability. For sure I will support such product.

Debarati, Beauty and skin care social media infkuencer

## Appendix

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