Reuse-based Reverse Value Chain for Sustainable Apparel Industry

Doctoral thesis submitted by

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Abstract

Reverse value chain is a concept which maximizes utility of a product; before and after end-of-product life cycle. Its main components are reuse, repair, up-cycling and down-cycling. This thesis has investigated the business of apparel 'reuse' to develop a reuse-based reverse value chain model for the apparel industry. The research began by understanding the existing theory of reverse value chain. The theory includes literature review of value chain from the apparel industry as well as from other industries. A conceptual framework has been developed by considering processes of reverse value chain such as collection, sorting and reprocessing. Business system, product price, product design, product reuse information, government legislation, and consumer environmental attitude have been figured out important factors influencing reuse-based reverse value chain of apparel.

Consequently, the thesis has undertaken mix method (qualitative and quantitative) approach to study reuse-based reverse value chain. Exploratory method based on multiple case study has adopted to explore the current sustainable practice of apparel reuse. Organization were visited and unstructured interviews were conducted with founder and senior managers. The results have been utilized to develop a model from current practice of collection, sorting, and reprocessing. Qualitative findings and model were further strengthening by mathematical model formulation. Analytical hierarchy process, Genetic algorithm and Markov principle have been used for the analysis of reuse-based reverse value chain. The thesis has been concluded by theoretical contribution, implications and ways to improve the proposed model along with providing scope for future research.

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Abbreviation Used

CLSC: Closed loop supply chain

EOL: End of life

SEZ: Special economic zone

KSEZ: Kandla special economic zone

EOU: Export oriented unit

MCDM: Multi criteria decision making

AHP: Analytical hierarchy process

Kg: Kilogram

SEK: Swedish Kronor

NOK: Norwegian Kronor

RON: Romanian Leu

INR: Indian Rupees

1 Chapter: Introduction to the Research

The aim of this chapter is to provide a background for this research which is on reuse based reverse value chain for the sustainable apparel industry. The chapter starts with a brief on natural resource depletion and environmental degradation to provide a background to the study. Then the chapter builds on the gap from the existing literature in the area of the reverse value chain to briefly describe the objectives of the research. Next, the chapter describes the scope of the research. Finally, it concludes with an outline of the thesis with a brief description of each of the remaining chapters.

1.1 Background

Natural resources can be considered as the most precious gift of nature that is acting as a foundation for the survival of the living beings (Rosenberg 1973). It is important to note that with a rapid increase in population, economic development and consumption, the degradation of these resources is faster than the cycle of recovery or generation of natural resources (Brander 2007). The natural resource base is further shrinking with the invention of new technologies that explore and exploit the untapped quantities of natural resources (Brander 2007; Rosenberg 1973). Non-renewable resources such as oil, coal, metals and minerals are diminishing at a faster rate and are expected to become scarce for the future generations (Bell, Mollenkopf, and Stolze 2013a). An estimated global consumption of textile based product such as apparel is more than 99 million tons (Paras, Pal, and Ekwall 2017). Per capita of textile consumption and disposal of an American is 31 kg while for the United Kingdom it is 30 kg (Chen and Burns 2006; Bruce, Daly, and Towers 2004). The average per capita textile and clothing consumption in Nordic countries is 16 kg (Tojo et al. 2012). Apparel manufacturing process involves the use of huge amount of chemicals, water and energy (Triantafyllou and Cherrett 2010). Fashion industry

(apparel and footwear) consume nearly 10% of global energy and in terms of volume, it is second largest industry after the food industry (Kuo et al. 2014). On an average, 1 kg of clothing production requires 400 litres of water, 4 kg of chemicals, 400 MJ of energy and 13 m^2 of agriculture land. Nature needs a long time to regenerate these natural resources (Pal 2014). In the given situation, available natural resources cannot able to meet the clothing requirements of the present (7 million people) as well as growing population in future (Bell, Mollenkopf, and Stolze 2013a).

Fashion, food, drink, transport and other household wastes collectively contribute to 70%-80% of global environmental pollution (Farrant, Olsen, and Wangel 2010). The apparel and textile industry has a second highest negative impact on the environment after the oil industry (Diabat, Kannan, and Mathiyazhagan 2014). Every year million tons of textile are consumed and discarded (Paras, Pal, and Ekwall 2017). Majority of these clothes are either incinerated or exported to the developing economies particularly in the absence of proper channel to bring back to consumption cycle (Naoko Tojo et al. 2012; BÜYÜKaslan 2015). This creates a huge amount of environmental pollution and degradation to the natural resource base (Hart et al. 2010). Waste incineration and landfill emit various kinds of harmful gases which results in pollution and pose serious threats to the environment and human health (Fletcher and Grose 2012). Hence, there was a need to study the mechanisms of apparel reverse value chain to minimize the environmental burden (Prothero and Chapman 2011). It has been identified that reuse of apparel may significantly contribute to reducing the environmental burden (Farrant, Olsen & Wangel ; 2010). The total energy extraction associated with the collection, sorting, baling, selling and distribution of disposed of garments is 2.6% (cotton) and 1.8% (polyester) as compared to the energy required to manufacture them from fresh materials (Woolridge, Ward, Phillips, Michael,

Simon Gandy; 2006). Given the magnitude of the harmful impacts of apparel consumption and disposal, it is important to understand the nuances of the current practices in the apparel reuse that can contribute to the theoretical knowledge as well as assist in improving the current business practices.

1.2 Research Motivation

The basic motivation to undertake this research was the concern for the environment, its protection and resource conservation for future generations. The apprehension regarding the depletion of natural resources and environmental degradation is quite apparent among scholars and practitioners (e.g.,Besiou, Georgiadis, and Van Wassenhove 2012; Ozkir and Basligil 2012; Bell, Mollenkopf, and Stolze 2013a). Charity and social organizations are also working to increase the life span of the product. Hence, it became an important point of enquiry as evident in the academic literature across several domains. To illustrate, in the last few years, there are plethora of research papers on the reverse logistics (e.g.,Jack, Powers, and Skinner 2010; Bernon, Rossi, and Cullen 2011; Rogers, Melamed, and Lembke 2012) and closed-loop supply chain management (e.g.,Kannan, Haq, and Devika 2009; Huang et al. 2013). In addition, resource and environment conservation practices such as sustainability (e.g.,Defee, Esper, and Mollenkopf 2009; Goworek 2011), recycling (e.g.,Huang et al. 2013; Ruiz-Torres, Ablanedo-Rosas, and Mukhopadhyay 2013) and reuse (e.g.,Domina and Koch 1999; Besiou, Georgiadis, and Van Wassenhove 2012) also got attention from the researchers. Interestingly, the studies so far have focused on the consumer related aspects of sustainability, recycling and reuse (e.g.,Shulman, Coughlan, and Savaskan 2010; Bianchi and Birtwistle 2012). However, these works fail to address the challenges and opportunities faced by other stakeholders of the reverse value chain (Bianchi and Birtwistle 2012). Therefore, current research makes use of reverse

value chain literature to study the apparel reuse. Until now, there have been no empirical studies undertaken to study the business of reuse in the context of apparel reverse value chain and a few studies conducted on recycling and consumer disposable behaviours. Moreover, the reverse value chain is still an immature area of research for the apparel industry. Thus the motivation for current research lies on researcher's genuine intention to contribute towards the growth of reverse value chain for the apparel industry.

1.3 Research Gap and Problem

Reverse logistics or closed loop value chain has recently become an important field of examination amongst researchers (Ruiz-Torres, Ablanedo-Rosas, and Mukhopadhyay 2013; Hawley 2006; Qiang et al. 2013). These concepts have been widely studied across several industries. The automobile industry was the prominent one among all in terms of research focus (Schultmann, Zumkeller, and Rentz 2006; Paksoy, Bektas, and Ozceylan 2011; Tomasic, Dukic, and Safran 2013; Wang et al. 2013). Several studies were conducted in the electronic industry context (Kumar and Putnam 2008; Ozkir and Basligil 2012; Lehr, Thun, and Milling 2013). The other prominent industries which were captured by earlier researchers include food, computer and aviation industry. These scholarly works were mainly concentrated on the optimization. A few studies theoretically discussed reverse logistics or closed loop in the textile and clothing industry (Ekstrom and Salomonson 2014b; Alkazam 2013; Brooks 2013). These studies elaborated on the practices of reverse logistics in the textile and clothing demonstrating practices with the help of some case studies. No study so far has attempted to develop a closed loop value chain model for the textile and clothing industry, albeit its significance (Abraham 2011; Ruiz-Torres, Ablanedo-Rosas, and Mukhopadhyay 2013).

Lately, *reuse* has gained unprecedented consideration from the academicians. However, relatively, this is a new phenomenon as a practice in the textile and clothing industry (Eriksson-Zetterquist 2009). Therefore, the findings of this endeavour are expected to provide novel and interesting insights for academicians as well as practitioners. To provide a multicultural perspective, different case studies have been undertaken across different locations (Mills 1959). The extant literature revealed that several researchers discussed reverse logistics in textile and clothing industry. However, limited attempts have been undertaken to explore the phenomenon of reuse in textile and clothing industry. Further, several researchers have theoretically argued that there is a need to develop a reverse value chain model for the textile and clothing industry (Abraham 2011, Ruiz-Torres, Ablanedo-Rosas et al. 2013). The literature review in this thesis suggests that there is a gap in understanding of the process of reuse to optimize value recovery in the reuse-based reverse value chain. The motivation together with research gap determines aim and objectives of the current research.

1.4 Research Aim and Objectives

Based on the aforementioned research gap, the present study is envisaged to propose relevant ways to reuse discarded and used products by studying the reuse phenomenon in the apparel industry. The focus of the thesis is to conceptualize and analyse the practices of apparel formal reuse at the industrial level. Precisely, the aim of the research is to develop a reuse-based reverse value chain model for the apparel industry. To attend to the aim of this research, three objectives were formulated as follows:

Objective I: *To develop a theoretical framework for the reuse-based reverse value chain for the apparel industry.*

Objective II: *To empirically investigate the business of used apparel in the different charities and organizations.*

Objective III: *To apply mathematical tools and techniques to analyze reverse value chain model of the apparel industry.*

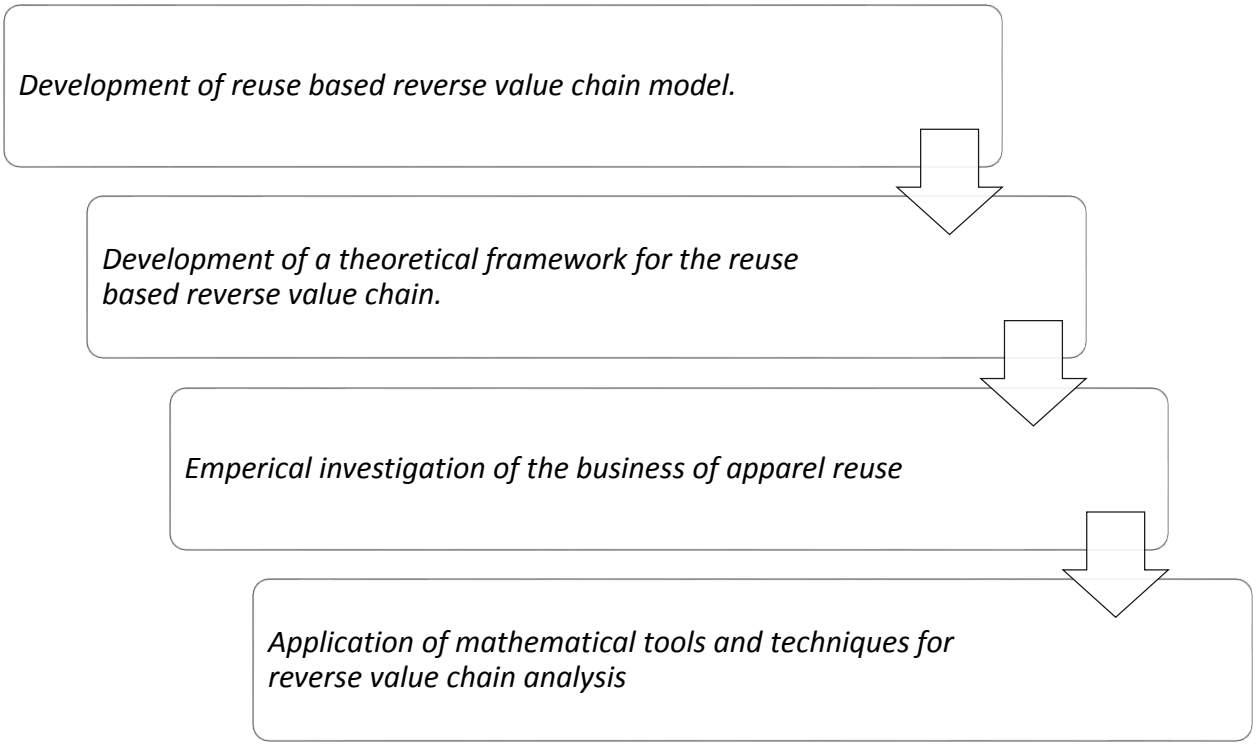

Figure 1-1: Research aim and objective

1.5 Research Relevance

The relevance of this research can be comprehended in terms of theoretical, practical and societal implications. The existing literature highlighted the need for strengthening the knowledge base of reuse-based reverse value chain specifically in the clothing industry context. The research is drawn from two separate research domains i.e., waste management and supply chain management. The resource conservation lens of environment management contributed to the novel contribution in the area of supply chain management. The work also aims to bridge the gap

between the practice and the academic knowledge. Consequently, the findings of this study will help practitioners to design closed loop value chain model to maximize their return. It will enrich practitioners understanding of their processes and the factors influencing their current practices. Hence, the managers will be able to monitor and control the processes accordingly. The consumers will also get attracted towards closed loop value chain and contribute significantly to the success of it. The insights from this research will provide guidelines to the policy makers and thus, will have a societal impact. This will also help in attracting and engaging more people in reverse supply chain processes and thus, creates livelihood opportunities for them.

1.6 Research Scope

One of the important delimitations of this research is the field in which the research will likely to contribute. Supply chain management and waste management have motivated the current research. The research has explored and employed different techniques of waste management to provide the best solution to manage reverse value chain. It is evident that the use of waste management techniques is the key part of understanding supply chain management but no contribution in the field of waste management is used to motivate the study. The scope of research is factors, process and design of reverse supply chain. Reuse in the reverse value chain of the textile industry is particularly appealing for current research.

1.7 Thesis Structure

This thesis is divided into seven chapters. Chapter 1 will focus on the formulation of research and presents research objectives and sub-objectives. Chapter 2 will cover a detailed literature review on reverse value chain to identify different process and factors influencing it. Chapter 3 will elaborate on the methodology used for this research. Chapter 4 has three subchapters on

different case studies undertaken in this work to understand the best practices in the industry. Next, in Chapter 5, mathematical modelling will be used to the model the reverse value chain for apparel. Chapter 6 will provide a detailed discussion regarding the findings to provide insights and to provide a reverse value chain model that underpins the theoretical and empirical knowledge. Chapter 7 will finally present conclusion by summarizing the overall contribution of the research. Figure 1-2 depicts the outline of the thesis.

Table 1-1: Thesis Structure

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2 Chapter: State of the Art Literature Review to Develop Conceptual Framework

This chapter provides an understanding of reverse value chain for the apparel industry on the basis of content analysis of available literature. First, the concept pertaining to value and reverse supply chain is investigated, irrespective of the industry. Secondly, the literature with a focus on reverse value chain in the apparel industry is explored. Following the detailed review of the literature, a conceptual framework has been developed for reuse-based reverse value chain for the apparel industry.

2.1 The concept of value

The concept of value is perceived as use or exchange worth derived from a product or process (Pal 2017). Use-value is understood as consumer assessments for a product or process usefulness, whereas exchange-value is the amount of money a consumer would like to spend to receive particular service or product (Lepak, Smith, and Taylor 2007). The economic implication of creation of a product or service and consumer willingness to pay for it is considered as value for an organization (Porter 1985). The customer use value is translated into monetary benefits to discuss in comparison to exchange value. An exchange could happen successfully only if the sum of all use value will be higher than transaction cost or exchange value (Lepak, Smith, and Taylor 2007). Klassen (2009) has discussed that value concept is not limited to economic value as triple bottom line acknowledges the existence of social and environmental value. (Schenkel et al. 2015) has identified multiple tangible and intangible values apart from an economic value such as environmental value, customer value and information value. Environmental value includes minimization of raw material use, reduction of waste and prevention of environmental degradation to achieve the green image. Customer satisfaction or loyalty termed as customer value, whereas information value intended to improve the product and process design.

2.1.1 Value creation and value chain

Resources and process of organizations are combined together to create value. The created value could be in the form of product or service (Cova, Dalli, and Zwick 2011). The organization with limited resources involved in value creation process to gain a competitive advantage over the competitors (Jayaraman and Luo 2007). Value creation could be internal as well as external. The organization can interact or collaborate with other organizations to combine resources or process to jointly create value (Cova, Dalli, and Zwick 2011). A value chain is series of value creation steps involve resource input, process and product/service (created value) to the next level in the chain. Every step add a certain amount of value and increase the overall worth of product and service (Jaligot et al. 2016). Kaplinsky and Morris (2001) defined a value chain as "the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use". The set of physical and technological activities are performed to create value for customers. Porter (1985) defined these activities into nine generic categories under the headings of primary and secondary activities. Primary activities are involved in product creation, sales and aftersales service as below:

Inbound logistics: It consists of sourcing of raw material or inputs for the production. The activities associated with inbound logistics are material handling, warehousing, inventory control, transportation, and return to supplier.

Operations: It consists of conversion of inputs or raw materials to final products with the help of activities such as manufacturing, assembly, finishing, packaging, testing and equipment maintenance.

Outbound logistics: It consists of the distribution of finished products to the buyer. This consists of handlings, warehousing, delivery, and scheduling of finished products.

Marketing and sales: It is processed to introduce product and service to buyer and provides means to purchase the products. This is done through the process of advertising, promotion, quotations and pricing.

Service: It is an activity to maintain or enhance the value of the existing products through installation, repair, training, parts supply and product adjustment.

Support activities assist each primary activity by providing infrastructure, human resource, technology and procurement supports. Support activities are as follows:

Procurement: It refers to purchasing of raw materials, machinery and office material used in value creation process in the organizations.

Technological development: It is a range of activities performed to advance the existing process to create improved product or service.

Human resource management: It involves recruitment, training, development and compensation of manpower involved directly or directly in the firm value creation.

Firm infrastructure: It consists of activities such as general management, planning, accounts, finance, legal and quality management.

These activities are performed to conceptualize, design, manufacture, distribute, sales and support product or service to the consumer.

2.1.2 Value recovery and reverse value chain

Value recovery is process to maximize the return from the discarded, scrap, surplus, obsolete and waste material by utilizing residual value and minimizing the cost associated with the reverse logistics (Tibben-Lembke 2002). Value recovery process is complex, time consuming and costly, therefore most of the organizations focus on cost and ignore the recoverable value (Kumar and Malegeant 2006). The value recovered in reverse value chain must be higher than cost incurred in recovery process. The financial benefits is an important condition in the recovery process but not necessary conditions (Guide and Van Wassenhove 2009). Value recovery is perceived as benefits created or extracted through various multiple reverse logistic steps internally and externally with the help of other members of reverse value chain (Jayaraman and Luo 2007). Value created through reverse logistics are much beyond the economic benefits for wider range for external stakeholders (Lepak, Smith, and Taylor 2007). Environmental and social value could also be created in reverse value chain for wider network. Environment is an important stakeholder towards which organization is trying to create ecological value (Davis and Kay 2013). Value recovery from a product in the reverse value chain is a hierarchy process. Differential amount of value could be recovered depend upon the condition or quality of product (Ellram 1996). The value recovery can be done through the process such as reduce, reuse, repair, redesign, recycle and incineration. 'Reduce' is the way of minimizing the consumption of materials and energy used during various processes of manufacturing. 'Reuse' is the way of extending the lifespan by bringing product under new reuse cycle after end of use (Wang and Hsu 2010). This can be aided using processes like repair and redesign. 'Repair' could be considered as reinstating functional value while 'redesign' could be treated as the process of improving the functional or visual appeal (Dervojeda, Verzijl, and Rouwmaat 2014).

‘Remanufacturing’ conceptualized as an industrial process in which products are reshaped to give them a new look by refurbishing (Guide, Jayaraman, and Linton 2003). ‘Recycling’ is processing of product for material extraction for its physical properties. Hence there are different ways to recuperate values from end of life or end of use of a product (Naoko Tojo 2012). Different type of value recovery processes are discussed in details as below:

Reuse: It is process of using recovered product for the same purpose for which it was originally designed (Rahman and Subramanian 2012). Maximum amount of value can be recovered in the reuse process (Gobbi 2011) as product is available for use without any cost and with almost same value as new (Fleischmann et al. 2004). The possible way of reuse is informal exchange or swapping between friend or family or formal trade such as secondhand sales or donations (Tibben-Lembke 2002).

Remanufacturing: It is a process of breaking down products into parts (Rahman and Subramanian 2012). The recovered spare parts can be input for the production (Fleischmann et al. 2004). The quality of remanufactured products is similar to new products and offered at the same price and in the same market (Gobbi 2011). The other recoverable options such as reconditioning, refurbishing repair, and upgrade are closely related to remanufacturing and used interchangeably in the management literature (Vlajic, Mijailovic, and Bogdanova 2018). These recoverable options are slightly different from each other in terms of processing and the final product (Thierry et al. 1995).

Recycle: It is a process of collection, categorization, and processing of products for material recovery (Gobbi 2011). Product lost its original functionality in the recycling process and it is low-value process (Thierry et al. 1995). Recycling is only profitable for precious material

(Fleischmann et al. 2004). Segregation of material is complex and in absence of mixed or blended material the recycling yield inferior quality of material (Alkazam 2013). There is also a huge cost associated with the recycling process therefore recycling is not feasible option in high wage countries (Carlsson et al. 2015). Recycling at international scale requires transportation that is also unsustainable and costly (Dervojeda, Verzijl, and Rouwmaat 2014).

Incineration: The last recoverable option is incineration to generate heat or energy from non-recoverable products (Ellram 1996). This is last recoverable option as the product or its material cannot enter to use cycle (Paras, Pal, and Ekwall 2017).

Disposal to landfill is not advisable as this doesn't provide any recoverable components (Vlajic, Mijailovic, and Bogdanova 2018). Landfill process also emits a lot of harmful and poisonous gases in our environment (Paras, Pal, and Ekwall 2017).

2.2 Supply chain

Supply chain comprises a chain of different partners which performs the functions like material procurement, production, distribution and many more. This network exists in manufacturing as well as in service organizations (Handfield and Nichols 1999). The value chain can be conceptualized as a chain of activities via which a product passes through conception stage to the disposal stage (Kaplinsky and Morris 2001). Earlier, the focus was given on a unidirectional flow of material across the supply chain but gradually the focus has been shifted to bi-directional flow. Due to enhanced complexity, there is a need to do efficient recovery at each stage. This is mainly based on the principles of optimization and cost minimization(Yang et al. 2013). Various efforts have been made in order to bring back the disposed-off product by closing the loop of forward chain. This can be done with the help of different reverse chain activities i.e. reuse, refurbishing, repair, remanufacturing, recycling or redesign (Jayaraman and Luo 2007). A value

chain in which downstream and upstream activities are combined is called closed loop value chain. Gradually, closed loop value chain has developed as an independent research subject (Paksoy, Bektas, and Ozceylan 2011). Many government and non-government organizations have also extended their support and contributing significantly to maintaining closed loop supply chain operations to save natural resources for future generations (Dururu et al. 2015).

The natural resource depletion and environmental degradation can be controlled by avoiding the entry of virgin (new) raw materials (Kuo et al. 2014; Chen and Burns 2006). The concept of closed loop value chain is based on the principle of 3R (i.e. reduce, reuse and recycle) or 6R (reduce, reuse, recycle, recover, redesign and remanufacturing) (Wang and Hsu 2010; Govindan, Soleimani, and Kannan 2015). This helps in controlling the entry of new materials in the value chain (Ji 2007).

2.2.1 Reverse supply chain

Fleischmann et al. (2000) identified main difference between traditional and reverse supply chain. Traditional supply is endogenous factors, so the quality, quantity and timing can be controlled according to capacity and demand from the customer. While reverse supply is exogenous factors, highly unpredictable and influenced by the high level of uncertainty. Nature of reverse supply chain is also uncertain as recovery of the returned product is not triggered by market demand. Furthermore, the volume of reverse supply is low through a large number of supply point. Fleischmann (2001) has highlighted the characteristics of recovery network in reverse supply chain i.e. coordination (between disposer and reuse market), supply uncertainty and disposition activities. Coordination is required between disposer market (the place where the used product is released by the user) and reuse market (the place where the demand for used

product occurred). But the availability of used product is hard to achieve in the reuse market due to supply uncertainty in the recovered network. Disposition is main activities and inspection of the product should be performed as early as possible to determine recovery option. Fleischmann et al. (2004) highlighted the mechanism of traditional and recover networks; pull strategy is adopted in the traditional network while in the reverse network push mechanism is generally accelerated by government legislation or consumer awareness. In the traditional supply chain product differentiation are delayed to achieve higher value while in the reverse supply chain, the condition of value is assessed as soon as recovered to maximise value.

Main components of the reverse supply chain are drivers, recovery options, product characteristics, actors and phases. Economic and environmental factors are main drivers of recovery network. Driving factors are determined by supply chain factors (internal) or factors affecting surrounding (external). External factors can be summarised as economic, marketing, legislative and aftermarket protection. An internal driver depends upon manufacturing and distribution facilities (Fleischmann 2001; Rogers and Tibben-Lembke 2001). The recovery option depends upon the condition of product: direct reuse, resale, repair, refurbishing, remanufacturing, cannibalisation, recycling or landfill (Fernández 2004). Status of product return could be production returns, commercial returns, product recalls, warranty and service return, end of use and end of life return (Fleischmann 2001; Krikke, Hofenk, and Wang 2013). A number of actors varying according to recovery network. The disposed of the product can return back to forward chain that can be called as closed loop chain. The actors for closed loop chain could be suppliers, manufacturers, wholesalers or retailers. The product can be returned through the alternative chain that could be specialised or common for all products. The actors for alternative recovery networks could be recycling and sorting companies, dedicated logistic or

transport provider, municipalities or government agencies, brokers or any other profit making companies (De Brito and Dekker 2004). A number of recovery phases vary according to recovery network. In general, phases appear as acquisition or collection, transportation (centralised or decentralised), inspection/selection or separation/sorting, reprocessing or reconditioning and disposal (Fleischmann 2001; Guide, Jayaraman, and Linton 2003; Krikke, Bloemhof-Ruwaard, and Van Wassenhove 2003).

2.2.2 Closed loop supply chain

A classical form of supply chain consists of suppliers, manufacturers, distributors, retailers and end consumers. Whereas a reverse supply chain is a process of recovering value out of disposal from point of consumption. Reverse logistics can be defined as "*the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal"* (Rogers and Tibben-Lembke 2001). In closed loop value chain, the forward and reverse value chain considers simultaneously. Closed loop supply chain (CLSC) is *"management to design, control and operate a system to maximize value creation over the entire life cycle of a product with the dynamic recovery of value from different types and volumes of returns over time"* (Govindan, Soleimani, and Kannan 2015).

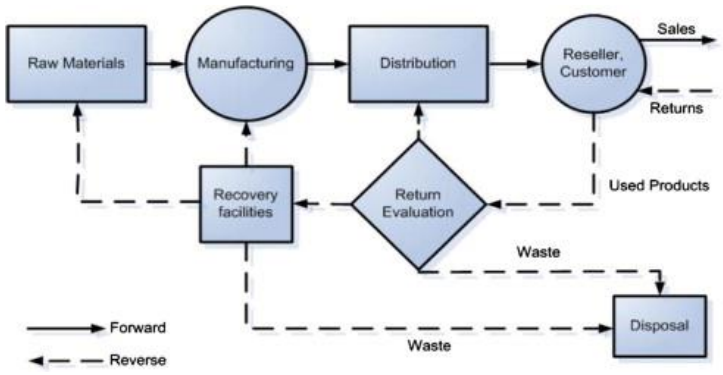

Figure 2-1: Forward and reverse logistics (Govindan, Soleimani, and Kannan 2015)

The closed loop supply chains subject is established to create revenue by acquiring products from consumers and recapturing the residual or unused value (Guide and Van Wassenhove 2009). CLSC management is aligned with legislation of environment and natural resource protection to minimize the waste creation. The current social and environmental legislation focus on natural resource conservation, sustainable product design, waste management and pollution control (Wang and Hsu 2010). Environmental legislation along with economic benefits has amplified the significance of closed loop supply chain (Sasikumar and Haq 2011). CLSC has recently raised interest among researcher and practitioner apart from the legal and commercial benefits. The acquisition of products on the reverse side of the supply chain is complex compared to raw material sourcing. Operation of CLSC is largely depended upon acquisition of products from the consumer (Morana and Seuring 2007). The product acquisition is a process of getting back products from the user. Reverse logistics (RL) is to move collected products back to different supply chain partners (Morana and Seuring 2007). (Krikke, Bloemhof-Ruwaard, and Van Wassenhove 2003) has identified four main kinds of product acquisition i.e. end-of-life, end-of-use, commercial, re-usable. Collection refers to the activities of product acquisition. The

collected products are inspected, re-processed, transformed, re-market and re-distribute (Fleischmann et al. 2000).

CLSC can be observed from processes, customers, and products perspective. The process perspective looks into product return procedures. CLSC constitutes recovery processes along with the forward supply chain processes such as sourcing, manufacturing, assembly, and distribution. Returned products are categorized according to quality and economic evaluation. The testing and sorting are done to decide the state of products and most optimal reuse options such as direct reuse, repair, refurbish, remanufacturing, cannibalization, and recycle. Re-marketing is done to create and develop a market for the recovered products (Morana and Seuring 2007). The good condition products that can be used in the existing state are cleaned and repackaged. The products that required little rework are repaired to bring parts and products back in working condition. During the remanufacturing process, the collected products are completely disassembled and defected parts are replaced with new one. The remanufactured products can be sold in the original market. In refurbishing process, the products are improved to achieve better functional and aesthetic quality but lower than the original products. The process of parts extraction from a product that can't be restored for use is called cannibalization. If returned products or its parts can't found suitable for use, then recycling can be done to extract material. The products could be incinerated if neither parts nor material recovery is possible. Energy can be recovered by burning products through incineration process. If none of the recovery processes is suitable, then physical products can be disposed-off to the waste landfill (van Nunen and Zuidwijk 2004). Table 2-1 summarises the list of research done in the area of CLSC across the various industry with process focus.

Table 2-1: Closed loop supply chain studies across different industries (Paras, Pal, and Ekwall 2017)

Research	Industry	Process
(Das and Dutta 2015)	Electronics	Collection
(Saphores and Nixon 2014)	Plastic, glass and metals	
(Kim, Glock, and Kwon 2014	Food products	
(Zhang, Berenguer, and Shen 2015)	None	
(Zaarour et al. 2014)	None	
(Ozkir and Basligil 2012)	None	
(Zhao, Liu, and Wei 2013)	None	Sorting
(Beamon and Fernandes 2004)	None	
(Abdallah, Diabat, and Simchi-Levi 2012)	None	
(Hsu, Alexander, and Zhu 2009)	None	
(Dururu et al. 2015)	Domestic items includes daily needs	Reprocessing
(Ozceylan, Paksoy, and Bektas 2014)	Electronics	
(Gallo, Romano, and Santillo 2011)	Electrical and electronics	
(Genchev, Richey, and Gabler 2011)	None	
(Lopes et al. 2014)	Clothes, accessories, furniture and electronic equipment	All/ Not Specific
(Abdulrahman, Gunasekaran, and Subramanian 2014)	Automotive, electrical/electronic, plastics, steel/construction, textiles and paper	
(Jindal and Sangwan 2014),	None	
(Rogers, Melamed, and Lembke 2012),	None	
(Das and Chowdhury 2012)	None	

The customer perspective of CLSC relates to customer behaviour. The behaviour of customers can be related to purchasing, re-use, repair, discard and disposal information. The analysis of consumer data provides useful perspectives for product use and return. The product data are

directly or indirectly collected from products to analyze CLSC from product perspectives. The analysis of product data can be used to redesign the product for the efficient recovery. The data will also help to improve forward supply chain operation along with recovery stage (van Nunen and Zuidwijk 2004). There is a need for industry-specific research for the closed loop supply chain or reverse value chain to study each process of reverse logistics (Kumar and Putnam 2008).

2.2.3 Sustainable supply chain

Sustainable development meets the requirements of the present without compromising the need of future generation (Seuring and Müller 2008). The central concept of sustainability is a triple bottom line that talks about minimum and balanced approach between environmental, economic and social dimensions of sustainability (Elkington and Rowlands 1999). A sustainable supply chain considers all three dimensions of sustainability i.e. economic, environmental and social while managing material, information and capital internally as well externally. Sustainable supply chain encompasses the concept of green and environmental supply chain at the border level (Seuring and Müller 2008). In sustainable supply chain fulfilling social and environmental criteria is important along with achieving customer needs and economic criteria to remain competitive. "A sustainable supply chain as one that is operated in a way that generates competitive returns on its capital assets without sacrificing the legitimate needs of internal and external stakeholders and with due regard for the impact of its operations on people and the environment" (Kleindorfer, Singhal, and Wassenhove 2005p.489). Seuring and Müller (2008) have identified two strategies for the sustainable supply chain. First is supplier management for risks and performance and advocates the consideration of environmental and social criteria for supplier economic evaluation. The second strategy is supply chain management for sustainable

products that demand the life cycle based standards for environmental and social performance of products.

A sustainable supply chain is concerned with management or raw materials, inventories, manufacturing and finished goods from points of origins of raw material to consumption by the end user in such a way to minimise the negative impacts on triple bottom line (Zaarour et al. 2014). The sustainable supply chain also considers reverse value chain operations such as reduction, reuse, repair, recovery, disassembly, refurbish, remanufacturing, and recycling as these operation has huge impacts on environmental, social and economic dimensions of the triple bottom line of sustainability (Guide, Jayaraman, and Linton 2003). Therefore sustainable supply chain has multi-echelon business involving forward and reverses value chain from cradle to grave and vice versa (Zaarour et al. 2014). Due to lesser economic benefits, the sustainability in the supply chain is mainly inspired by externally such as by government, customers or any other stakeholders (Gold, Seuring, and Beske 2010). Industries are facing pressure on environmental and social issues from government legislation and competitors parts from other stakeholders such as consumers and brand owner. Therefore organizations are forced to adapt sustainable practice to improve social and environmental measures (Diabat, Kannan, and Mathiyazhagan 2014).

2.3 Apparel industry

Textile and apparel industry is major sectors for developed as well as developing economies. The industry is greatly diverse and heterogeneous in nature (Bruce, Daly, and Towers 2004). Textile and apparel industries fall under small and medium scale industries. Textiles industries comprise of spinning unit, dyeing units, fabric manufacturing unit and apparel manufacturing unit. Apparel manufacturing comprises of design, sampling, material procurement, manufacturing, distributions and retailing (Keiser and Garner 2008). Apparel manufacturing consists of three steps i.e. cutting, sewing, and finishing. All the three process of apparel manufacturing is a labour intensive process. Hence to minimise the cost, the process of apparel manufacturing could be offshored to the lesser developed economy (Bruce, Daly, and Towers 2004). In pursuit of lower manufacturing cost the apparel manufacturing firms in developing countries took advantage of lower environmental and social awareness and regulation (Shen 2014). The global apparel manufacturing industries is second most polluting (after oil industry) and socially challenged industries. Adaptation of sustainability in the apparel industry could be strong motivations to reduce raw material and hazardous chemical consumption towards minimisation of environmental pollution. The current value chain of apparel become more complex with the rise in product complexity. The season dependent and fast fashion concepts in the apparel industry reduces the life of an apparel and resultent consumer discsrd clothes after season not after enf of life (Dervojeda, Verzijl, and Rouwmaat 2014).

2.3.1 Value creation in apparel forward supply chain

A typical forward value chain of textile starts from cotton farming and grave at consumer discards. The whole value chain of apparel is multi-echelon and distinct with own product, supplier and consumer (Keiser and Garner 2008). Each echelon of apparel value chain can work

independently or can be vertically integrated to have all value creation activities under one roof. Value creation at each step is intended to increase the worth of products to earn higher revenue. A designer develops an apparel design based on the fashion forecast. The manufacturing companies received order and design of apparel. The product development process which consists of sampling is done before mass production. The bill of material for apparel is generated to start procurements of fabrics and trims. Base upon samples, the industrial engineering departments develop operation bulletin to start manufacturing of apparel. The manufacturing process of an apparel starts with cutting of fabrics. The cutting panels are fed to sewing lines and stitched apparel comes out of line. The stitched apparels are finished and packed according to order. The packed order is shipped and distributed to the retailers. End consumers purchase the apparel use and discard it after the end of use or end of life. Figure 2-2 (a) depicts the apparel forward value chain.

2.3.2 Value recovery in apparel reverse supply chain

Rogers and Tibben-Lembke (2001) have emphasized that the purpose of the reverse value chain is to recapture or to recreate value from discarded products. The clothing products are discarded much before their end-of-life and hence, it is important to recover maximum value from donated clothes. Textile and clothing products are widely attributed for their negative environmental impacts (Cumming 2017). Recapturing the unutilized value from the discarded products is resource efficient as well as the environment-friendly process. The incineration process for energy extraction is the least preferred method among all the alternatives (Carter and Ellram, 1998). The activities of the reverse value chain are depicted in below figure:

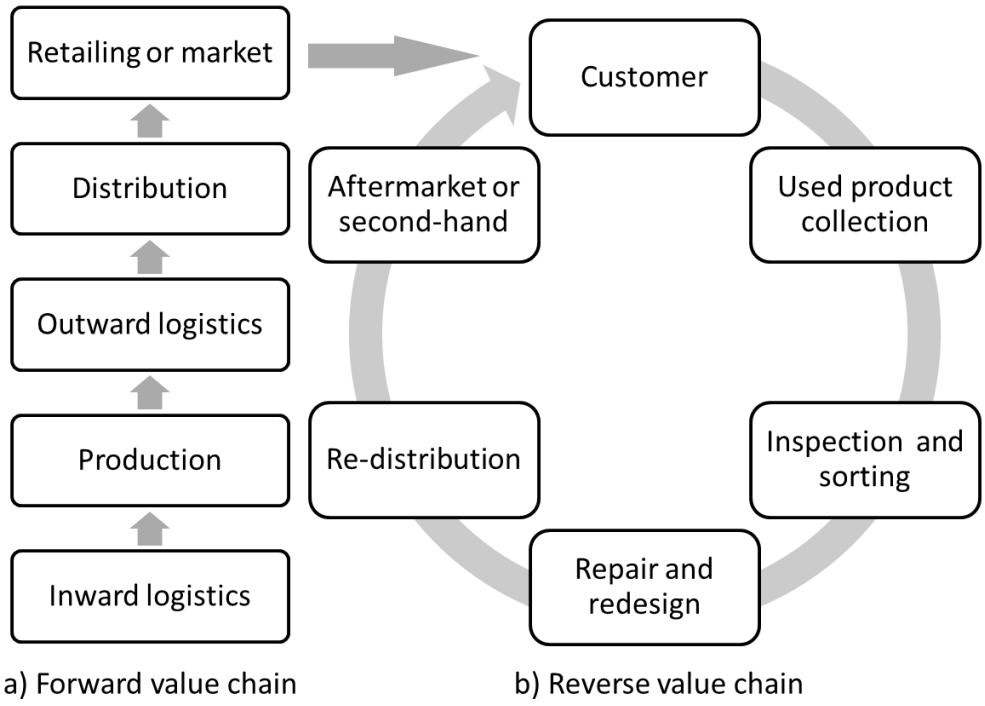

Figure 2-2: Apparel forward value chain and reverse value Chain, adapted from (Abraham 2011)

In the reverse value chain, reuse is found to be more resource efficient than recycling for material extraction. However, collection of discarded product from consumer is difficult. In the present situation even in western Europe, it is a big challenge to get back products from the consumers (Morana and Seuring 2007). Pal and Gander (2018) advocated the direct reuse of clothing products over other recovery options. The product return and recovery highly depends upon the availability of return channel. The facilities such as collection boxes, return offers, repair and redesign services accelerate the product return (O'Reilly and Kumar 2016). This is important to collect clothes and bring it to the reverse cycle of use.

2.4 Reverse value chain process for the apparel industry

The are several processes starting from the spinning of cotton to garments stitching. Every process adds some value to the product. The textile industry has been considered the second

largest in the world, consuming nearly ten percentage of global energy, after the food industry. Many hazardous chemicals are used and emitted in the garment manufacturing processes. To overcome this, few firms have taken initiatives to reduce the harmful effect of toxic chemicals. But a significant minimization seems difficult to achieve (Kuo et al. 2014). The situation is alarming since the disposal rate has also increased. Textile waste could pose a threat to the environment because disposed of garments ultimately go to landfilling or incineration.

Textile and the associated apparel industry are widely blamed for its environmental impact. Even in developed countries up to two third of textile waste is condemned to landfill. At landfill, fibres decay slowly and emit toxic and harmful gases (Cumming 2017). A closed loop system is a right alternative to reduce the volume of textile waste. Majority of the materials used in the production of clothes can be recovered from discarded product and can return to consumption cycle. Even though technically most textile materials are recyclable, but practically it is difficult and costly to execute. The recycling of fibre blends can generate lower quality fibre. Mono-fibre clothes have been proposed for better recyclability, but mono-fibre clothes can't provide a solution for the fast changing apparel industry. This advocates the direct reuse of clothing products over other recovery option (Pal and Gander 2018). The long life apparel products such as outer and work wear are designed for complete recyclability. However, it is challengeable to get back products from the consumer (Morana and Seuring 2007). The product return and recovery highly depend upon the availability of return channel. The facilities such as collection boxes, return offers, repair and redesign services could trigger product return (O'Reilly and Kumar 2016). Different kind of closed loop method is appropriate according to environments and cost structures (Savaskan, Bhattacharya, and Van Wassenhove 2004). Majority of the research has emphasized on the recycling/remanufacturing method to close the loop even though direct reuse, repair and

redesign are more sustainable and environmentally friendly options (Qiang et al. 2013; Yuan et al. 2015). There is some cost associated with the process of the reverse value chain. These cost incurred for primary and supportive activities. Profit is the difference between value created and cost incurred in the creation of value (Porter 1985). Based upon the above discussion, the conceptual framework for reuse-based reverse value chain for apparel industry is proposed as follow:

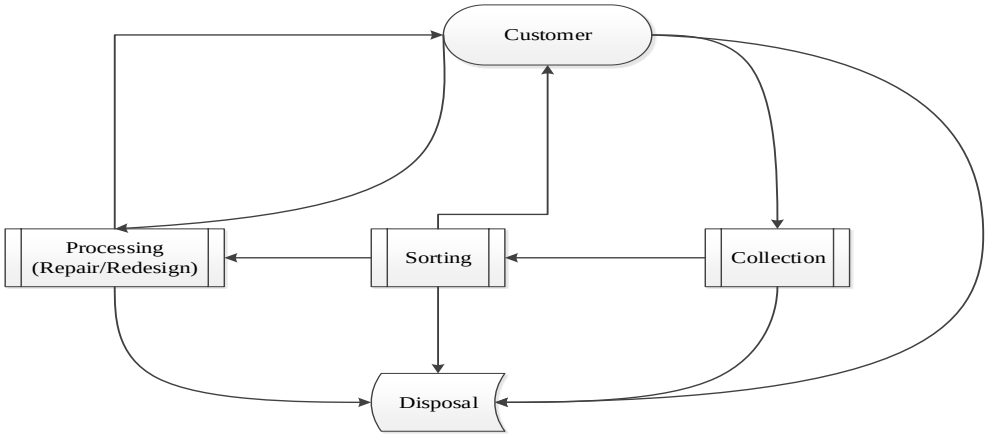

Figure 2-3: Conceptual framework for reuse-based reverse value chain for apparel (Paras and Pal 2018)

Each processes of reverse value chain are discussed in detail in the coming section.

2.4.1 Collection

The reverse logistics in apparel industry is driven by charity organizations. The apparels are mainly collected through collection box and second hand shops. Big fashion brand such as H&M also collaborates with charities or commercial companies to manage product return. The commercial collection companies acquire and process the collected apparels according to conditions (Shen 2014). Other retailers have also launched different kinds of schemes to collect textile material (Naoko Tojo et al. 2012). Charities organization could also co-operate with retailers to acquire clothing from people's home or workplace (Ekstrom and Salomonson 2014b).

Some of the textiles collectors in the UK has placed textiles bank in schools and periodically visit schools and brief students about environmental benefits of textile reuse (Morgan and Birtwistle 2009).

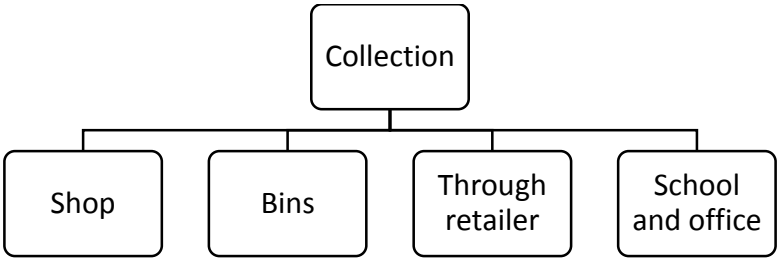

Figure 2-4: Method of used clothes collection

Farrant, Olsen, and Wangel (2010) have advised good quality of clothes collection can't be done through collection box. Usually, people disposed-off textile garbage in boxes but they bring quality clothes to donate at second hand shop. Charities are collecting apparels for charity but in reality, they make money from second hand clothes sales. The collected clothes are exported to commercial recyclers and are not freely distributed (Brooks 2013). This demoralizes public trust and can reduce the volume of textile and clothing collection (Ekstrom and Salomonson 2014b). The current system of textile collection in developed countries is turn out to be very competitive and complex with the entry of commercial collector. The relationship and financial benefits of the charitable and commercial organization are not revealed (Norris 2012).

2.4.2 Sorting

The future direction of product i.e. second life or waste stream is decoded during the sorting process. On the basis path, different amount of value can be captured from the discarded products. (Jayaraman et al., 2008). Segregation at source is most efficient and cost-effective method. If products are segregated at the source the highest amount of value can be captured.

Delay in sorting also leads to unwanted logistic cost because unwanted goods or waste is transported to all way to central sorting facilities along with valuable goods (Moise 2008).

The amount of value extracted from collected clothes depends on the sorting process. Each of these categories has a different product such as shirts, dresses, blouses, pants and lingerie (Botticello 2012). The collection partner of H&M grouped the collected textiles into re-wear (clothes that can be re-worn), reuse(as ragas and wipers) and recycle(generate fibres to make insulating materials) (Shen 2014). Below Figure 2-4 depicts the basic flow of apparel during sorting process:

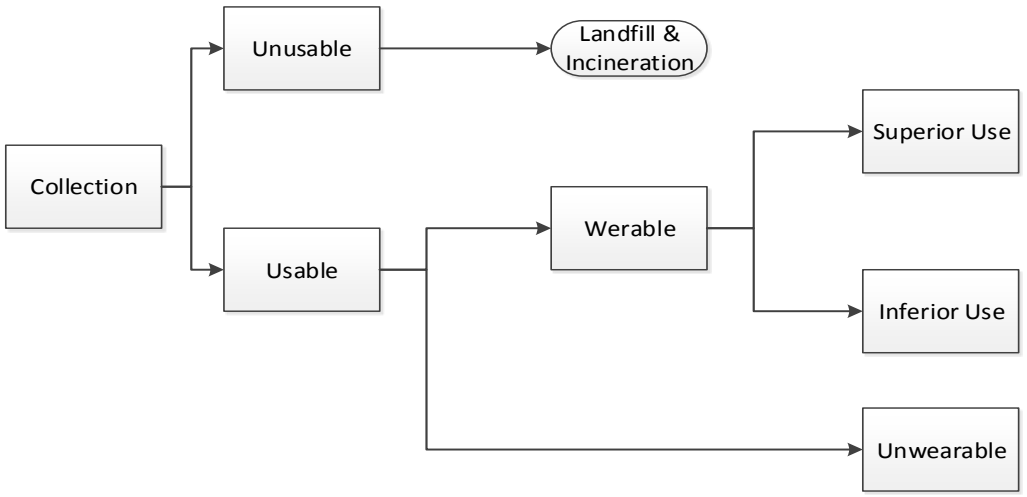

Figure 2-5: Process of used clothes sorting

For the recycling purpose, collected textiles are sorted according to their material composition, colour, size and recyclable suitability (Mo, Wen, and Chen 2009). Sorting of clothes on the basis of colour means there will be no requirements of bleaching and re-dye, resultantly there will be saving of energy and water. Sorting process is a critical step and required the intervention of technology to improve sorting (Alkazam 2013). Latest technology such as automatic conveyer

belt, infrared, and robotics are being tested and implemented for the used clothes sorting (Carlsson et al., 2015).

The reputation of used apparel exporter depends upon the judgment of clothes quality. The companies are employing knowledgeable and careful sorter to gain and retain reputation (Norris 2014). Inefficient method of sorting may be costly and unable to extract maximum value from waste stream (Carter and Ellram, 1998).

2.4.3 Reprocessing to create value

The waste clothes can be converted to a new value ranging from high-value vintage clothes to the low-value rags and wipers for the cleaning purpose (Pal 2017). The second hand clothes donated are generally considered as gift or waste with no or very less value to the donor. However, in most of the cases, the donated clothes have an unutilized value that can be properly realized through reverse value chain activities (Brook 2012). The collected clothes gain significant value after sorting and reprocessing (if required). The product can undergo various reprocessing steps depending upon the condition of returned clothes. The dirty clothes can be washed and minor repair can be performed to fix broken stitch and buttons to restore basic functionality (Sandberg, Pal, and Hemilä 2016). Sometimes value addition activities such as redesign or upcycling is also performed to improve the existing apparel. Downcycling could be an alternative to capture existing value if clothes are not suitable for direct reuse or upcycling (Paras and Curteza 2018). (Hawley 2006) presented a pyramid model for volume-to-value creation ratio in the used clothing as depicted in below Fig 2-5:

Figure 2-6: Pyramid for used clothes (Hawley 2006)

The maximum amount of clothes (approximately 48%) is used in the domestic markets or exported to developing countries. Unique or good brands garments are rarer and consider as Cherrie or diamond in the used clothing business. Rags and wipers for cleaning and recycling for fibres have gained significant attention. European flammability legislation has mandated to higher wool content in upholstery and protective clothing (Hawley 2006). This has increased the demand of low quality or recycled woolen fiber in the European countries. Recycled woolen fibres are also used for making blankets in India and wall-filling materials in western countries (Norris 2012).

The amount of value created by an organization gives a competitive advantage to one organization over others (Pal 2017). The organization can exploit available resources and processes to create new value in form of a product or service (Cova et al., 2011). However, the reverse value chain activities are labour intensive, therefore, the outsourcing or offshoring could be a suitable option to achieve cost efficiency (Skinner et al., 2008; Bernon et al., 2011). The creating of value in reverse logistic requires good skill to repurpose and reprocess to maximize

the number of used clothes. Higher economic value can be achieved by increasing the volume of clothes for superior use (Tojo et al., 2012; Ekström and Salomonsson, 2014). The product not suitable for reuse can undergo to repair, refurbish or remanufacturing (Krikke et al., 2004). The reprocessing comprised of minor or major deformation depends upon the requirement of a new product (Abraham 2011).

2.4.4 Redesign and upcycling

A number of designers and second hand clothing companies are making efforts to turn textile waste into cutting end designs. But still, the total amount of redesign clothes are limited in the amount (Tojo et al. 2012). A redesign can be performed to turn clothing products into cushions, pillow or new clothing. For example, the sweater can be turned into a pair of pants for the child. Fabrics of jeans and trousers have long life hence this can be re-cut and re-stitched into other products (Abraham 2011). Reuse and redesign of existing clothes avoid production of new apparel (Farrant, Olsen, and Wangel 2010). Below figure depicts the steps involved in the re-design process:

Figure 2-7: Redesign Process (Paras and Curteza 2018)

Other aspects of clothes reuse is repair and restoration that can extend the life of useful clothes (Goworek et al. 2012; Guiot and Roux 2010). Altering, remaking and refashioning clothes is another way to extend the life of clothes. The quality, price and appearance of used clothes that are offered for sales of second hand clothing market can be improved with laundry services (Imo and Maiyo 2012). The charities from Nordic countries export used textile materials to east

Europe for recycling. It is not financially viable to set up recycling units in the developed countries (Ekstrom and Salomonson 2014a). Cotton waste is converted into fibres and then produced non-woven fabrics. Polymer-based manmade fibres are converted into granular through washing and smelting (Mo, Wen, and Chen 2009). The reprocessing of used clothes generate a significant amount of employment in handling, cleaning, restyling and redistribution process (Bigsten and Wicks 1996).

2.5 Factors affecting reuse-based reverse value chain for apparel

There are several parameters which influence the process of the reverse value chain. Important factors listed and discussed as below. Deriving from the literature in the aforementioned section, the major determinants of reuse-based reverse value chain may include a business system, product designs, product price, product reuse information, legislation and consumers' environmentally conscious attitude. The important factors have been identified which that could have a positive impact on the reverse value chain business of apparel. This has been illustrated in Figure 2-8.

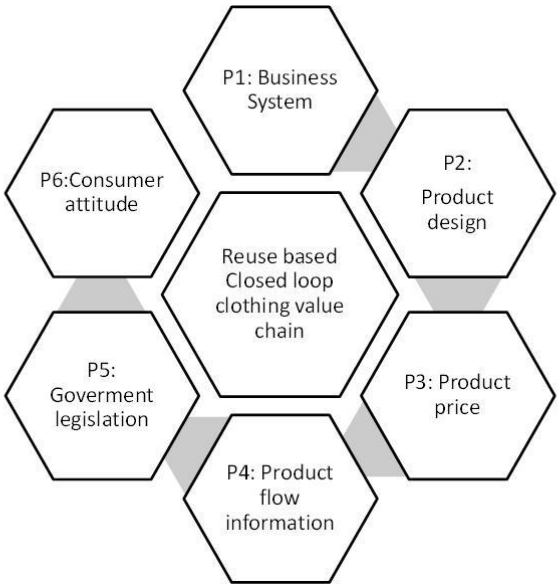

Figure 2-8: **Factors affecting reused based reverse value chain (Paras, Pal, and Ekwall 2017).**

System: In the majority of the cases, these activities are carried out by charity organisations. These organisations do not have proper infrastructure to perform reverse value chain activities. The volunteers work with charity organizations are mostly semi-skilled or retired persons. They tend to carry out activities in a traditional way. So there is a need to develop the business model in collaboration with charity organisations. The main source of collection of old clothes is a donation, hence business model cannot be developed without incorporating social factors (Parsons 2002). The process of collection, sorting and reprocessing are supposed to be studied considering social factors. Moise (2008) also highlighted the need for separate mapping of the activities of the reverse side of the value chain. This will help in understanding the business of collection, sorting and reprocessing at a minute level. In the current situation, there are different players for each process involved in the reverse value chain of the apparel industry. Fragmentation and lack of collaboration are identified as major factors responsible for inefficiencies. This highlight the need of the complete network of the system which might comprise of different subsystems for whole value chain (Abraham 2011).

Design: Fashion products are highly dependent on the style and trends prevailing at a certain point in time. This creates interest towards styles which were in great demand during previous decades. This has created a unique market for fashion product that is called vintage (DeLong, Heinemann, and Reiley 2005). Different kinds of value addition like print and embroidery can further help in increasing the aesthetic value of old products (Hiller Connell 2011). However, repair and redesign of old products are labour intensive processes. The process can be simplified by considering future reuse of products or its components during initial designing stage (Das and Chowdhury 2012).

Price: In the past, the worn cloth was exchanged between friends and family (Sanderson 1997). But now this informal exchange has taken the shape of formal exchange via stores, where old or used clothes are sold at affordable prices. Several consumers' go to second hand store in search of quality products at a lower price (Guiot and Roux 2010). This highlights that price of the used product is another important factor which decides saleability (Horvath, Autry, and Wilcox 2005). Price of the old product should be kept in such a way that it should attract customers. There should be a significant price difference between old and new products so that consumer should purchase old in the case of inability to buy new products (Atasu, Guide, and Van Wassenhove 2008).

Information: In a current situation, not a single supply chain can function without the help of management information system or enterprise resource planning. Information has become a key driver of any business. This also plays an important role in the operation and strategic decision-making process of reverse logistics (Ferguson and Browne 2001). Different technologies are available to provide timely and accurate information in the forward supply chain. Similar kind of technologies can be used for reverse logistics activities of apparel industry (Das and Dutta 2015). The trade of second hand apparel is subjective in nature due to several variable parameters. This leads to the problem of quality which can be reduced by proper communication among the different partners (Abimbola 2012). Proper information between consumer and partners of reverse will help in meeting the requirements of each other.

Legislation: Successful waste management practices need intervention from local government authorities; the same applies to the recovery of textile and apparel. For the first time in the year 1970 in the UK, it was found that local authority collaborated with grass root people to collect waste (Oldenziel and Weber 2013). This mutual cooperation was quite successful. In a recent

development, Ulsan Metropolitan authority in Korea has signed a memorandum of understanding with LG Electronics to carry out a collection of all electronic waste irrespective of brand and product (Das and Dutta 2015). Hence, the success of non-profitable reverse logistics more or less depends on the favourable government legislation. This clearly highlights that there is a need for similar government intervention for clothing and textile recovery too.

Consumer attitude: Disposal of clothes into the collection bin or charity shop is highly dependent on the individuals' behaviour and attitude. Environment-conscious consumers' are prone towards proper disposal (Bianchi and Birtwistle 2010). It has been also found that consumers' that consider themselves responsible for environment tend to visit second hand shop very frequently. While other sets of consumers that do not like to shop or wear used clothes tend to purchase new clothes. Hence, this can be stated that environmentally conscious attitude of consumers influences purchase decisions as well as disposal (Lim et al. 2012).

2.6 Direction for future research

Based on the review, this section identifies potential gaps for the future which can help in strengthening the literature related to apparel reverse value chain. Following research directions can be considered by future researchers:

- There is a dearth of studies related to the development of conceptual framework as well as an empirical model for apparel reverse value chain (Abraham 2011). Most of the earlier works were theoretical in nature (Horne 1998; Parsons 2002). The conceptual model can further be extended by the development of mathematical modelling followed by empirical validation.

- Including this, most of the studies are qualitative research. There is a huge scope to carry out quantitative empirical studies in this area (Cervellon, Carey, and Harms 2012; Goworek et al. 2012).
- There is need to standardize various processes like the collection, sorting and redesign (Abimbola 2012; Laitala and Klepp 2014). Therefore, in future researchers can contribute in this area.
- From the descriptive analysis, it can be seen that most of the studies were done in American and European contexts (Morgan and Birtwistle 2009; Bernon, Rossi, and Cullen 2011). This gives an opportunity for future researchers to validate the findings in other cultures.
- The reverse value chain of apparel is highly unpredictable and stochastic in nature. Therefore, researchers are invited to design a resilient closed loop value chain for clothing (Horvath, Autry, and Wilcox 2005) with the help of advanced operation research techniques.

2.7 Chapter Summary

This chapter has reported on the review of the literature on reuse-based reverse value chain for the apparel industry. The chapter started by providing background on the concept of value, value creation and value capture. The combinations of value creation and value capture offered a theoretical basis for understanding forwards and reverse value chain respectively. The current research is built on the literature of supply chain management that includes reverse supply chain, closed loop supply chain and sustainable supply chain. The details literature review of the reverse value chain of apparel is performed to identifying each process i.e. collection, sorting, and reprocessing in details. The basic principle of the collection, sorting and reprocessing are

adapted from other industry for the reuse-based value chain model for the sustainable apparel industry and holistic understanding of factors affecting each of process. Factors such as system, design, price, information, legislation, and consumer environment conscious attitude have been identified as the important factors affecting reuse-based reverse value chain. There is limited empirical and analytical understanding of reverse value chain for apparel industry. The current research addresses the gap in literature by adapting exploratory and mathematical modelling techniques. The next chapter will present research methodology that will be used for conducting an empirical investigation and analysis.

3 Chapter: Mix Research Methodology – Qualitative and Quantitative

The current chapter broadly describes the methodology undertaken for the research. The chapter started by providing an overview of the philosophical orientation of research. Specifically, the chapter discusses the research philosophies and approaches dominantly used in the present research work. Further, the chapter builds upon the case study and data collection for qualitative and mathematical analysis. The last section will summarize the chapter after describing ethical considerations of the study.

3.1 Philosophical orientation of research

Over the centuries, research has moved from periphery to the centre and consequently, became an integral part of every discipline. Research may be considered as a combination of two words, 're' which means 'again' and 'search' which means to 'find out'. Therefore, in research, a researcher observes the phenomena again and again from different dimensions to provide unique and meaningful insights (Kumar 2005).

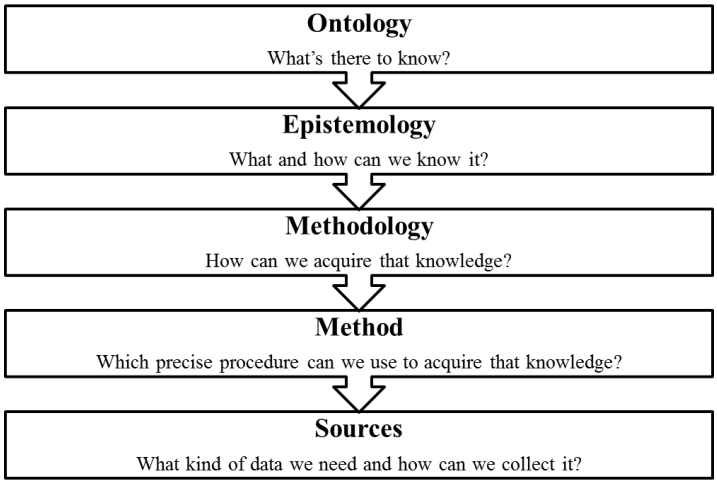

Figure 3-1: Dimensions for evaluating research philosophies

There are several scholars who have defined 'research' from their perspectives. Kerlinger (1986) defined research as a *'systematic, controlled empirical and critical investigation of propositions about the presumed relationships about various phenomena'*. Research may be conceptualized as '*a structured inquiry that utilizes acceptable scientific methodology to solve problems and creates new knowledge that is generally applicable'* (Grinell, 1997). In other words, it is a systematic investigation to find out a solution to an unsolved query (Burns, 1997). The research philosophy that a researcher adopts primarily tends to govern the assumptions and the way a researcher approaches a problem. This, in turn, will help in designing the overall research strategy.

The popular four research philosophies identified in the literature include positivism, realism, interpretivism and pragmatism. These philosophies are generally compared and understood based on four dimensions as ontology, epistemology, axiology and methodology (depicted in

). Ontology presents a researchers' view of the nature of reality; epistemology represents researcher's view regarding what is acceptable knowledge, axiology presents the role of values in research and methodology represents the method considered appropriate to handle a research problem. Positivist philosophy assumes that whatever we can observe has a credibility to be tested. With this approach, a researcher generally formulates hypotheses based on the theories available in the literature. Realism philosophy advocates that an object exists independently of human thoughts and the human sense portrays the world correctly. This approach governs a researcher's approach to carrying out research at the individual level, group level or organizational level. Interpretivism philosophy appreciates the role of humans as social actors. Pragmatism philosophy advocates that researchers should study the subject of his/her interest and may use different ways to study that subject.

Saunders et al. (2011) pointed out that research philosophy not only governs what a researcher will do but also how he will approach that problem and the way of handling it. There are various research philosophies, but, the authors mentioned that each philosophy has a merit in tackling different objectives. Therefore, it is not right to evaluate which philosophy is better. However, which is better depends on the research question (s) that a researcher wants to address. Interestingly, the debate is mainly between positivist and interpretivist approaches, i.e. indirectly between choosing the qualitative or quantitative method. Over a period of time, research has evolved from traditional scientific methods to more advanced techniques of quantitative and qualitative research (Logie-MacIver et al., 2012). Now, several researchers are using a mix of qualitative and qualitative methods to strengthen the results of their studies (Hanson & Grimmer, 2007). Mixed method is popular in the area of supply chain management as it provides subjective and objective insights to the research (reswell, 2003; Golicic and Davis, 2012, Adamides *et al*., 2012).

The two most common research approaches in the literature are an inductive and deductive approach (Saunder et al., 2011). The deductive approach involves building and testing the hypotheses and propositions which are formulated from the existing theories in the literature. Its basis lies in the positivist philosophy of research. The inductive (related to interpretivism) approach advocates the theory building approach by collecting data with the help of interviews or focus group discussions. The third research approach is abductive that is a combination of both inductive and deductive. Abduction approach involves comprehending theoretical knowledge gained in each visit before the next visit to the field. This can be considered as an iterative process which is carried out each time till the time results in a saturation point (Glaser 1978). The selection of the aforementioned approaches is dependent on the objective of the

study. The present study comprised of inductive, deductive and abductive approach at different stages to figure out answers to the research problem. In general, this work is based on the authoritarian approach, case study based exploratory research and phenomenological approach. The qualitative data is collected from the exploratory case studies, and quantitative data (primary and secondary) is obtained from respondents and publically available data sources.

3.1.1 Authoritarian approach

An authoritarian approach relies on the creation of knowledge from the secondary resources. Merton (1965) highlighted that it is very important for a researcher to thoroughly review earlier works to figure out an appropriate research gap. A researcher tends to avoid self-assumptions and tries to validate the findings with the existing knowledge created by fellow researchers. Several times a researcher may find a research similar to his/her work being carried out at some other places may be in the same department, university, state or country. To avoid this problem, researchers can use several ways to do a thorough check may be with the help of conversation with other researchers, archives, knowledge resource centres and online repositories (Czarniawska 2014). In a similar manner, the existing literature was considered as the building block for this research and the work was started by reviewing the extant literature. The review helped in developing conceptual frameworks based on the systematic review of reuse, reverse logistics, closed loop supply chain literature and review of profiling techniques to understand the existing theoretical knowledge of redesign and upcycling. The conceptual frameworks and findings of the literature have been discussed in Chapter 2 of the thesis.

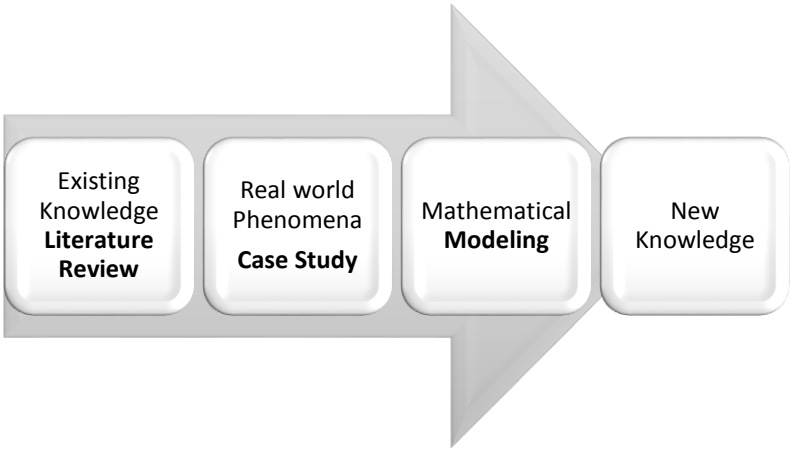

Figure 3-2: Process of knowledge generation

3.1.2 Empirical and phenomenological approach

The empirical findings for the current research is collected with case study approach. As Glaser and Strauss (1967) advised that the theory built by observing empirical practices can provide more meaningful information which is difficult to capture by the deductive approach. This approach also helped in identifying a different kind of practices at a particular site. The theory building is a continuous process in which collection of field material, coding, analysis and theorising are continuously carried out (Czarniawska 2014).

The knowledge can also be created through logical reasoning and interpretations apart from authoritarian and empirical ways. The phenomenological approach is a way to recognize, understand and document a specific phenomenon as it is perceived. Phenomenology is concerned with the study of a phenomenon from an individual's perspective and interpretation. This provides powerful acumens on subjective issues. Phenomenological research focuses on the description and does not start from preconception or hypothesis. The interpretive dimensions to phenomenological approach facilitate in theory building (Husserl 1970). The phenomenological approach has been used to provide logical interpretation to the case study based on the

exploratory findings. Chapter 5 uses Analytic hierarchy process, genetic algorithm, and Markov chain principle for modelling reuse based reverse value chain. Analytic hierarchy process technique is used to find best reverse logistics alternatives in the first subchapter. The concept of modularization and the interactive genetic algorithm is described in the second subchapter to model redesign practice within used clothing network. In the third subchapter Markov principle is used to perform the life cycle assessments of used clothes.

3.2 Research process and chronology

The research has been carried out under the Sustainable Management and Design for Textiles project of Erasmus Mundus Joint Doctorate Programme. The research was started at the Swedish school of textile, university of Boras, Sweden in October 2014 and carried out until March 2016 for 18 months. Next, the research was undertaken at the faculty of textile, leather and industrial management, 'Gheorghe Asachi' technical university of Iasi, Romania for 18 months i.e., from April 2016 to September 2017 based on scheduled mobility. At last, the research was carried out for 12 months at college of textile and clothing engineering, Soochow university, China from October 2107 to August 2018. Overall, four years of research duration were spent across two European universities and one Chinese university.

Product reuse in the reverse value chain spreads across several domains. However, in the dissertation, it is mainly studied under the purview of Supply Chain Management and Reverse Logistics. Further, it is important to acknowledge that a few kinds of literature from sustainability, re-design and remanufacturing within textile industry helped in comprehending the findings in an elaborative manner. The methodological framework of inductive, deductive and abductive are adopted at different stages. The deductive approach was used to gain authoritarian knowledge from the reverse logistics, closed loop supply chain, redesign and reuse literature.

Subsequently, an inductive approach was undertaken to gain knowledge from the field. The practice of reuse in the closed loop clothing value chain is an emerging phenomenon and hence, abductive approach assisted to document new knowledge gained from each of the field visits.

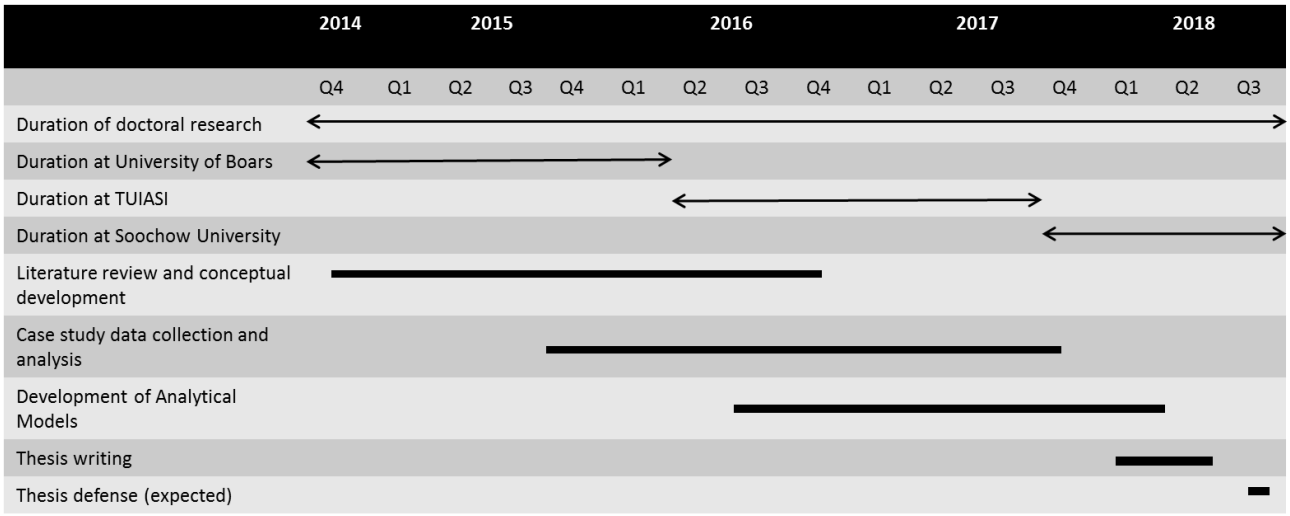

Figure 3-3: Chronology of research

The PhD research started from department of business administration and textile management, university of Boras, Sweden. There the research was more aligned towards business administration and textile management aspects. The conceptual framework development and exploratory study to understand the management of clothes reuse in the reverse logistics was carried out at the university of Boras. This has laid down a path for understanding the process of clothes redesign to improve the reuse practice. Subsequently, phenomenological approach adopted to perform analysis through logical interpretation at faculty of textile, leather and industrial management, "Gheorghe Asachi" technical university of Iasi, Romania and college of textile and clothing engineering, Soochow University, China. The PhD thesis consists of seven chapters resulted from different research undertaken over the period of four years at three different universities.

3.3 Case study method

The case study can be defined as an *empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident* (Yin 2009, p:18). The case study is suitable to find out answers to 'why' and 'how' questions. The current research aims to understand the why the clothes should be reused and how clothes reuse process can be improved. Hence, the case study methodology was considered appropriate for the study. The case studies can consist of single or multiple cases with different levels of analysis. A single case study could involve multiple sites Czarniawska (1997). During this research, four cases were explored involving multiple sites. In a case study, a qualitative, quantitative or both kinds of approaches can be used to understand a phenomenon (Eisenhardt, 1989). Fourth explorative case study on Romanian charity organization is complemented by a quantitative study. Details of each of the methods adopted in the research work are depicted in the below table:

Table 3-1: An overview of explorative case studies and data collection

Study type	Swedish local charities	European charities	Romanian used clothing organization	Indian used clothing sorting and grading organization
Charities and organization study aim	General understanding of clothes reuse practice	Overall understanding of clothes reuse business	Understanding of Romanian used clothing network.	Understanding the influence of developing the economy in global reverse logistics of clothes.
Researcher engagement	Volunteer for one organization and outsiders for others	Intern for one organization and outsiders for others	High-level engagement with one organization and outsiders for others	Outsider
Time duration	9 months (in 2015-2016)	11 months (in 2015-2016)	12 months (in 2016-2017)	4 months (2015-2016)
Data collection	6 In-depth semi-structured interviews, 11-12 onsite visit and 1 volunteer participation	15 In-depth semi-structured interviews, 10 onsite visit, 2 weeks internship, company documents, 1 note from internal seminar and intern at 1 organization for 15 days	11 In-depth semi-structured interviews, 13-14 onsite visit, company documents and the visit of company stall in the street festivals	10 In-depth semi-structured interviews, 8 onsite visit and secondary data available in newspapers, government reports an scientific articles.
Outcome	Chapter 4 (4.1)	Chapter 4 (4.3)	Chapter 5 (5.1)	Chapter 4 (4.2)

There is a plenty of information available in the field that needs to be theorized and documented to create new knowledge. The insights gained from observing people and their work helps to understand the real problems of their lives. Correspondingly, carefully observing an organization's activities will help in manifesting real-time issues from practitioners' viewpoint (Mol 2002). Case studies account for the largest amount of work among different subjects in the form of books and articles (Denzin and Lincoln 2011). The study of a particular practice or phenomena is termed as a case study (Czarniawska 2014). A series of organizations are selected to perform different window study (Czarniawska 2007). These window studies in the form of mini cases helped in comprehending different phenomena related to reuse in the closed loop value chain across different locations. The case studies are conducted in Western Europe, Eastern Europe, and India. In other words, studying organisations at multiple locations enhanced the robustness of the findings (Herriott and Firestone 1983). The current exploratory study can be divided into three cases and the findings are presented in Chapter 4. The first subchapter of Chapter 4 has documented the findings from Swedish local charities. The findings from the European multinational charities are described in the second subchapter. Third subchapter presents insights from Indian used clothing sorting and grading companies

3.4 Data Collection

3.4.1 Access to case study data

The researcher was stationed at Boras, Sweden and Iasi, Romania for one and half years each spread across 4 years of the total research period. The organization selected for the study is based on convenient and snowball sampling. The starting point of the research was the first case study i.e., an exploratory study of Swedish local charities organisations. The researcher has done desktop research to find out the relevant organisations. Nine organizations located in Boras,

Sweden were found relevant to the research. The organizations were contacted by telephone and email to get the appointment. Three organizations agreed to the visit and interview. However, others have either denied or referred to their warehouses because they were doing the only retail operation in Boras. The researcher has identified two more relevant organisations during the process of organisation search. So, in total five organizations were identified

During the second phase, the multinational companies located in other part of Europe were approached to develop an overall understanding of reverse logistics operation of clothes. In total nine organizations were selected, three were from the UK, one from Norway and remaining others were from Sweden. The UK is one of the leaders in the used clothing business that was the main reason to include British organisations. One of the Norwegian organisations was also selected to understand the practice of used clothing. In addition, the researcher also approached companies located in other parts of Europe such as Germany, Netherland, France, Belgium, and Finland. However, most of the companies have not shown interest in participation in the research. The visit and interview plan to these nine organizations were finalised through email exchange.

The third phase of data collection was done in India. All the companies were located on the western coast of India. Only eight companies agreed to share information out of total 20-22 companies. A trip was organised in the month of December 2015 for 7 days to Kandla, Gujarat, India. The fourth phase of data collection has done during a stay in Iasi, Romania. The data collection in the fourth phase started by searching and contacting used clothing companies located in East Europe mainly in Bulgaria, Hungary, and Romania by email and phone. However, the researcher has not received any reply from the Bulgarian and Hungarian companies. Therefore, 4^{th} stage of data collection for the current research confined to the

Romanian companies that have agreed to collaborate in the current research by sharing information.

3.4.2 Interview

The interview is most common techniques to collect data during exploratory research (Czarniawska 2014). A formal email was sent to the interviewee to give brief about research and aim of visit/interviews, prior to conducting onsite visit and interview. This has given an opportunity to the interviewee to prepare data for the optimum benefits of the interview. Interviews were focused and last for more than 60 minutes. Long interviews give an opportunity to collect more relevant data (Charmaz 2006). The interview was started by understanding the context, history and timeline of developments in the selected organization. Proper field note was also made with the help of notebook along with interviews recording (Zimmerman and Wieder 1977). The field notes were carefully made for the non-recorded interview. The response provided by interviewee and firms are recorded and presented as unanimous. These are referred as I1, I2, I3....and so on for interviewee to maintain confidentiality. The Swedish, European, Indian and Romanian firms are represented as S1, S2…; E1, E2…, I1, I2…., and R1, R2…. to main confidentiality. Below Table 3-2 clearly depicts the details of interview and observation made at each stage of data collections:

Table 3-2: Research stages, interviews and observations details

Organization		Location	Interview dates	Observation duration
Stage1: Swedish local charities	S1	Borås, Sweden	17 August 2015 20 August 2015	7-8 half day visit*
	S2	Limmared, Sweden	02 September 2015	1 day visit
	S3	Fristad, Sweden	04 September 2015	2 day visit
	S4	Borås, Sweden	10 September 2015	1 day visit
	S5	Borås, Sweden	02 September 2015	2 day visit
Stage 2: European Multinational charities	E1	Gothenburg, Sweden	28 September 2015	1 day visit
	E2	Oslo, Norway	26 October 2015	1 day visit
	E3	Stockholm,Sweden	21 September 2015	1 day visit
	E4	Jönköping, Sweden	24 September 2015	1 day visit
	E5	London, UK	05 November 2015	1 day visit
	E6	Gothenburg and Stockholm, Sweden	22 January 2016 24 February 2016	2 day visit
	E7	Eskilstuna, Sweden	21 January 2016	1 day visit
	E8	Stockholm,Sweden	18 February 2016	1 day visit
	E9	Leeds, UK	27 July 2016 28 July 2016	2 Weeks[$]
	E10	London, UK	14 July 2016	1 day visit
Stage3: Indian sorting and grading organizations	I1	Kutch, India	15 December 2015	1 day visit
	I2	Kutch, India	16 December 2015	Half day visit
	I3	Kutch, India	16 December 2015	Half day visit
	I4	Kutch, India	17 December 2015	Half day visit
	I5	Kutch, India	17 December 2015	Half day visit
	I6	Kutch, India	18 December 2015	Half day visit
	I7	Kutch, India	18 December 2015	Half day visit
	I8	Halol, India	19 December 2015	Half day visit
Stage 4: Romanian Second hand clothing organization	R1	Iasi, Romania	15 March 2017	7-8 day visit
	R2	Prahova, Romania	09 November 2016	1 day visit
	R3	Bucharest, Prahova, and Iasi Romania	3 August 2017 5 August 2017	1 day visit at each location
	R4	Iasi, Romania	21 July 2017	1 day visit
	R5	Bacau, Romania	01 August 2017	1 day visit
	R6	Ramnacu Valeca, Romania	02 August 2017	1 day visit

Note: *Includes participatory observation as volunteer.
$ Internship from 15 to 29 July 2016

3.4.3 Observation

The observation can be participant or direct (Czarniawska 2014). In the present work, both kinds of observations have been utilized to get meaningful insights. In direct observation, actors are being observed by the researcher while during participant observation, the researcher works as an actor as well as an observer. Direct observations are also done to observe activities on the shop floor. Field notes were prepared to record the findings (Rosen 2000). During observation, shop floor in-charge or the manager were accompanied to facilitate the structured observations. Czarniawska (1997) suggested that shadowing help to understand action and network of the organization. Used apparels were taken as an object to understand the process. Shadowing is a technique in which particular person or object is followed and observed for a particular length of time. It is easy and ethical to a shadow of objects compared to a person. It is better to call it as following objects. Apart of the traditional approach, modern approach adopted to field study as suggested by Barley and Kunda (2001). The data collected with the help of semi-structured interviews from the organizations involved in the activities of clothes reuse. The questions served as a guide in interrogating the current practices of the organization. Electronic recording tools have been used to record for analysis and future references (Steinar 1996).

The approach of direct observation is utilised for the current study. Indirect observation has been avoided due to ethical reasons. Both kind of direct observations i.e. direct and participatory were adopted for the current study (Brinkmann 2012). However, due to the constraint of time and permission, non-participant observation like shadowing and stationary observation have been performed for the majority of window studies. Photographs and videos also supported observation (Collier and Collier 1986).

To understand the process of reuse, apparel was considered as the unit of analysis and observed in an organization from the input stage to the output stage. The form of the objects changed from initial stage to final through different actions. In this research used apparel is actant, different actions are acted upon apparel throughout the reverse value chain process (Greimas et al. 1982). The transformation occurred to the objects (i.e. used apparel) throughout the process, which are also verified with photographs taken at various stage. The shadowing people have focused on the action of the particular individual while the following object enables to understand the complete network. A lot of actants exist in the network, so it is important to know about important actent (Czarniawska 1997).

3.4.4 Tools Used

Tools for doing fieldwork are constantly changing and digital forms are getting popular day by day. Still, the handwritten and self-observations hold its importance. Microsoft excel spreadsheet found to be more systematic especially in arranging findings according to theme and codes (Czerwinski, Horvitz, and Wilhite 2004). However, the effort has been done to minimize the use of diaries. Features of the smartphone have been used to capture photographes and other multimedia files. It is easy to remember and interprets digital files (Brown, Sellen, and O'hara 2000). So the technique of photo diary has been utilized for this research. However, some of the organisations have not permitted to use a digital device for photographs, audio or video recordings. It is unethical to use the digital device without permission (Czarniawska 2014). Notes were made in the diary for each organization. Quality of photograph and video depending upon camera and photographer (Collier and Collier 1986). Hence, the precaution has been taken to capture object and respondents/people properly so that it can be analysed easily in future.

Information about the practice of reuse is also collected with help of cyberspace through web browsing and web data collection (Megens and Martin 2003). It is quite easy to collect information through cyberspace. Follow up to interviewer were done through email to get further clarity. As suggested by Meho (2006), the online synchronous interviews were also conducted to overcome geographical separation. Some of the interviews were asynchronous, which were done through the exchange of emails.

3.4.5 Analysis

Materials collected form interviews and observations are interpreted to the text. The material collected on the basis of abductive approach for different case study has gone through constant comparative analysis till saturation (Glaser and Strauss 1967). This has been found that even though companies are located in same geographical locations but they differ in terms of operations. This is different from the traditional content analysis as categorisation and propositions were found on the basis of observations. Narrative analysis has been used for classification and categorisation of materials. Various codes and emerging themes such as collection, sorting, and reprocessing process has been used for the categorisation of materials. Content analysis has been done for the literature review. A systematic literature review has been done for the study of closed loop supply chain. While profiling approach has been for reviewing the literature of redesigning /upcycling as a scientific paper published in this field is less.

At first phase, data analysis of semi-structured interviews was aimed at findings emerging themes by pinpointing, examine, and observing emerging pattern within the collected data (Braun and Clarke 2006). The emerging themes further help in developing a new theory with the help of exploratory research (Eisenhardt 1989; Eisenhardt and Graebner 2007). The transcribed

interviews and other information collected were coded in NVivo 10- a qualitative analysis software developed by QSR technologies. The themes from different interviews were compared to find emerging themes and also mapped with existing literature to develop new theoretical knowledge. As the external validity of the research is contributing to the theory and practice (Yin 2013). The themes pertaining to the reverse value chain of clothing can be generalised to the other industry. Beside this findings can be generalised to the other social and geographical setup too (Cho and Trent 2006).

As Glaser and Strauss (1967) have suggested a structure for the study, this study have chapters and subchapters as mentioned in Table 1-1. The aim of the structure of thesis is to theorize findings in chronological order. The chronology is the easiest way of exploiting or arrangement. This is also called establishment of a temporal connection (Mandler 2014). An attempt has made to make description and arrangement of thesis coherent. The thesis is concluded by suggesting model, implication and future direction (Czarniawska 2014: 124). The literary notion of thesis arrangement or plot is to highlight the contribution of research work in the form of theoretical and managerial contribution (Polkinghorne 1988). It is important for the thesis to be well intact and connected to each other. The strategy of embedding (subordination) has been used by setting chapters and subchapters (Todorov 1977). This outcome embedded in thesis have a structure and subordinated to one another in the form of a sequence. The outcomes of gap identification from literature review determine the mix methodology adopted in current research. The reuse-based model for apparel industry is developed (Mandler 2014) and analyses with the help of qualitative and quantitative techniques.

3.5 Analytical Modeling Techniques

3.5.1 Multi-Criteria Decision Making (MCDM)

In the recent days, multi-criteria decision making (MCDM) has received considerable attention from scholars. MCDM techniques enable the decision maker to advance problem-solving where several criteria must be taken into account for decision making (Staikos and Rahimifard 2007). MCDM was introduced in early 1970, and since then a number of theories and models have been developed for decision making. MCDM is concerned with structuring, planning and solving problems that involved multiple criteria. These multiple criteria could be used to solve complex issues or problems that could affect several partners (Carlsson and Fullér 1996). MCDM utilises the knowledge from several fields such as mathematics, behavioural decision theory, economics, computer science and information technology. This method classifies alternatives in a small number of categories and rank alternatives as subjective preferences. Sometimes these subjective subjective data are imprecise, uncertain and indefinite that is difficult to analyse. The fuzzy tool has been found useful to deal with these complex decision-making situation (Bellman and Zadeh 1970). MCDM and Fuzzy logic have been used together for techniques such as; analytic hierarchy process (AHP), a technique for order preference by similarity to ideal solution (TOPSIS), analytic network process (ANP), vlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) and decision making trial and evaluation laboratory (DEMATEL). The degree of fuzzy logic applications are differ for each of MCDM techniques (Asemi et al. 2014).

The analytic hierarchy process (AHP) is widely acceptable multi-criteria decision-making technique, which includes subjective and objectives measures (Saaty) AHP offers the hierarchical procedure to control the consistency of evaluation criteria and decision alternatives.

The analysis of decision problem in the AHP can be done by four steps (Govindan, Sarkis, and Palaniappan 2013).

Step 1: Identification of factors/sub-factors

The relative importance of factors/sub-factors is rated by using pair-wise comparison. Matrix set up to compare factors/sub-factors to each other.

$$A = a_{ij}\,(i, j = 1,2, \ldots\ldots, n)$$

$$\begin{bmatrix} 1 & & a_{1n} \\ & 1 & \\ a_{n1} & & 1 \end{bmatrix}$$

Where a_{ij} is an integer and $0 < a < n$.

Step 2: Normalized the pair-wise comparison.

Divide each entry by the sum of all entry of its column

$$\frac{a_{ij}}{\sum_{i=1}^{n} a_j}$$

Calculate the average of each of the row by dividing the sum of row by number of elements of a particular row

$$\left(\frac{a_{i1}}{\sum_{i=1}^{n} a_j} + \frac{a_{i2}}{\sum_{i=1}^{n} a_j} + \ldots\ldots\ldots\ldots + \frac{a_{in}}{\sum_{i=1}^{n} a_j}\right)\frac{1}{n}$$

Step 3: Perform pair-wise comparisons for each of alternative for particular sub-factors. The pair-wise comparison for alternatives should be normalized.

Step 4: Rating derived from step 2 and step 3 need to be combined to calculate an overall rating for each of alternatives.

$$R_i = \sum S_i A_{ij}$$

Where:

$R_i =$ Overall relative rating for factor i

$S_i =$ Average normalized weight for factor i

$A_{ij} =$ Average normalized rating for factor j with respect to factor j

3.5.2 Genetic algorithm

Genetic algorithm (GA) is an artificial intelligence and mathematical optimization technique that has repeatedly been used to solve a problem more quickly when classic methods are too slow. GA is inspired by the biological mechanism of natural evolution from one generation to another to generate a best possible solution. The new solution is obtained through three steps i.e. selection, crossover and mutation (Tseng, Chang, and Li 2008). At the selection phase, two parents are selected based on their suitability or fitness. In the next step, selected parent crossover or reproduced to obtain new individual. During crossover half of two or more parents are swapped to create a new solution. The third step is a mutation to bring small tweak or improvement in the new individual. Mutation is applied to bring diversity to the existing population (Kurniawan et al. 2014). Genetic algorithm methods can be used for grouping irregular shape at an optimal level (KARGAR and PAYVANDY 2015). It is difficult to achieve

the best grouping through the manual method of hit and trail. The heuristic approach of genetic algorithm can achieve best fit to the group (Fischer and Dagli 2004; Junior, Pinheiro, and Saraiva 2013). In interactive genetic algorithm (IGA) the user can give fitness to each individual instead of the fitness function and can also interact with the individual. Thus IGA can receive input from the user and interpret user information, therefor IGA is better than GA tool (Kim and Cho 2000). In the recent days, the approach of genetic algorithm can are also used in the textile industry to solve various problems (Leo Ho Wai and Wallace 2003; Wong and Leung 2009). Yang and Lin (2009) have used a genetic algorithm in the footwear industry to solve pattern problems.

Modularization technique is widely useful and accepted method for the product design and manufacturing to improve the performance of supply chain. It is wise to reduce the large system into small subsystems due to the rise in the complexity of product design and manufacturing. Under the concept of modularization, the small and simple process is also clustered into subassemblies for easy handling. In the modular structure, a functional unit is treated as sub-parts with few interactions between sub-parts. There are numerous benefits of modularizations such as improvement in the manufacturing efficiency, supply chain efficiency and overall effectiveness. Modularization technique has evolved over a period of time and can be categorized into three categories: 1) Matrix-function classification, 2) Cluster-graph-math-artificial-genetic classification, and 3) Sustainability classification (Ma and Kremer 2015). Matrix method uses clustering technique to sort components into different product module. Function method breaks down complicated function to generate subsystem or module (Zhang and Gershenson 2003). Clustering method helps in the formation of group components on the basis of similarities and differences. Graph method uses matrix technique to sort and create a module. Mathematical programming uses operation research technique to form group or module.

Artificial intelligence technique uses computer science knowledge to cluster the components. Similarly genetic and heuristics methods are also used for module forming (Jose and Tollenaere 2005). Social, economic and environmental aspects of sustainability can also be considered to create module or classification (Ma and Kremer 2015).

Modularized system is the concept that draws its foundation from intelligent design system. This enables the manufacturing process to achieve high quality and shortened design and manufacturing process. The system of modularity also provides flexibility for the disassembly and redesign after the end of life (EOL) (Lu et al. 2010). Discarded product after the end of life can be beaked down into parts or components to encompass unused value associated with it. There are different EOL options available for the retired product such as reuse, remanufacturing, up-cycling, down-cycling, landfill and incineration. The concept of modularization maximizes the use of a part or set of parts extracted from a product. The module structure enhances the performance and sustainability (Ma and Kremer 2015). Modularization design strategy standardized the design process for the mass customization. Under the concept of modularization, one part can be fabricated into more than one product. This strategy has been successfully adopted and implemented by the electronic industry. Modularization is the technique for the product and process redesign formalization to reduce the parts or components variations (Wadhwa et al. 2006). An intelligent garment design process on the basis of modularization technique has been used by (Zhou et al. 2016) for flexibility and user-friendly design process.

3.5.3 Markov Principle

A stochastic process can be represented by $Y = (Y_n, \mathrm{n} \in \mathrm{I})$ where Y_n is a random variable for each $\mathrm{n} \in \mathrm{I}$. For Y to be stochastics the value I of should be infinte. Stochastics process can be

divided into discrete and continuous. A discrete stochatstic process can be represent by $Y = (Y_n$, n = 0,1,2, ……), where n is non negative number and X will have discrete random variables. For a continuous stochastic process $Y = (Y_t, 0 \leq t < \alpha)$ n is non-negative real numbers and can X have continuous random value. A markov chain is a discrete time stochastics process therefore have countable states. A sequence of random variables Y_0, Y_1.....with value in countable set X is a Markov chain if at anytime n, the present states Y_{n+1}, Y_{n+2}.....is only depend upon the previous states Y_n, Y_{n+1}.....values (Serfozo 2009).

A stochastic process $Y = Y_n : n \geq 0$ with limited set Y can be called Markov chain for any state $i, j \in$ X and $n \geq 0$ if,

$$P\{Y_{n+1} = j | Y_0, \ldots, Y_n\} = P\{Y_{n+1} = j | Y_n\} \quad (1)$$

$$P\{Y_{n+1} = j | Y_n = i\} = p_{ij}$$

Where p_{ij} is probability of transition from i to j state in the Markov Chain. For any state sum of all outgoing probability will be one. This can be represented by $\sum_{j \in x} p_{ij} = 1, \ i \in X$. Equation (1) depicts Markov principle as future state $Y_{n+1}$is only depends upon immediate current stage Y and independent of all previous stage $Y_0, \ldots., Y_{n-1}$ and the value of $Y_n \in$ X. As discussed state X is finite and countable, which can be written as $X = \{X_1, X_2, \ldots, X_r\}$ or $X = \{1, 2, 3 \ldots . r\}$. Transition matrix T for Markov chain consists of all transitions probability and can be denoted as below:

$$T = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1r} \\ p_{21} & p_{22} & \cdots & p_{2r} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ p_{r1} & p_{r2} & \cdots & p_{rr} \end{bmatrix} \quad (2)$$

T is stochastic matrix because the sum of any row will be 1. A state, $i \in X$ is called transient if $p_{ii} \leq 1$and absorbing if $p_{ii} = 1$. It is not possible in a Markov chain to come out from the absorbing state, once reached there. In a Markov chain there should be at least one absorbing state and it should be possible to reach to the absorbing state from all the stage (Sericola, 2013).

A Markov chain can be determined by state and transition matrix. In the beginning or at starting state at $= 0$, state probability matrix is $v^0 \in X$. Then future state matrix after n transition at the time $t = n$, v^ncan be calculated with the help of transition matrix T as follow:

$$v^1 = v^0 T$$

$$v^2 = v^1 T = v^0 T^2$$

This can be generalised as follow for the transition:

$$v^n = v^0 T^n \quad (3)$$

In finite Markov process, state matrix can be calculated using above formula (Pickl, 2011).

3.6 Ethical considerations

Maintaining ethicality at all levels is considered as an integral part of any research. The present research was also carried out with a few ethical considerations as (i) the confidentiality and anonymity of the respondents was maintained (ii) the participants interview and filled the survey

on the voluntary basis (iii) the participants were briefed about the broad objective and background of the research to provide clarity to them (iv) it was ensured that the way of analysing the results will not harm respondents in any way (v) consent was taken from each of the respondent before recording the interview (vi) the interview protocol was designed in such a way so that it should not harm the privacy of the respondents and (vii) it was ensured that the data collected from the respondents in any form will be used only for academic purposes and will not be misused.

3.7 Chapter Summary

The chapter presented the philosophical and methodological approach adopted for conducting current research. This thesis has adopted an authoritarian approach to summarize the existing knowledge. Subsequently, the case study based exploratory approach is adopted to document the practice. Phenomenological approach is chosen to further refine knowledge through logical interpretation. Qualitative techniques in the form of multiple case studies have been used to analyse the apparels reuse in closed loop value chain. The data collected in the form of interviews, observations and documents from European and Indian companies are presented in details for the evidence. Abductive reasoning was adopted to build theory form the case study. The case is supported with quantitative technique to provide logical interpretation of knowledge. Finally, this chapter demonstrated data analysis to draw conclusion. The next chapter will present the findings from exploratory case study.

4 Chapter: An Exploratory Case Studies of Charity Organizations

The aim of the multiple case studies is to understand the practice of apparel reuse across different settings and identify unique patterns to develop a holistic model. The findings from each of the cases are presented in the form of descriptive write-ups to get insights from the cross-case analysis. An overview of the organization and the respondents are presented at the beginning of each case. The reverse logistics of apparel is considered as the main focus of study in each of the cases. The findings will be discussed by broadly categorizing the reverse logistic operations into the collection, sorting and value creation through reprocessing

4.1 Swedish Local Charity Organizations

The case study is based on the local charity organizations located in the north-west part of Sweden. The chapter deliberates about the three stages i.e. collection, sorting and reprocessing (repair/redesign). An overview of the organization and the respondents selected for the current case study is shown in the below Figure 4-1:

Local charity (S1)	Local charity (S2)	Local charity (S3)	Local charity (S4)	Local charity (S5)
•Founder •Chief operating officer	•Founder	•Founder	•Founder	•4 Managers (group interview)

Figure 4-1: An overview of the respondents from Swedish charity organization

4.1.1 Case Description

The charity organization S1 was started almost 10 years back to provide relief to the people of Russia. Earlier, the founder of the organization S1 was involved in different charity operations in the eastern and northern Europe. The S1 charity operates from two nearby locations from the

industrial area of Boras municipality. The population of Boras municipality is approximately one hundred thousand. The organization S2 has started its operations to support children and old aged people of Latvia. Used apparels and old furniture are collected from the households and the money earned from the sale of these products is utilized for building schools, hospitals and houses for the homeless people. With an initial economic support from EU, the organization S2 started its operations. Organization S2 is located in a small town which falls under Limmared municipality. The population of the Limmared town is approximately eleven thousand. The charity organization S2 which was founded in the year 1997 is involved in the business of used textiles since 2001. The organization's warehouse and second hand retail shop is located in the industrial area at the outskirts of the city. The organization has established a good trust and relationship with government of Latvia and Sweden in last 20-year operation. The charity organization S3 is located at a small town in Fristad municipality. The total population of Fristad town is five thousand. The founder of the charity S3 is associated with international charity organization since 1976 and that was the main reason for starting S3 under the umbrella of an international charity organization in the year 2001. The charity organization S3 is located next to the railway station and near the city center which is one of the prime locations in the city. The charity organization S4 works under the same international charity organization as S3. The charity S4 is located in the city of Boras. The organization S4 started its operation in 2004. The prime aim of the organization S4 was to provide a meeting place for the people who live without family. There is a dedicated cafeteria section in the organization where people meet and chit-chat. The organization S5 is a local government-run charity organizations. S5 was started in the year 2002 in the Boras city. The prime objective of the organization was to provide a workplace for the disabled people. The municipal based charity organization S5 has a collaboration with a

famous international charity organization to perform its operation of used clothing. The organization S5 also receives logistics support from the sister charity organization which also works in that particular municipality. Table 4-1 provides brief details of the charity organization considered for the current study.

	Organization S1	**Organization S2**	**Organization S3**	**Organization S4**	**Organization S5**
Location municipality	Boras	Limmared	Fristad	Boras	Boras
Organization Affiliation	Individual	Individual	International Charity Organization	International Charity Organization	Local Municipality
Profit/year (SEK)* in 2014	1.5 Million	1.4 Million	25,000	Nill	NA
Area available (Square meter)	1500	1600	300	500	500
Manpower working	Employee: 7 Volunteer: 10-15 Municipality/Job Agencies: 10	Employee: 5 Volunteer: 60-70 Municipality/Job Agencies: 5	Volunteer: 30	Volunteer: 35	Employee: 4 Municipality: 20
Main products	Furniture, Clothes	Furniture, Clothes, Accessories	Clothes, Accessories and Crockery	Clothes, Accessories and Crockery	Clothes, Accessories and Crockery
Main functions	Collection, Sorting and Sales	Collection, Sorting and Sales	Collection, Sorting and Sales	Collection, Sorting and Sales	Sorting and Sales
Operation focused	Russia(now Ukraine)	Latvia	Meeting Place/ Earn Profit for an international charity organization	Meeting Place/ Earn Profit for international charity organization	Provide place to work for disabled person

Table 4-1: **Profile of organizations chosen for the case study**

4.1.2 Collection Process

The charity S1 collects different kinds of household items like furniture, textiles, clothes, toys, electronic products, books, utensils, music CD, and DVDs. Collection of discarded products at the S1 stores is one of the most popular ways to collect discarded items. In addition, at several times, employee of S1 also visit door to door to collect the discarded items. Besides this, S1 also receives factory leftovers in the form of fabrics and trims from the local clothing manufacturing company at regular intervals. They have allocated a separate section to sell these fabrics and trims in the store.

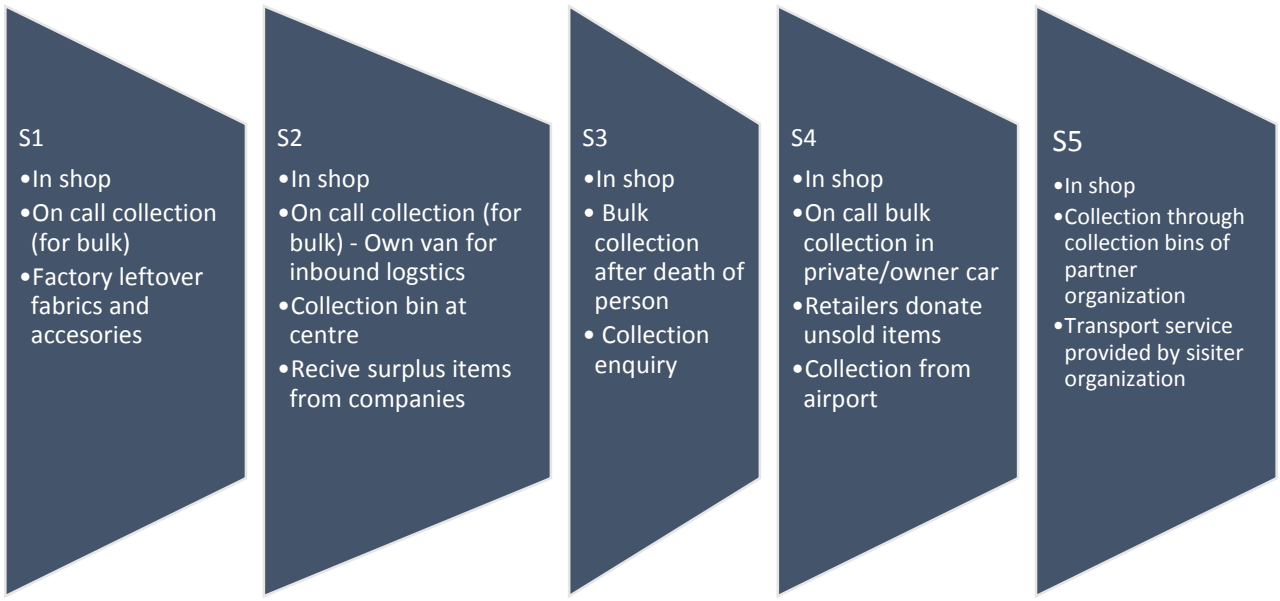

Figure 4-2: Mode of the collection in Swedish charity organizations

Most of the time the donor drops the clothes which he would like to donate to the shops. The organization S1 does not accept dirty, smelly or unwearable clothes. The in-house collection by van is carried by the company for bulk donations only. Interestingly, it has been shared by the store manager that after the death of a person their children donate all of their parents belonging to us. This includes clothes, furniture and all other household items.

S2 receives a good amount of collection because it is located on the outskirts of a small town and there is no other charity organization in the vicinity. The organization has relatively better infrastructure facilities in the form of their own warehouse where the two floors are exclusively used for the storage and sale of clothes and other household items. Furniture is stored and displayed in the basement for sale. Availability of company-owned van for inbound logistics and truck for outbound logistics provide an ease of collection and transportation of goods. At present collection is done in the vicinity of 10-12 kilometre area and clothes are distributed among 6 charities organizations in Riga, Latvia. These charities further donate goods to the people in need and sometimes directly give donations to schools and hospitals.

Organization S3 mainly operates from the collection done at their shops. The donor visits shops and donates goods at the counter. At several times even local inhabitants come and inquire about the procedure and the kind of items accepted at the organization. Similar to S1 the organization S3 receives bulk collections after the death of a person. As founder of the organization S3 demonstrated:

> *"Recently someone has died in my sister family and all of his belongings (which includes, clothes and other household items) are donated to our shop."*

These kinds of donations are a source of bulk collection for S3. However, the founder of S3 highlighted the importance of their own vehicle but at the same time stated the inability to afford to own transportation facilities. The need for training is also highlighted to increase collection. The organization S4 also works under the same international charity organization. Along with in-shop collection, the founder of the S4 personally visits donors on call for bulk collection. The

founder of organization S4 also receives a call to collect unsold clothes from the retailers. As S4 founder told:

> *"Today I got a call from an e-retailing company and want us to get new clothes from them. But I cannot show you the name of the company. Because maybe they do not want us to share company name"*

However, the retailer does not want to disclose the name to maintain confidentiality. Beside this S4 also receive a collection from the airport authority, as stated by founder:

> *"Sometimes people leave or forget clothes when they fly from Landvetter airport (nearest airport). I go to Landvetter every third week to collect clothes from the airport authority."*

The charity organization S5 has collaborated with a multinational charity organization to collect used clothes from local inhabitants. There are 5 collections bins installed at the different place of the city. The sister organization of S5 helps to bring all collected clothes from collection bins to the shop.

4.1.3 Sorting Process

The S1 organization receives a significant amount of collection but not able to store clothes due to space and manpower limitation in the warehouse. The sorting of clothes is mainly done on the basis of quality i.e., into export quality and domestic quality. Domestic quality clothes are further categorised into different sub-categories such as men, women and kids. These clothes are not sorted according to style, price or functionality. Export quality is categorised into summer and winter collection. Only good quality products are kept at the second hand store located in Borås, Sweden. The charity organisation also has a shop in Finland. Majority of the inferior textile

products which is not found suitable for the domestic sales are sold to African dealers. As founder of S1 explained:

> *"For export baling is done, each bales weight 45 kg which is prepared on the basis of colour and type of garments. Generally, summer clothes are dispatch to Africa. While winter clothes are delivered to Romania and Finland."*

Only white and coloured clothes are categorised in order to make bales before shipping to African traders.

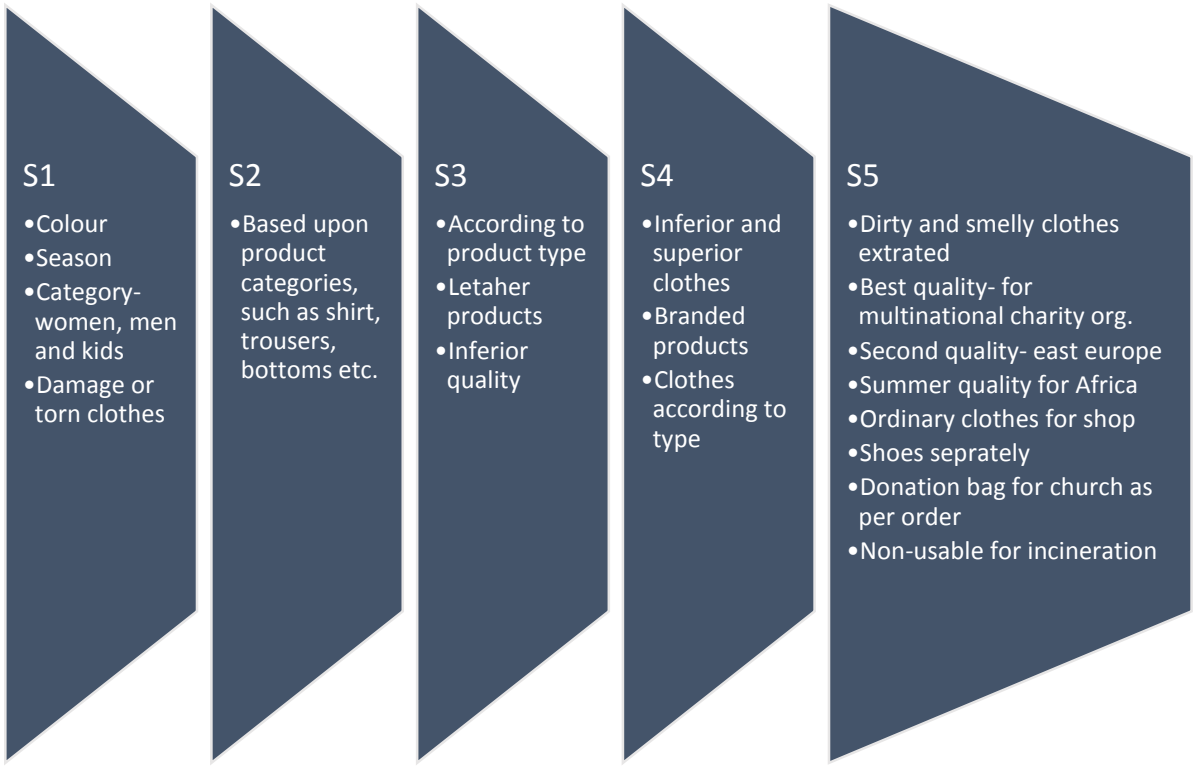

Figure 4-3: Sorting process at Swedish charity organisation

Organization S2 performs sorting of clothes based on the garment types such as a shirt, trousers, and skirts. There are no fixed set of rules that are followed for sorting as it is primarily

performed by an individual employee. The decision to put clothes into a particular category is done by subjective evaluation of the single person. Good quality of clothes is taken out for sale in the shop and other sorted clothes are kept in the cartons. Organization S3 has limited space to store and sorts clothes. However, all clothes are sorted as soon as clothes are received and stored according to products type (leather-based product stored separately) in different cartons. The inferior quality goods are kept separately and transported to the multinational charity organization's central warehouse in the nearby city. Similarly, organization S4 performs sorting operations at the basement of the store and decides on what to sell and what to send to the central warehouse located in the Gothenburg. As founder of the organization S4 states:

> *"We delivered unsold garments to the central location of multinational charity. Which then further put in a bigger container and transported to Holland."*

The sorted clothes are categorised into product types and displayed in the store for sale. The organization S5 has better sorting process as compared to the other organizations. Each collected bag is received in the sorting area that weighing almost 20 kg. One volunteer opens the bag and drops clothes on the sorting tables. Initially, all dirty and stinking clothes are taken out. Then one of the employees look on the clothes and segregate clothes according to the category. The organization has a different category for sorting. The finest quality clothes are separated for multinational charity organization shops. Then second quality goes to east European countries such as Poland. Summer clothes category is generally prepared for export to Africa. Shoes are stored in one bag. For the donation to church or emigrants purpose, bags are prepared as per order or their requirements. Ordinary clothes are kept for sale in the store. Non-usable clothes are moved to energy station for the incineration. The organization S5 receives 2 SEK for each

kilogram of sorting from the multinational charity organization. On average S5 is able to short 800-1000 kg of clothes every week.

4.1.4 Value Creation through Reprocessing

Every organization is trying to extract maximum monetary value from the collected clothes. for the Swedish charities, the main source of monetary gain is the money earned from the sales of second hand clothes. Price of products is an important factor that determines saleability of used clothes. Better products at a lower price are easily purchased by customers for e.g. high fashion or vintage clothes are picked by the consumer at first sight only. The organization S1 sales used clothes at a basic price as explained by chief operation officer:

> *"In our shop in Sweden, the price is very little i.e. 20 SEK. Even similar in Finland. Export to Africa is done at clothes (7 SEK/Kg), footwear (6SEK/kg), and other textile material (5 SEK/kg)."*

However, the organization told that the African dealers want to take everything but do not want to pay for the goods. This is the reason S1 tries to sell more in domestic markets and earn profit to run various projects.

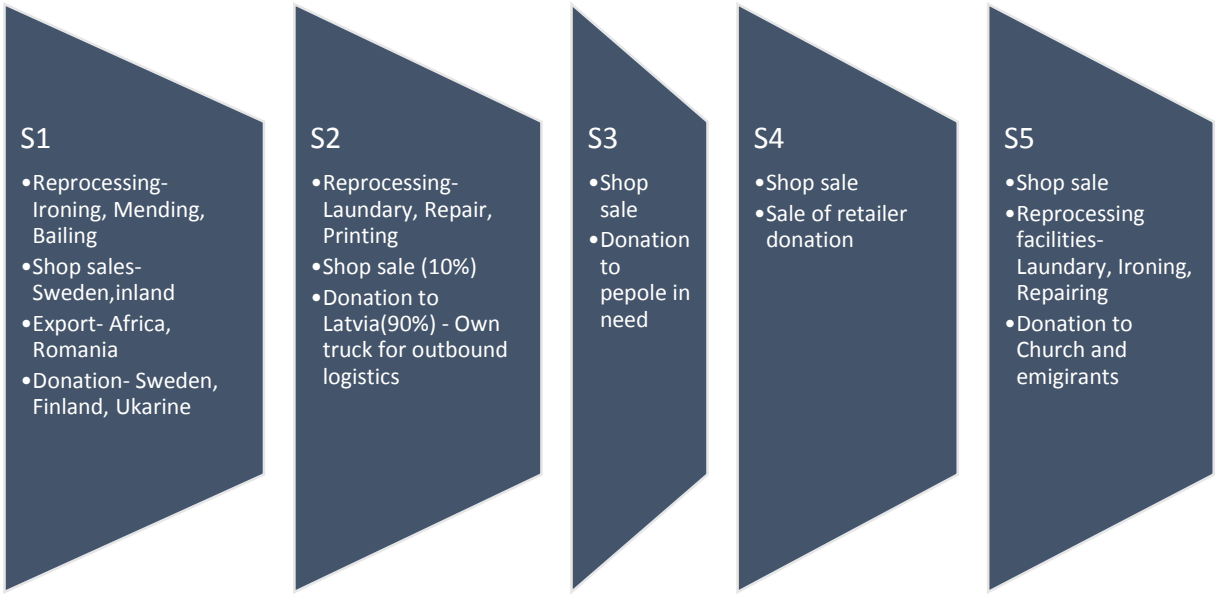

Figure 4-4: Value creation activities at Swedish charity organisation

A significant amount of progress has been made by the organization S2 in the recent years in terms of clothes donation, for example in the year 2009, 450 meter^3 used products were delivered to Latvia. This has increased to 750 meter^3 in 2015. Similarly, money earned from the sale of the used product has been increased from 600,000 SEK to 2 Million SEK from 2009 to 2015. S2 tries to restore value and perform value addition by washing, repairing and printing. S2 found that nowadays competition exists in the second hand clothes market. Trousers are sold at the price of 60 SEK, while t-shirt at the price of 40 SEK.

The main source of earning for organization S3 is from the selling of used clothes. Different colour of price tag is marked according to the household products. The group of volunteer decides the price for clothing. As founder of S3 demonstrated:

> *"Different colour sticker is put on household products like a red sticker for 5 SEK and yellow for 10 SEK. The price for clothing product such as children jackets 50 SEK, teenager jackets 50 SEK, for long dress 100 SEK and for Suite 100 SEK."*

All unsold items are transported to the central location of the parent organization. S3 needs to pay transportation charges for the movement of clothes. Hence, to increase the sales, S3 gives discount up to 50%, especially during Christmas festival. S4 and S3 are working under the leadership of same charity organization. Hence, S4 is also trying to sell maximum to increase revenue and minimise transportation cost on the unsold items. In the S4 shop, good branded clothes are sold at the price of 100 SEK while simple products like t-shirt are sold at 10 SEK. Another normal product is sold at the price of 40-50 SEK. Charity organization S5 sale basic garments such as t-shirts at the price of 25 SEK, while other products like jackets are sold at 200 SEK. All the profit earned from the sale of second hand clothes goes to the multinational charity organisation. The organisation provides basic repair facilities such as broken stitch or buttoning. One of the managers at S5 told:

"We prepare a packet for newborn baby with different clothes for Mozambique."

Used clothing companies receive a huge amount of collection of baby clothes as the clothes are discarded once baby grows up. The packet prepared by S5 for Mozambique is a good solution for the collection of baby clothes. S5 also receive the laundry order from companies to clean dresses, towels and other textile materials. This is also an important source of earning for S5.

4.1.5 Other Important Findings

Besides the process of collection, sorting and value creation, a few important observations are imperative to be mentioned in this subsection. Such as the charity organization S1 trying to reach to the customers via various innovative approaches such as through feedback form. As per feedback from the chief operation officer:

"In last three weeks. 26 people visited our shops on the basis of mouth publicity. 5 people by seeing an advertisement in newspaper. 6 people came here by seeing our websites internet. 23 by seeing signboard on main road and 1 by seeing an advertisement at a public place."

The S1 charity performs these kinds of activities to reach to the people. Mouth to mouth publicity is found to the most effective method as some of the donors came and donate the furniture by hearing about the organization from others. Factory leftovers are received from the nearby garment manufacturing company are also huge in demand. This has been observed that people are frequently visiting leftover sections of the shop and searching for the right colour of zipper for their bags and jacket. One other interesting fact that was found at S1 is about the indirect assistance of local government. As founder of S1 illustrated that:

"Government pays money for a prisoner who worked in the organization. We have one such person working in the organization. Similarly, we have one Narcotic/Alcoholic person working in our organization. Beside this we also have employed some unskilled and untrained person for them job agencies provide 80% of the salary".

This is found to be a substantial indirect support for the organization from the government. S1 has also employed 7 employees on the payroll. For the better working condition, the organization has planned to move to a bigger space.

Similarly, in the S2 charity organization, prior to 2009 there were 15 volunteers and 2 employees, now this has been increased to 4 employees and 60-70 volunteers. In addition, 4-5 disabled and unskilled person work in the S2 for and their salary come from employment agencies and the local government. The organization S2 is able to receive good financial support from Swedish government organization The founder of this organization stated

"We receive 500,000 Kronor from social department Stockholm each year for social work. Local government gives 600,000 kronor for employing disabled people and. from employment agencies we are getting almost 200,000 kronor for employing and training unskilled and unemployed person.

The organization S2 is financially sound under the effective leadership and good relation with Swedish and Latvia government. Founder of the organization states:

"This (2015) year, 1 Million 40 thousand are saved after all payment."

Most of the money is spent in Latvia, but sometimes if required money is spent in Sweden also. Recently, S2 has spent money in building old age home and repair of school in Latvia. The organization S2 also promotes internship for school students. School students from Latvia come to Sweden to get exposure to education and culture. Similarly, Swedish Students also go to Latvia under the guidance of S2. These kinds of activities attract attention from media that helps organization S2 to build a good image.

The founder of the S3 organization was associated with an international charity organization since 1976. Therefore, it was personally important for him to open charity organization under the umbrella of an international charity organization. The organization was started in 2001 in a small town Fristad and has received an initial startup finance and administrative support from the international charity organization. The main aim of the organization was to provide a meeting place for the homeless people. There are approximately 280 similar meeting places and shops currently available across Sweden. The charity organization also invites a different group of people to the shop, for example, the founder of S3 told:

"Every Tuesday afternoon group of 10-15 ladies come here and knit for small baby. Knitted clothes are given to hospital or mother who does not have money to buy clothes."

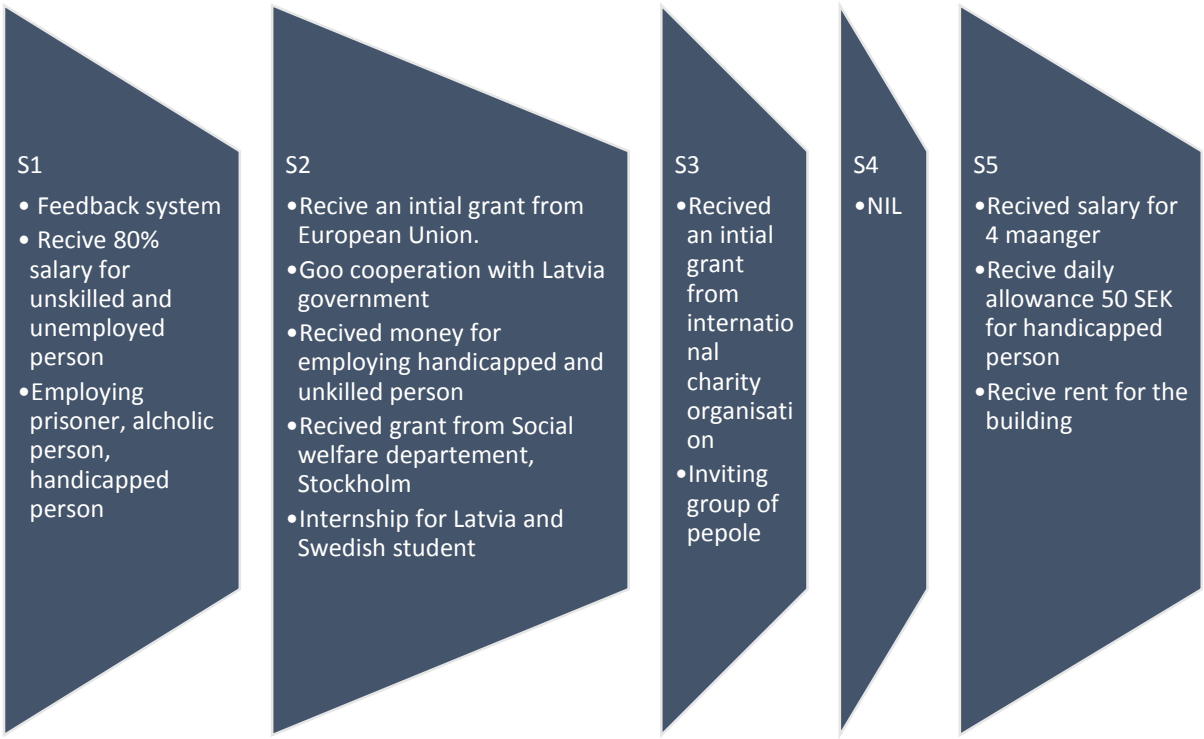

Figure 4-5: other important findings at Swedish charity organisation

Even though S4 works under the brand name of same multinational charity organization as S3, but have not highlighted any unique findings. As S5 is a municipal organization and receive all kind of financial support from the local municipal organization such as rent, employee salary and a daily allowance of 50 SEK is provided to the physically challenged people.

4.2 European Multinational Charities Organization

This study is carried out to understand best practices that exist in the apparel reuse business. The European Multinational charity case study has documented the collection, sorting and value creation activities carried out by the large and international charities. This section aims to further advance knowledge gained from the first case study by documenting the practice of multinational charity organization. Multinational charities have a better understanding of used clothing business and value creation. The details of each multinational charities and respondents are depicted in the below figure:

Figure 4-6: An overview of the respondents from European organizations

4.2.1 Case Description

The majorities of organizations selected for the current case study are located in Sweden while three companies located in United Kingdom and one in Norway. Among 10 selected companies for the current study, 7 seven are non-profit charity organizations. Whereas two of the

organization i.e. E3 and E5 is for-profit organization and E7 is recycling mall work under the local municipality. E3 and E5 are not charity organizations, therefore these two organizations are selected to achieve theoretical saturation pertaining to apparel reuse business. Organization E1 is multinational charity location and started operation from Gothenburg, Sweden from 1965. The organization has well-established system of collection, sorting and redistribution to different shops. Organization E2 is a sister company of one of the famous charity organization engaged in the used clothes collection and sorting. The charity organization E2 is a most famous organization in Norway and manage collection of clothes from all over Sweden. E3 is profit making organization located in Stockholm, Sweden. The organization has a very long success story in the paper recycling and recently entered in the textile recycling. The charity organization E4 is one of important non-profit organization involved in the collection of used textiles in Sweden. The organization has a registered office in the capital of Sweden and recently started sorting operation in Jonkoping, Sweden under an agreement with the local municipality. E5 is profit making used clothing organization. The organization collects clothes in London and sale to company-owned shop in France and export to developing countries. Organization E5 is 30 years old privately owned company. While all others organization studied are registered charity organization except E3 and E5. Hence, these company pays all taxes as per legislation. The charity organization E6 and E2, work under the same international charity organization. E6 has a huge presence in Sweden whereas E2 has a huge presence in Norway. There are multiple collection point and sorting station in Sweden for E6. The sorted clothes are sold to different second hand clothes shops owned by organizations. E7 is working on a novel and unique concept called recycling mall. The recycling mall located near district energy station, where a consumer can donate used clothes and other household items. The donated clothes and other items are

sorted and sold in the second hand shop located in the same mall. E8 is one of the oldest charity organizations in Stockholm. The clothes are collected through various events and sold in the shop and exported to developing countries. The charity organization E8 has a separate division to perform redesign activities. Recently a redesigned store is also opened at a central location near Stockholm train station. The charity organization E9 is also working under a multinational charity organization. E9 works under a multi-charity organisation which is one of the largest collectors of used textile in the UK. The sorted and graded clothes are sold through company-owned shop, online shops and also exported to developing countries. The charity organization E10 located in central London. The organization collect clothes and sale through 2-3 company owned shop after sorting and grading. Description of European charity and for-profit are summarized in below Table 4-2:

Table 4-2: Descriptions of the European organization

Organizations	Location	Main products	Operation focused	strengths
European Organization1 (E1)	Gothenburg, Sweden	Clothes & Textile, Footwear, and Other Households	Collection, Sorting & Sales(Domestics & Export-EU)	Collection & Sorting
E2	Oslo, Norway	Clothes & Textile, Footwear	Collection, Sorting & Sales(Domestics & Export)	Collection, Sorting, Export
E3	Stockholm, Sweden	Textile, clothes and paper	Collection, Sorting and Recycling	Recycling
E4	Jonkoping, Sweden	Clothes & Textile, Footwear	Collection, Sorting & Sales(Domestics & Export)	Sorting
E5	London, United Kingdom	Clothes & Textile, Footwear	Collection, Sorting & Sales(Domestics & Export)	Export Downcycling
E6	Stockholm, Sweden Gothenburg, Sweden	Clothes & Textile, Footwear	Collection, Sorting & Sales(Domestics & Export)	Collection, Sorting, Sales(Domestics)
E7	Eskilstuna, Sweden	Clothes & Textile, Footwear, Sports, and Construction materials	Collection, Sorting, Refurbishing and Redesign	Collection, Redesign
E 8	Stockholm, Sweden	Clothes & Textile, Footwear, and Other Households	Collection, Sorting, and Redesign	Collection, Redesign
E 9	Leeds, UK	Clothes & Textile, Footwear	Collection, Sorting, and Sales	Collection, Sorting and export network
E 10	London, UK	Clothes & Textile, Footwear	Collection, Sorting, and Sales	Collection, Sorting and domestic sales

4.2.2 Collection:

Organization E1 collects clothes from in and around Gothenburg. E1 has collaborated with small charity organization in different municipalities which are commonly called friend organizations. Logistic manager of E1 has explained about collection method as follow:

> *"There are small bin and large bin used for the collection. Collection from small bins goes to friend organization in particular city. While large bin collections are brought to the Gothenburg sorting station. Collection done at Malmo directly exported without sorting to Poland buyer."*

The friend organization of E1 sorts and grade clothes for the E1 in different municipalities and received a fixed amount for each kg of sorting. The organization E1 has own transportation to perform collection as demonstrated by the logistic manager:

> *"We have 2 Big trucks and 4 small vans are used for the collection. Trucks are used to load the bin directly from the large collection box. While Van is used to collect bags from small bins."*

Organization E2 has adopted almost all innovative techniques to do collection along with a conventional way of collection such on the shop, collection bins etc. Recently organization E2 has collaborated with postal department to receive used clothes through postal services from the consumer. In addition, they have also collaborated with a local collector. As explained by E2:

> *"We have some partner; they do a collection for us. These are some companies located in the far area and some people working for them"*

These partners are collecting from those places where few people live. Even some of the partners are using the ferry to transport back goods to the central location. Organization E3 is trying to improve quality of collection for recycling and reuse. Collection manager of E3 highlighted:

> *"Professional organizations like us face problem due to Cherrie picking by charity organizations from second hand clothes."*

Organization E3 is in talks with a housing association to receive clothes directly from the end user. Organization E4 has collaborated with local municipalities for collection and sorting of used clothes. Organization E4 has installed collection bins at various locations in the city. The municipal organization is responsible for inbound logistics of clothes from collection bins to sorting station. Organization E5 is a profit making organization and hence, primarily focus on good quality of the collection. Organization E5 has an agreement with more than 1000 schools, some private firms and municipalities. E5 organize information session for students to highlight the benefits of reuse and recycle. As per owner of E5:

> *"This has been observed that primary school are better in donation than secondary school. Maybe in secondary school students are not feeling comfortable in carrying old clothes bag to school."*

There are in total 600 smaller bins and 250 larger bins placed in all over London. The organization E5 pays a fee to different private firms and municipalities, which varies and depend upon the amount of collection and season. Altogether 16 vans and trucks are used to bring the collection to the factory from different collection points. Organization E6 is much more focused on collection, sorting and sales. To improve the quality of collection the organization is organizing different kinds of collection events such as pop up collection similar to pop up sales

apart from doing collection from traditional means i.e. through larger and smaller bins. Collection manager at E6 tried to implement various innovative approaches but all methods are not successful as demonstrated by her:

> *"We have tried to collect from the office of different companies, like bigger company and bank. What we found out that volume is not comfortable. It means we cannot go to the office to pick up a bag of 2 Kg. For us is important to get volume. We also have some cooperation with some retailers. We have our containers in their store. But it is not profitable."*

Recycling mall E7 has collection area on the ground floor for the individual resident. E7 does not accept industrial waste. A person can drive through the mall to drop unwanted goods. There are total three collection points, which accept the donation. The first collection point is meant for all hazardous products. While collection point no. 2 is opened in winter while collection point no. 3 is accepting all kind of items during summer. Mall accepts all kind of items including textiles and furniture. Apart from the in-house collection, Organisation has two collection bins located at a nearby city. Stores are not allowed to receive a direct donation in the mall store. Adjacent to the mall, there is recycling station where one can drop all kind of a non-usable waste. Organisation E8 do not collect through collection bins. The organization E8 advertise about collection events on their websites and request inhabitant to come and donate clothes. Organization E9 and E10 also do most of the collection through collection box and on shop collection. However, they are trying to use another innovative method to do collection also. A different approach has been adopted to achieve competitiveness. Organization E1 has collaborated with local municipality for collection, while organization E6 and E8 organizes collection events.

4.2.3 Sorting:

The conveyor belts are used for the sorting in the E1 organization. However, the decision about the category is made manually at three points. At first point, export quality (Europe and Africa) are taken out. The first stage of sorting is done with the help of elevated work station. The clothes from first sorting station to second sorting station reach via a tubular channel. At the second stage of sorting product are categorized into different types such as trouser, dress, shirts etc. While at the third stage price are marked and product are kept in different boxes according to the category. Logistic manager of E1 has highlighted:

> *"We sort almost 2500-4000 Kg per day in the factory. In the organization we collect, sort and sales."*

Organization E2 is keen on efficient sorting. Companies have conveyer belt system to sort useful clothes for their own store. The reaming unrequired clothes are directly moved down to bailing machines and bales are prepared automatically for the export. Further to minimize cost, E2 is trying to develop one-touch sorting floor. The sorting floor is being designed in such a way, so that export goods will be touched only once throughout all sorting process. Organization E4 also feels the challenge in this business due to the sudden rise of players. To minimize cost and improve operation, the company is thinking to implement sensor-based technology for the sorting process. At present E4 collaborated with local municipalities to perform sorting and provided a complete infrastructure for the sorting process. E4 and E2 are moving towards high and sophisticated technology to improve sorting process, Whereas Organization E5 has moved back to manual sorting to improve efficiency and accountability of employees. Owner of the E5 shared his personal opinion as follow:

"It is almost impossible to get good quality sorting with the help of Infra-red or another automatic sorting."

Organization E5 keep on revising the plan to sustain economically in the high volume and low-income business. For instance, conveyer belt system for sorting changed back to manual in E5. This gives better monitoring of quality and volume of work done by each employee. Organization E6 perform initial sorting at conveyer belt to remove garbage and pick clothes into different categories such as trousers, jeans etc. Defecated or stained clothes are left for export. During the second sorting, the clothes moved to different sections on the basis of its type. At the second stage the quality of clothes is carefully checked and if found unsuitable then moved under export items. The organization E6 is kept on revising sorting categories to fulfil the demand of shops and achieve perfection in sorting process.

The sorting process at E7 is similar to the backend retail operation or distribution. The collectors of donations keep all items into different sections. The shop manager comes and collect the items (clothes) from their sections. The shop manager or owner are not allowed to pick items from unsorted or others sections. Sometimes items are also sorted based upon requirements of vocational design school and handed over to school to perform redesign activities. Mall manager of E7 highlighted as follow:

"Each store receive items based upon their item list agreement. Myself and shop owner has decided item list, the type of items a shop can receive from sorting section."

Organization E8 also have conveyer belt sorting station. Good quality clothes with whole or stain are generally picked up for redesign section. Similar to the all other companies the charity organization E9 and E10 perform sorting with the help of conveyer belt.

4.2.4 Value Creation through Reprocessing:

The charity organization E1 has seven stores in Sweden. Besides the domestic sales, E1 export to Lithuania, Poland and Belgium. E1 is trying to make as much as money possible. E1 also try to get a grant from the government for different welfare projects. This has been observed that Organization E1 is not normally doing repairing or washing operation, even though small-scale facilities are available in the factory. As per logistic manager of E1:

"If clothes are expensive or vintage in nature then only we wash or repair"

The organization is selling good quality clothes in own stores throughout Sweden while export inferior quality goods. Unsorted clothes are exported to East Europe while second-grade goods (after taking out clothes for domestic sales) are sold to the third party located in Belgium. However, the company has collaborated with different municipal organizations to make collection and sorting process cost-effective. Organization E2 is also looking for recycling partner. Organization E2 has quite a different approach to work. The company has a sister company which take care of all export activities. The sister company has focused on European and non-European export. A Sister company of E2 also helps E6 and E8 to export the sorted and unsorted textiles. Various steps have been taken by E6 to improve sales in the domestic and international market. According to collection manager of organization E6:

"Now we are in the partnership with leading retailers. We had a lot of surplus jeans; we figured that is a good item to cooperate with them. That was something

that complementing their customer while we have a surplus, so it was a win-win situation for both of us."

Besides this company also keep on making a new strategy for selling goods in own store. Various new techniques including collaboration with web-based collection platform were done to improve collection. Categories of products are revised to improve sorting technique. Organizations E7 and E8 are giving primary focus on the improvement of used product value. E7 is basically facilitator (like mall management) and try to improve the value of old products by remade or refurbish, while the E8 organization is redesigning new clothes from old clothes. Even organization has developed a new brand for redesigned clothes. Exclusive stores for redesign clothe has opened at a central location in Stockholm.

To improve the value of collected goods, Organization E7 and E8 are involved in redesign activities. Organization E2 and E5 are trying to increase earning by collaborating with other supply chain partners. The E5 organization has also emphasized on down cycling to extract value from waste such as making wipers and rags for the industrial or domestic purpose.

4.2.5 Other Important Findings:

Almost all innovative method of collection, sorting and value creation has been found. For example, E2 collaborated with postal department to receive used clothes packet. New sophisticated technology is under consideration for the effective sorting. For example, E3 is planning to installed infrared technology for sorting whereas E2 is planning to have one-touch floor to minimise material handling during the sorting process. E2 and E5 are down cycling the non-usable clothes and convert clothes to wipers and rags for industrial and domestic use.

Whereas E8 has engaged in upcycling and established own redesign brand and open an exclusive store for upcycled clothes.

4.3 Indian Sorting and Grading Organizations

The economic feasibility of reverse logistics operation seems to be impossible in the developed countries. The offshoring the reverse logistics operation to the developing countries could be a solution. To import and re-export used apparel after sorting and grading is a unique business in India. Under this study, seven Indian companies from Kandla SEZ (special economic zone) were visited and interviewed. To understand the phenomena, one of the Indian EOU (export oriented unit) was also visited and interviewed. Two traders were also interviewed to get an insight on the unique business of sorting and grading. Below figure has summarised details of the selected companies and the respondents:

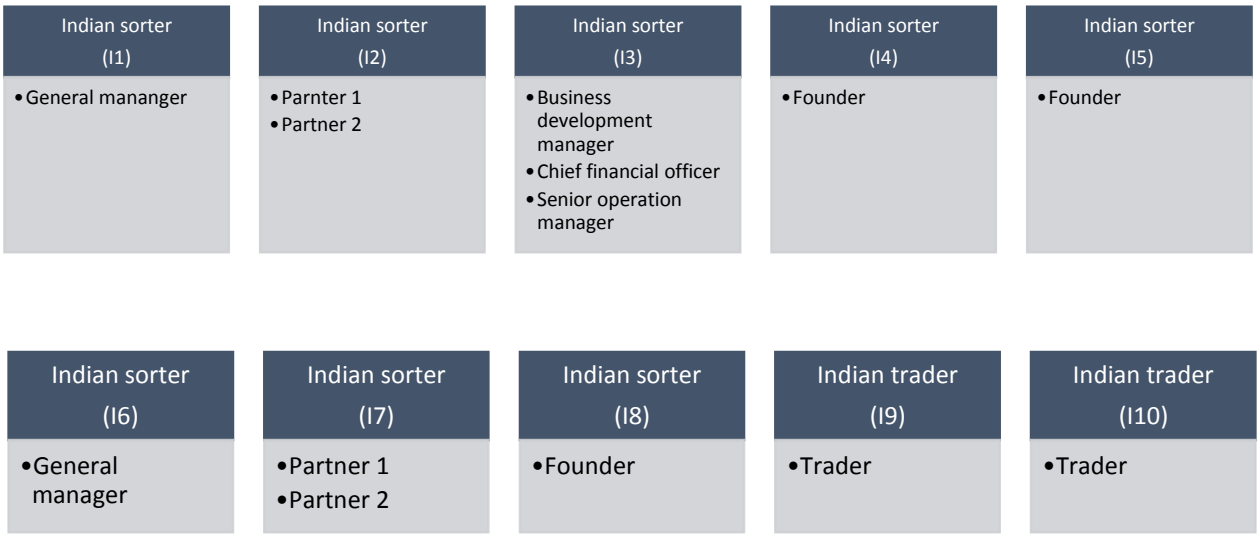

Figure 4-7: An overview of the respondents from Swedish charity organization

4.3.1 Case Description

Organization I1 was started in the year 2004 and have a head office in Mumbai, the economic capital of India. In the Kandla SEZ, the company has a factory for sorting, grading and recycling operations. Organization I1 also engaged in the various innovative practice of redesign at the

head office in Mumbai. Organization I2 started its sorting and grading operation in 2014. This was family business and grandfather of one of the partners of I2 was in second hand clothing business from the last 40 years. Previously they were traders involved in buying and selling graded clothes. In 2014 the Organization I2 has purchased the license and work under own name. The organization I3 is one of early entrant and started its operation in the SEZ from 2001. The organization I3 has well-established factory which is spread in 80,000 square meters for sorting and grading. For the organization I4, the second hand clothing business is family business. Previously the founder of the company was engaged in the business of domestic second hand clothing business. In 1998 the founder of the organization I4 enters into the sorting and grading business under a partnership. Later in 2003, the partner has left the company and since 2003 the founder of I4 is doing business independently. The I4 has a total area of 1, 25,000 square meters in the Kandla SEZ. The founder of the organization O5 is one of the dynamic and young entrepreneurs of sorting and grading business. He was working for shipping and logistics companies, prior to entering into the current business. Organization I5 started in 2001 and at present has three factories in the Kandla SEZ with total area 3, 25,000 square meters. Organization I6 is also a well-established in the sorting and grading business. The company was started in the 2009 and at present has a trading office in Africa. The total area of organization O6 factory is 50,000 square meter. Organization I7 started its operation in 2001 from the time government has issued the license. The total area of organization O7 is 20,000 square meter. Organization O8 is located near Vadodara as one of the export-oriented units which have a license to import and re-export used clothes. The organization was started in the year 1982 and at present spread into 2, 61,000 square meters.

Table 4-3: Description of Indian sorting and grading firms

Company (Establishment year)	Area (Sq. Feet)	Facilities	Country of Import	Output Product	Country of Export	Strength
Organization 1 I1, (2004)	80,000	Conveyer belt Cutting machines Recycling facilities	Major: North America and Europe. Minor: Korea and Australia.	Graded Clothes Acrylic Yarn Mutilated Garments	Africa	In-house recycling facilities, Vast experience in the recycling business
I2, (2014)	100,000	Conveyer belt Cutting machines	USA and Canada	Graded Clothes Wipers Denim cut off shorts	Africa	Area Number of employee 400
I3, (2001)	80,000	Conveyer belt Cutting machines	USA and Canada	Graded Clothes Wipers Denim cut off shorts	Mozambique Maputo Kenya Thailand UK(wipers)	Good management and Network
I4, (1998)	125,000	Conveyer belt Cutting machines	USA and Canada	Graded Clothes Wipers Denim cut off shorts Woollen clothes to a recycler	Tanzania, Uganda	40 Years' experience (family business) 4 units
I5, (2001)	325,000	Conveyer belt Cutting machines Repair and Ironing	USA	Clothes export	Zimbabwe	Passion, Best Management, Large setup
I6, (2009)	50,000	Conveyer belt Cutting machines	USA, Canada	Clothes export Wipers Garbage	Africa: East and West	Own shop in Africa
I7, (2001)	20,000	Cutting machines	USA, Canada, Europe	Clothes export Wipers Garbage	Africa	----------
I8, (1982)	261,000	Conveyer belt Manual cutting Recycling unit	Europe, USA	Clothes export Yarn Export Wipers Garbage	Italy Europe	Large Set-Up.

4.3.2 Import

Indian sorting and grading organization I1 is mostly used clothes from USA, Canada and Europe. Sometimes the organization I1 has also imported from South Korea and Australia. The cost of mixed clothes or rags is around 20-25 USD cents including freight. The composition of fabrics is most important aspects of the imported mixed clothes. Generally, in mixed clothes the composition of fabric which we receive is as follows: wool (5-10%), acrylic (40-45%), cotton (30-35%), polyester (5-10%) and rest are fancy materials such as jackets and other material. General manager of I1 emphasised the importance of fabric composition as follow:

> *"The main concern is a percentage of different fabric in the imported container. Suppose we are receiving 40-45 % acrylic and if in some lot, we found 10% acrylic only in some container then that is a problem. In that situation, we immediately contact the supplier and ask for price reduction may be 18 cents from 20 USD cents."*

Organization I2 import the clothes with the help of two-three traders. As the traders are able to provide good quality of mixed clothes and take margin of 1-2 USD cents per kg only. However, both partners of I2 has shown uncertainty over the quality of mixed rags, which cannot be predicted.

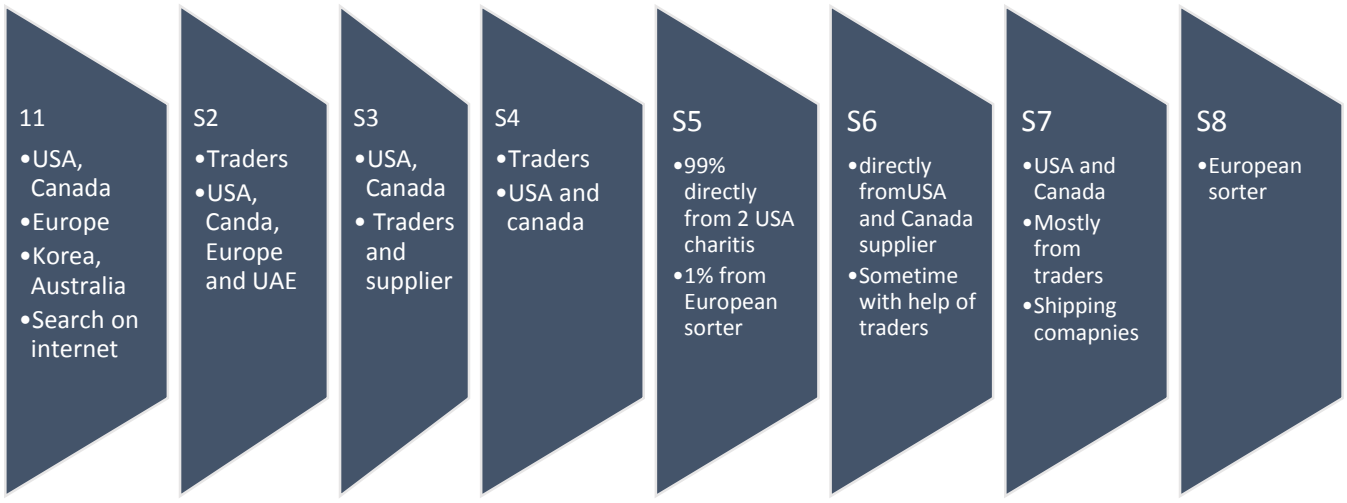

Figure 4-8: Used clothes import details for Indian organizations

Organization I3 is importing mixed clothes from USA and Canada. There are two suppliers from the USA and one from Canada for I3. From last 5 years, I3 import from Canadian supplier as they provide unsorted rags. However, Canadian supplier for I3 is not original collectors and most probably purchase from charities and sale to I3. Chief operating officer highlighted on the special kind of rags:

> *"There are 2-3 kinds of rags, one is special rags, in which you will get one type of items such as jeans rags, sweater rags or t-shirt rags. These are called special rags. That is cheap rags because you will not get good or export quality of products. Hence cannot make a profit."*

Therefore, special rags (with one type of clothes only) are not profitable for the Indian sorting and grading companies. Unsorted or mixed rags are profitable and all organisation are always searching for unsorted rags. As I3 chief operating officer demonstrated:

> *"if you are importing mixed rags, it is profitable as we are getting 30-45 % exportable materials. While in a special container, we even not get 10% export*

quality. so remaining we need to sale in Indian recycling market. There we are not getting good price"

Organization I4 has mostly doing negotiation with buyer to import mix rag at a lower price. There are no fixed used clothes collection companies through which I4 import, but most of the time company import from the USA and Canadian traders and collectors. I5 is one of an early starter of the second hand clothing business. Previously the import was done from European sorter on the condition of buyback sorted clothes. Now almost 99% mixed rag are imported from two USA charity organizations while reaming 1 % sourced from the European sorter. The organization I6 import mixed rags from the supplier of USA, Canada and sometimes through agents. The organization I7 imports the mixed rags from Canada and USA. Most of the times they get stocks of used clothing through the shipping company. As a partner of I7 highlighted:

"There are many shipping companies they bring mixed rags from USA or Canada ports. Those shipping companies charge for logistics only, we do not pay any money for the mixed rags."

The organization I8 is an EOU and import mixed rags from European countries from Netherland and Switzerland. There are some agents in Sweden through which the company also import used clothes.

4.3.3 Sorting

Organization I1 is sorting mixed rags on two small conveyor belts. The belt, accessories and all unwanted items are taken out in beginning. Later on wools, acrylic, cotton, polyester and fancy (fabric with the blending of different fibres) materials are taken out. The organization I1 primary focus in sorting is to extract recyclable material such wool and acrylic, while other materials

such as cotton and polyester sorted for the re-export as wearable clothes. In the organization I2, there are two sorting belts; the first belt is used to sort wearable clothes into almost 15 categories with 4-5 subcategories in each category. Unwearable clothes are moved to belt 2 to re-sort for wipers and other useful part extraction. I2 able find only 20-15% exportable material during sorting process as highlighted by one of the partners:

> *"In our imported materials, we are able to sort 20-25 % exportable materials, remaining other material need to be sold in the Indian market after mutilation. But the price of those mutilated goods in the domestic market is not sufficient."*

Sorting is an import process to extract value from the imported rags. As founder of I4 feels proper and careful sorting and grading is important for this business. I3 has well-established system to monitor sorting as the chief operating officer told:

> *"We have to do this to keep an eagle eye on the hand of shop floor worker. We employed the skilled, semi-skilled and also unskilled person. We need to watch what they are doing and how they are doing by employing a lot of supervisors. We have one supervisor on every 20 workers. There are three assistant production manager, who is getting a report from supervisors on daily basis. We have a production manager, whom you met yesterday. What I am doing. I am taking all reports from production manager or assistant manager."*

Most probably due to a good quality of imported rags, better sorting and quality monitoring system the organization I3 is able to find a higher percentage of wearable items for re-export. As the chief operating officer of I3 demonstrated:

"We are importing 60 containers in a month. every container has nearby 22 tones raw materials. we are exporting about 35% of 60 containers. We export near about 25-26 tons of sorted and graded materials and reaming selling to domestic recycling markets."

Organization I5 is one the leading organizations that have robust sorting infrastructure. I5 has elevated sorting conveyer belt and primary sorter workstation which is almost 8 meters above the ground. The primary sorters are doing initial sorting into 15 categories, which is further subdivided into different categories by the secondary sorter. The secondary sorters are receiving the clothes with help of a small channel.

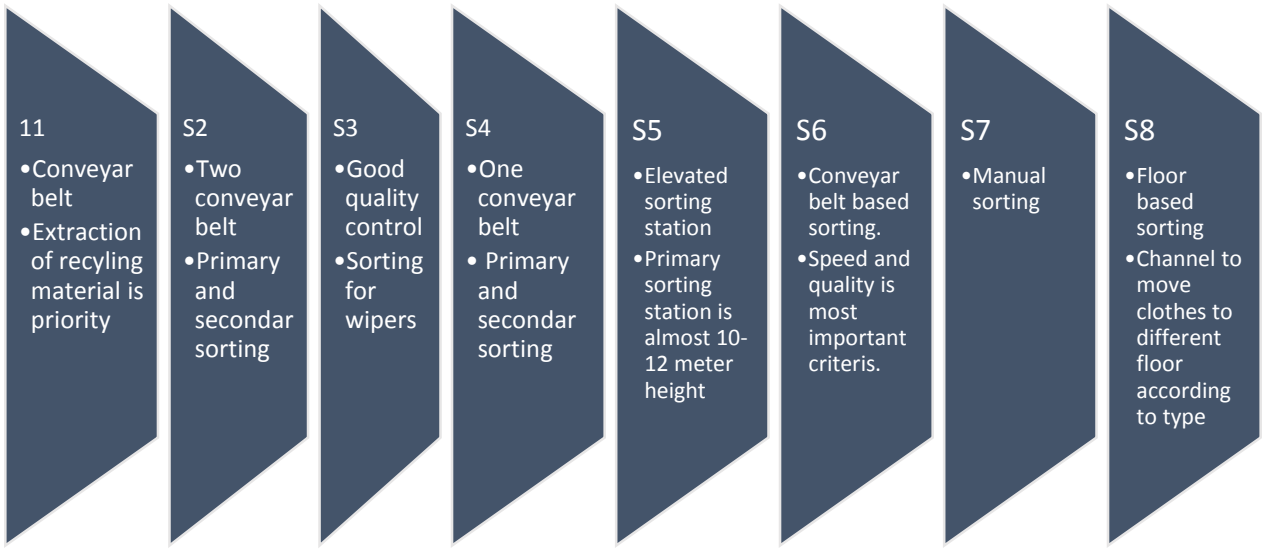

Figure 4-9: Sorting details for Indian organizations

The general managers of I6 feels that it is difficult to maintain quality in the sorting process. Most of the times the sorting problem occurs due to the inferior quality of imported mixed rags. Sorting quality is main factors that can give extra edges to one organization over competitor. The organization I8 has a unique way of sorting. There is a three-story building, especially dedicated to the sorting process. All clothes are moved to the third floor with help of a lift. On the third

floor, there is conveyer belt with the different working station. Each working station has a channel that opens on different floor. Based on the type of clothes, the sorters drop clothes to different channels and it directly goes to floor 1 or 2 where further processing of apparel is done. Wearable clothes are categorized according to the type of apparels, while woolen and acrylic clothes are extracted for recycling.

4.3.4 Value Creation through Reprocessing

After sorting and grading the second hand clothes are mainly re-exported to African countries. Similarly, organization I3 create values for the organization by importing mixed rags and selling to African country after sorting and grading. Chief operating officer of I2 explained:

> *"I think; we are getting raw material like the USA. we get it sorted and sale it to African counties, there is the demand for used clothing. In African countries, there are not much manufacturing companies, or you can say they lack in all kind of industries. India, China, Korea and Pakistan are major countries, who supply to them."*

An innovative approach such as I1 has integrated in-house recycling operation with sorting and grading. The organization I1 manufactured acrylic yarn of particular count. There are 2-3 fixed African buyers, they purchase yarn on regular basis. Apart from sorting used clothes I2 also reprocess old clothes to make wipers, denim cut off shorts, mutilation of sweater for domestic recyclers and garbage for sale in domestic markets. I3 has exported the sorted wearable clothes to Mozambique, Mahout and also found a new market for sorted clothes. The chief operating officer of I2 states:

"In Thailand domestic market, the clothes are not cheap compared to India their product is of high quality and price. So they are importing sorted used clothes from us."

The I3 chief operating officer has also highlighted the domestic market of mutilated clothes as follow:

"After sorting at least 30-35% we get exportable materials. So around 60% we have to consume in the Indian market. In India at Panipat is huge recycling market and there are many big companies. They are reprocessing mutilated garments like if they are getting sweater they are making yarn out of it. Then they are making a product and exporting to other countries."

Similar to I3 the organization I4 sales woollen items to Panipat recyclers. The sorted clothes are sold to Tanzania and Uganda. Whereas, I5 are mostly selling sorted and graded clothes to Zimbabwe. The company sells rags, second hand clothes and wipers to domestic customers. In the case of minor defects, repair and ironing operations are done sometimes. The founder of I5 highlighted that:

"Cost, quality and price are main factors through which we try to do better than competitor."

Figure 4-10: Value creation in Indian organizations

Organization I6 is able to export used clothes at the rate of 50 USD cent per kg. Wipers are exported at the price of 5 to 90 INR per kg depending on the quality. The I6 general manager explained the company sells sorted clothes and provide mixed packing list because:

> *"There are items called Hotcakes: which is a fast moving item. We offer slow moving item along with that at a lower price. As there is a pile of slow moving items stored in the factory."*

In addition, the company also sells wipers and garbage in domestic markets. In domestic markets wipers are sold at the price of 4 to 5 INR per Kg. The money earned from the sale of wipers is almost same for the organization I7. However, I7 will be able to earn a better price for sorted and graded clothes probably because of selling fast moving clothes only. I8 organizations also export graded clothes to Africa whereas recycled woollen yarn is sold to Italian companies.

4.3.5 Other Important Findings

There is a requirement of huge space for the mixed rags. Founder of I4 feels that there is not enough space to store the clothes even though organisation I4 has total area 1, 25,000 square meters. This is also found in general throughout observation as unsorted or sorted materials are kept in open space due to lack of space in the shed. Therefore, material handling was found to be major problems for most of the companies. Slow moving items further occupied storage space. Among all innovative way of doing business, I5 had started with buyback schemes in partnership with leading sorting companies in Europe. In the beginning, the founder of I5 stated the business under the buyback schemes with a leading sorter of Europe. The European used textiles sorting companies were providing mixed rags and buyback sorted and graded clothes. Some of the companies in KSEZ has opened their branch office in Canada to import better quality of mixed rags. There is some unique opinion about used clothing business as shared by the general manager of I6:

> *"for some company, this (sorting and grading business) is a method to rotate money."*

Founder of I5 stated that EOU needs to re-export 100% by volume while in KSEZ by value. The similar opinion is also shared by the general manager of I1:

> *"At present government has these rule on Value not on Volume. Means if we are exporting some quantity on higher value, then reaming goods in mutilated form can be moved to domestic market after payment of tax."*

However, there are discussions going on to change the legislation as stated by a partner of I2:

"Government is framing new policies, in which asking to export volume should equal to import. Whereas at present we are liable to export equal to the value of import"

The business of second hand clothing was profitable in the year 2004 when the government has allowed to sell used clothes in the domestic market after a major earthquake in the western part of India. However, after resistance from domestic textile manufactured the used clothes moved to restricted good items in the import list of the government of India.

4.4 Chapter Summary

The exploratory study of local charities organisation has different nature of the charity organisation. S1 and S2 are an individual owned charity organisation, whereas S3 and S4 work under the multinational charity organization. S5 is owned by the local municipality and collaborated with a multinational charity organisation. In terms of the collection, on shop collection is the most common phenomena that emerged out of the case studies. Factory and retailer leftover and surplus are found to be a valuable collection. Donation of personal belongings after the death of a person is found to be a good source of bulk collection. The collection of clothes from airport authority is another innovative way to receive good quality clothes. There is relatively little attention paid by Swedish local charity organisation on the sorting and maximising value of used clothes. In the second case study of European organisation, almost all innovative method of collection, sorting and value creation has been found. In Swedish and European case study cost of manpower was found main reason for sorting, grading, repairing and recycling of clothes. Offshoring the reverse logistics operation could be a good technique to make clothes reuse and recycle business cost effective. In the next chapter mathematical tools are used to model reuse-based reverse value chain for apparel industry.

5 Chapter: Development of Mathematical Models for Reuse-based Reverse Value Chain

The current chapter about mathematical modelling is built upon the insight gain from the exploratory case study. The empirical findings from the case studies helped to understand the reverse logistics process of clothes. The mathematical and analytical technique s has been used to model the reuse-based reverse value chain for apparel. In this three techniques viz AHP, Genetic algorithm and Markov principle have been used to model different aspects of reverse value chain of apparel. An AHP technique is used to make reverse logistic decisions in closed loop value chain. In the second subsection, a Genetic algorithm is used to develop an optimization model for the upcycling process. At last Markov principle is used to perform life cycle assessment of used apparel.

5.1 A Model for Reverse Value Chain Decisions

Undesired changes in environment and reduction of natural resources have necessitated the need for environment protection and resources conservation. Textile and clothing industries are the second largest in volume (after food) industry needs to contribute significantly towards protection environment by reducing the use of natural resources. There are different closed loop value chain methods to minimise the use of natural resources such as direct reuse, up-cycling and down-cycling. Incineration and landfill could be the last option for end-of-life (use) product for the environment protection. The selection of best closed loop value chain methods is multi-criteria decision-making problem as this involves complex decisions parameter. These subsections develop a model based on the fuzzy Analytic Hierarchy Process to determine the best method to close the loop of clothing value chain. On the basis of the result and its analysis, up-cycling emerged to be the best alternatives to close the loop of the clothing industry. The

Industry practitioner can use above model and result to make a decision in the fuzzy environment.

5.1.1 Factors affecting closed loop clothing value chain

Discarded and unwanted clothes can be converted into fashionable products. Various processes like shape modification, printing could increase value and use of particular clothes (Braungart 2006). The future use of material highly depends upon the material or fabric composition. A durable material is suitable for direct use or up-cycling. Woolen or Acrylic or other mono colour material is suitable for down-cycling. All other low qualities, multicolour and multi-fibres materials are incinerated (Subie, Mouritz, and Troynikov 2009). The economy is another factor, which determines the success of any process. Price is the main determinate of up-cycle or down-cycle product purchase (Zhao et al. 2013). Availability of technical and scientific knowledge is another most important factor. Recycling or upcycling process can be performed only in the presence of technology. In the absence of technology, discarded clothes could be reused or incinerated (Tipper et al. 2010). Below table depicts the summarised form of the goal, factors, sub-factors and alternatives.

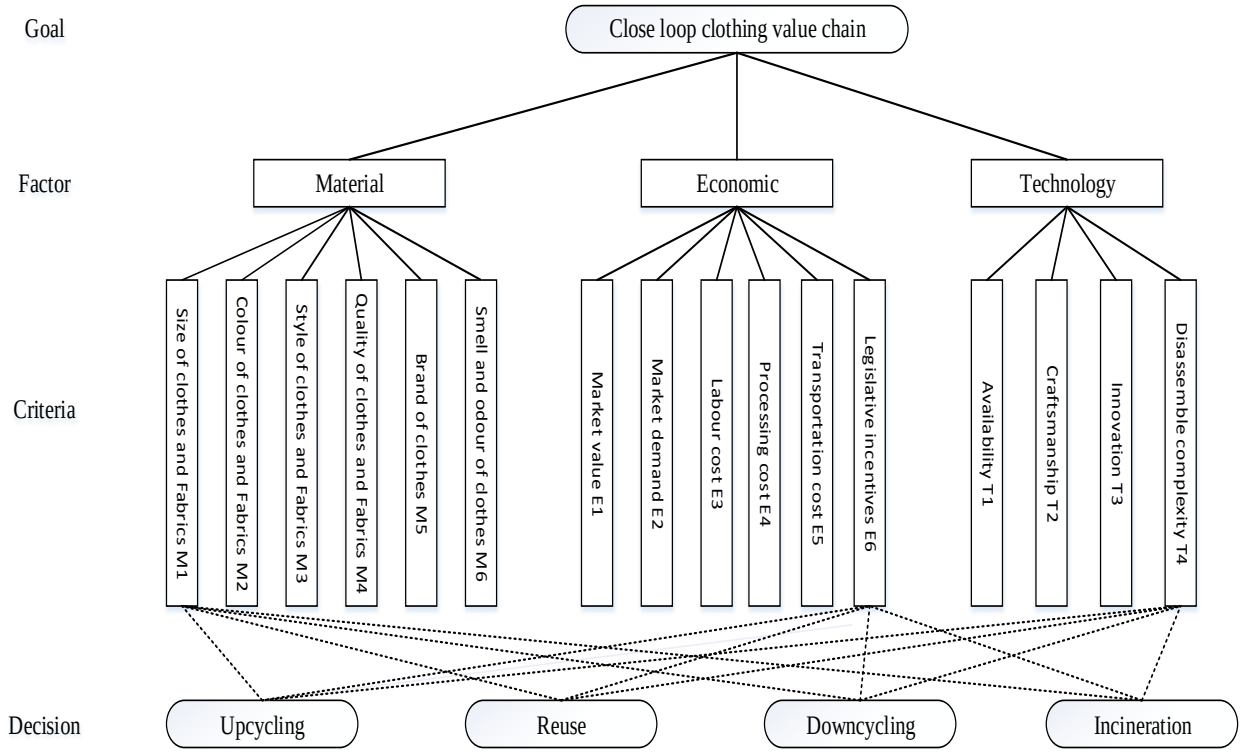

Figure 5-1: Factors, sub-factors and alternatives

Products with better aesthetic value are suitable for direct reuse. Easy upgradeability and smooth handling products become suitable for upcycling. Criteria such as material separation decides down-cycle ability. The cost and market potential are other factors, which decide reverse logistic direction (Metta and Badurdeen 2013). The economy is another driver for closed loop clothing value chain. In absence of economic incentives, dematerialization becomes cost factor for the firms. The major incentives for the economic feasibility are the expected value recovered from the used product (Abdallah, Diabat, and Simchi-Levi 2012). There is a relationship between the fabric quality and life of the clothes. Each clothes made up from particular fabrics has a certain lifetime. Technology is another important factor, which determines the quality of the recycled material. In the absence of technology, inferior quality of yarn could be generated through the down-cycling process (Gam et al. 2011).

5.1.2 Case Description

Organization R1 is Romania based redesign organisation located in the northern part of the country. The current organization under the umbrella of a 7-year-old social organization, that aims to protect the environment. The organization vision is to promote circular economy by minimisation of waste through collection and conversion of discarded textiles to a usable product. The positive impact on the environment is created by redefining clothes, extending the lifespan of textile and creation of new product. The customised product is created by using textiles collected from local people in the bins, workshop and factory leftover. The organization R2 is located in Prahova valley is sorting and selling used clothes through company-owned 9 shops. Unsorted used clothes are mostly imported from Germany and Netherland.

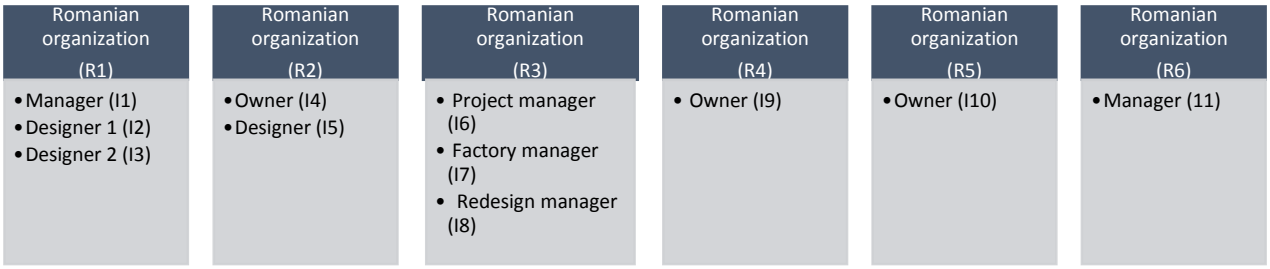

Figure 5-2: An overview of the respondents from Romanian organization

Organization R3 is a sister company of multinational charity organization. The head office of the company is located in the Bucharest and warehouse is in Ploesti. The organization has two redesign workshops, one is located in the Ploesti and other is located in Iasi. The main goal of the organization is to improve the employability and life of Roma people. Various charities and social welfare projects are undertaken to achieve the goal. The finance for the project is earned by the organization from the sale of second hand clothes. Redesign clothes and accessories are exported back to Norway for sales. Romanian organisation R4 located in the Iasi is the sister

company of a USA based used clothing company. R4 import used clothes and distribute throughout Romania. However, R4 also owned a store just adjacent to the warehouse in which the new items donated by USA retailers are sold. The organisation R5 is also a distributor of used clothing located in Bacau a small town in the northern part of the country. R6 is a sorting and grading companies located in Valcea region of the country. R6 import used clothes mostly from Austria and distribute to different second hand stores in Romania. The clothes which are not found suitable for sales in Romania are exported to Asia and Africa.

5.1.3 Calculation

The analytic hierarchy process (AHP) is widely used multi-criteria decision making (MCDM) tool. MCDM is a scientific field to develop a framework to analyse various factors and subfactors to make a decision. The AHP method developed by Saaty is one of the widely used methods for selection of best alternative, resource allocation and optimisation. The software package Super Decisions has been used to perform AHP analysis. Using Saaty (2008) opinions has been rated on pairs of various factors/sub-factors as per below table. For example, if the Material factor is assessed extremely important relative to economy factor then the score will be 9.

Table 5-1: Saaty score (Saaty 2008)

Scale Intensity	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment favour one factor over another
5	Essential or strong importance	Experience and judgment strongly Favour one factor over another
7	Very strong importance	A factor is strongly favoured and its dominance demonstrated in practice
9	Extreme importance	Evidence of favouring one factor over another is of the highest possible order of affirmation
2, 4, 6, 8		Intermediate values when compromise is needed

According to Melo, Nickel, and Saldanha-Da-Gama (2009), six to twelve interviews data are considered suitable for analysis by AHP method. Eleven closed loop or reverse logistics experts from apparel industry were interviewed to find out the weight of each factor i.e. material, economy and technology. The geometric mean is applied to achieve overall opinion to finalise weight of each factor. The AHP analysis was executed to examine consistency ratio (CR). The result is accepted if CR ration is equal to or less than 0.1 (Saaty 2008).

The study utilises the AHP method to measure the weight of each factor in the closed loop clothing value chain. The hierarchical model has three factors and can be further divided into sub-factors. These factors and sub-factors are considered for making the decision i.e. upcycling, reuse, down-cycling and incineration/landfill. The analysis has been started by giving weight to factors and subsequently pair-wise comparison has been done.

Ranking of factors/sub-factors for closed loop decision

Data gathered based on the response from experts were used to calculate importance of each factor after mapping criteria in the Super Decision software. Weightage of each factor found based on analysis i.e. Material: 0.6092; Economy: 0.3112, Technology: 0.0795. This shows that material factor has the highest importance, while technology was found to be of least importance. On the similar pattern of factors, the importance of one sub-factor within factors are calculated and found as Material (M1-0.14, M2-0.07, M3-0.13, M4-0.34, M5-0.19, M6-0.13); Economy (E1-0.18, E2-0.16, E3-0.19, E4-0.15, E5-0.20, E6-0.12) and Technology (T1-0.18, T2-0.34, T3-0.20, T4-0.28)

Pair-wise comparison of alternatives

Below steps were followed to conduct the pair-wise comparison. Details of each of these steps are will be discussed in the next paragraph.

Step 1 (Pair-wise comparison): Score of each factor, when considering a pair of decision options, was filled using the Saaty score system. One single score is filled for each pair-comparison. For example, when considering the **'**Quality of fabric and clothes' sub-factors of 'Material' factor, if more than moderate preferred the 'Upcycling' method than the 'reuse' method, then the score of 4 is filled.

Table 5-2: Example of the scores for the 'Quality of fabric and clothes' sub-factors of material factors

Material	**Up-cycling**	**Direct reuse**	**Down-cycling**	**Incineration/Landfill**
Upcycling	1	**4**	**5**	**6**
Direct reuse	1/4=0.25	1	**5**	**6**
Down-cycling	1/5=0.2	1/5=0.2	1	**7**
Incineration/Landfill	1/6=0.17	1/6=0.17	1/7=0.14	1
Sum	(1+0.25+0.2+0.17)= 1.62	5.37	11.14	20

Step 2 (Summed score): For each factor, the scores, achieved from all pair-comparisons, in each column (represented each decision option) were summed. For example, the sum of the upcyling column = 1 (i.e. comparison score between ‘upcycling' and 'upcycling' methods) +0.25 (i.e. comparison score between ‘reuse' and 'upcycling' methods) +0.20 (i.e. comparison score between ‘down-cycling' and 'upcycling' methods) +0.17 (i.e. comparison score between ‘Incineration/Landfill' and 'upcycling' methods) = 1.62, see above table.

Step 3 (Normalized score): For each factor, each score in each column was then normalized by dividing its score with its summed score (in Step 2) to make the adjusted sum of 1. For example, an adjusted score of comparing the up-cycling method with the reuse method= 0.25/1.62 = 0.154 (see below table). The adjusted sum of the up-cycling column is then 0.617+0.154+0.123+0.105 = 1.00.

Table 5-3: Example of the adjusted scores of the ‘Quality of fabric and clothes’ sub-factors of material factors

Material	**Up-cycling**	**Direct reuse**	**Down-cycling**	**Incineration /Landfill**	**Total normalized Score**
Upcycling	1/1.62 = 0.617	4/5.37 = 0.745	5/11.4 = 0.449	6/20= 0.300	(0.617+0.745+0.449+0.3)/4 = 0.528
Direct reuse	0.154	0.186	0.449	0.300	0.272
Down-cycling	0.123	0.037	0.090	0.350	0.150
Incineration/Landfill	0.105	0.032	0.013	0.050	0.050
Sum	1	1	1	1	1

Step 4 (Total normalised score): After that, the adjusted scores in each row (each decision option) were summed, and divided by the number of decision options (four in this case) to achieve the total adjusted score (see above table). Please note that the sum of total adjusted scores in each column must equal 1.

Overall rating of factors

Step 1 (Weight score): Once the total normalised scores of the 16 sub-factors were calculated, the weight score of each decision option of each factor is calculated by multiplying each total normalised score with its factor weight (calculated from the AHP). For example, the total weight of the up-cycling method when considering the **'**Quality of fabric and clothes' sub-factors of "material" factor equalled to the total adjusted score of 0.528 multiplied by the weight of the **'**Quality of fabric and clothes' sub-factors of "material" factor (0.34). It will be then 0.528 × 0.34 = 0.179.

Step 2 (Net weight score): Net weight score can be calculated after calculating total weight score of each of the 16 sub-factors. Net weight score can be calculated by multiplying the weight of factors with weight score. For example, weight of material, factor is 0.6092 and weight score of the **'**Quality of fabric and clothes' sub-factors of "material" factor is 0.179. It will be then give net weight score 0.6092 × 0.179 = 0.109. In a similar way, net weight score of all factors can be calculated.

Step 3 (Overall weight score): Once the total weight scores of each decision option of the 16 sub-factors are calculated, the overall weight score of each decision option was achieved by average summing the total weight scores of the 16 sub-factors in that decision option. To illustrate, the overall weight score for all alternatives are depicted in the below picture.

Table 5-4: Overall weight score

Alternatives rankings with structure	**Result**
Up-cycling	**0.4832**
Direct reuse	**0.3094**
Down-cycling	**0.1384**
Incineration/Landfill	**0.0724**

Up-cycling is found to be best alternatives to close the loop while direct reuse considered to be a second most preferred alternative as depicted in above table.

5.2 A Re-modularization Model to Optimise Upcycling Process

A clothes redesigned model based on the re-modularization technique has been developed. Re-modularization method includes extraction of different parts of old/discarded clothes on the basis of its future use suitability. Each extracted parts have different characteristics and usefulness. Some parts are highly useful while others are of less important use. Then on the basis of demand, each part is assembled and reconstructed to achieve functional and aesthetic value. Below Figure illustrate the flowchart of clothes redesign.

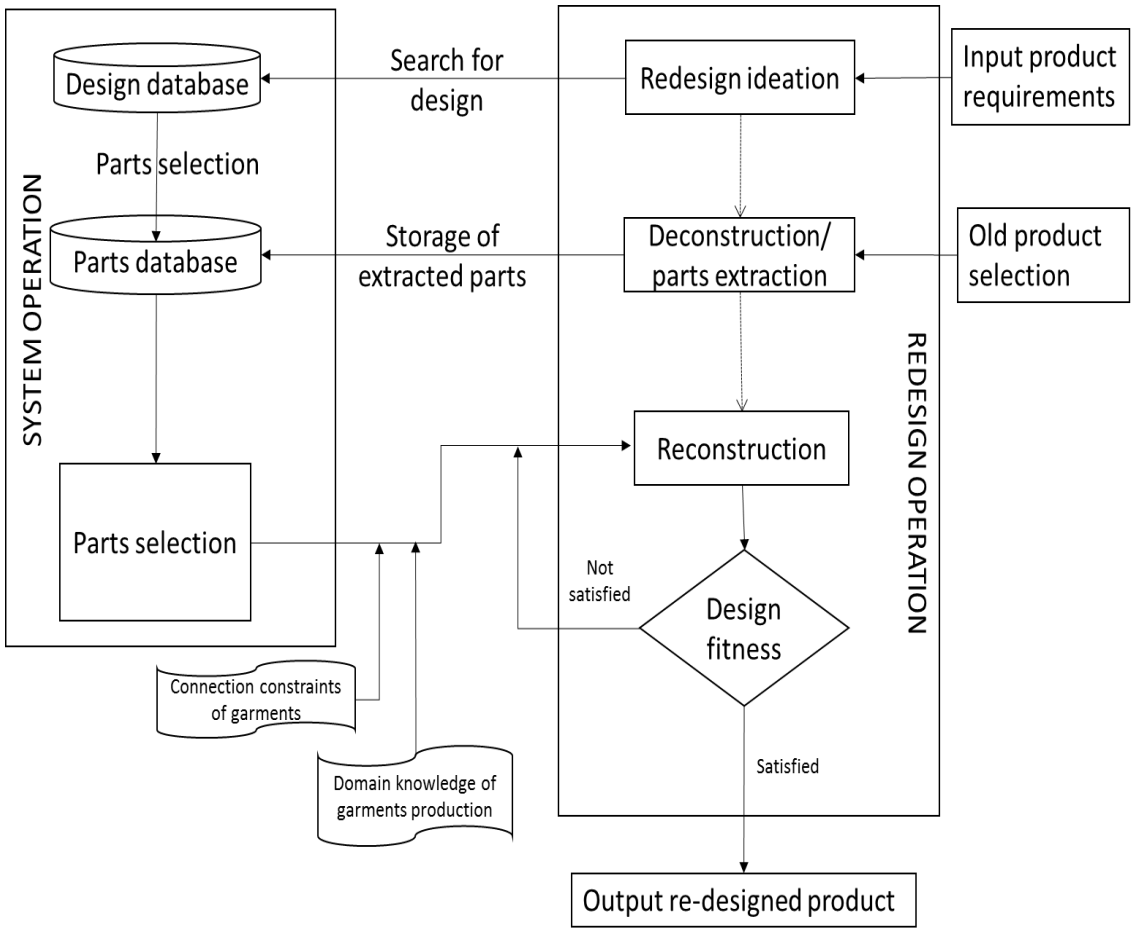

Figure 5-3: A modularized redesign process for clothes

On the basis of demand or redesign objectives, system operation is performed to search for the suitable parts that were extracted from old or used garments. The garments parts should be

selected based upon attributes and value of attributes in order to achieve high functional and aesthetic value of redesigned garments. Extraction, selection and connections of parts required domain knowledge of garment design and construction. If garments redesign outcomes satisfy the demand requirements, then the redesign process is considered to be completed otherwise more modification and reconstruction needed to achieve desired look. A designer can easily identify the suitable design and information about required parts with the help of garments re-design model. This model also facilitates the designer in the parts extractions from old and used garments for its optimal use. The database of design ideas and parts will enable the designers to make quick and fast decisions on the basis of previous redesigned outcomes. The modularized garments redesign model can be utilized extensively and effectively if redesign and parts databases are updated regularly. The garments redesign model based on re-modularization technique could become an important tool for redesigning process.

5.2.1 Extraction of parts

Different kinds of parts can be extracted from garments that can be categorized based on their importance into important and less important parts. During extraction of parts from used or discarded garments, following rules can be deployed:

1. Extraction of parts should be a medium level. Otherwise, connections and design could be complicated due to too many parts. Hence extraction of non-useful parts and its details entry to the database should be avoided.
2. Decisions about important and less important parts should make on the basis of its future use. Important parts are those parts that can be used for making an up-cycled or higher valued products.

3. Less important parts could be used for making down-cycled or lower value products such as bag, curtains or any other accessories.
4. Extracted parts will be used for redesign and reconstruction. Therefore, domain knowledge of textile and garment production is suggested to make subjective decisions.

On the basis of above rules, extracted garment parts can be categories into 12 types as illustrated in Table 1. Extracted parts details are determined by key design and composition attributes that can vary from product to product.

Table 5-5: Characteristics of re-design parts

Part type	Coding	Part name	Part attributes/characteristics
Important	M1	Body front	Shape, length, bust, fly, waistline, hem
Important	M2	Body back	Shape, length, waistline, hem
Important	M3	Sleeves half	Type, length, hem
Important	M4	Sleeves full	Type, length, cuff
Important	M5	Pant front	Shape, length, crotch length, waist level
Important	M6	Pant back	Shape, length, crotch length, waist level
Important	M7	Skirt body	Shape, length, cut, dart, pleat
Important	M8	Long dress body	Shape, Size, dart, hem
Less important	L1	Collar	Type, length, width
Less important	L2	Pocket	Pocket level, type, size
Less important	L3	Waist band	Waist level, waistline, width, length, number of layers
Less important	L4	Other accessories	Shape, Size,

Each part has certain characteristics and associated value to the attributes. Change in the type of the attribute will provide different parts. The products that is selected for redesign could consist of different parts. The redesign products will not have a particular part when the value of attributes is set to zero for that particular parts. For example, the shirt without pocket will have zero attributes value for the pocket.

Below definitions can be used to define the parts and its attributes mathematically:

$$M_{ij} = \{Mu, T, V\}, \quad i = 1,2,3 \ldots . n; \quad j = 1,2,3 \ldots . n \qquad (1)$$

Where

M_{ij} is to j^{th} portion of to i^{th} parts

$Mu = \{Mu_1, Mu_{2,} Mu_3 \ldots \ldots \ldots Mu_j\}$ is the set parts extracted from M products

$T = \{t_1, t_{2,} t_3 \ldots \ldots \ldots t_j\}$ is the set of attributes of parts i.e. important parts, less important parts etc.

$V = \{v_1, v_{2,} v_3 \ldots \ldots \ldots v_j\}$ is the value set of above attributes

5.2.2 Identification of parts

The system has a database of garments parts after extracting garments parts from used garments and determining the attributes and value associated with each attribute. Based on the product design requirements the idea for the redesign is developed and required parts are configured accordingly. The redesigned garments or accessories products required different important and less important parts. A binary decision variable has been defined to identify the requirements of parts as follow:

$$\alpha_{ij} = \begin{cases} 0 \\ 1 \end{cases} \qquad i = m, l \text{ (important, less important)} \quad j = 1,2,3 \ldots . n \tag{2}$$

For garments, $\alpha_{ij} = 1$ when ij^{th} parts is identified for the configuration. $\alpha_{ij} = o$ when ij^{th} part cannot be configured. During the redesign process of garments all important parts are present. Each part has binary decision value to identify the configuration and selection. Generally, the garments redesigned required important parts while accessories redesigned need less important parts. so $\alpha_{li} = o$ for the most of the case of garments redesigned, while $\alpha_{mi} = o$ for accessories redesigned.

Below Table 2 depicts the requirements of parts for the configuration of redesigned garments and accessories. Configuration or identification process is based on the importance. Important parts are necessary for garment redesigned while less important parts are barely required. The configuration of parts is requisitely based on redesign requirements.

Table 5-6: Selection and configuration of garment parts

Garments And Accessories	**Important parts**								**Less important parts**			
	M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**L1**	**L2**	**L3**	**L4**
Top wear	Y	Y	Y	N	N	N	N	N	O	O	N	N
Pant	N	N	N	N	Y	Y	N	N	N	O	Y	N
Skirt	N	N	N	N	N	N	Y	N	N	O	Y	N
Dress	N	N	N	N	N	N	O	Y	N	N	N	Y
Accessories	N	N	N	N	N	N	O	N	O	O	O	O
Bag	N	N	N	N	N	N	O	N	O	O	O	O
Curtain/Mat	N	N	N	N	N	N	O	N	O	O	O	O

5.2.3 Determinations of connections

The next step is parts joining after redesign configurations and parts selection. With simple linking of one part with others, the desired aesthetic value cannot be achieved. Patterns are required to stitch each part of seam or junctions. The connecting relationship among the interconnected parts needs to be determined for each seam. Each connecting part has a unique matching part to stitch. The matching and stitching of two parts need domain knowledge of garment design and manufacturing. Garments or accessories junctions can be defined as follow:

$$R_{ij} = \{id, M, T, V, Mu\}, \quad i = 1,2,3 \ldots . n; \quad j = 1,2,3 \ldots . n \tag{3}$$

Where

R_{ij} is j^{th} junctions of i^{th} parts

id is identification of connections sites or seam

M is main parts of the junctions

$T = \{t_1, t_{2,} t_3 \ldots \ldots \ldots t_j\}$ is the set of attributes of junction i.e. shape, location, size etc.

$V = \{v_1, v_{2,} v_3 \ldots \ldots \ldots v_j\}$ is the value set of above attributes

$Mu = \{Mu_1, Mu_{2,} Mu_3 \ldots \ldots \ldots Mu_j\}$ is the set of set of parts, which will connect to this parts.

The two parts M_1 and M_2 can be connected at seam id_1 with set a of parts Mu_{12} and Mu_{21}. Each junctions or side of parts of M_1 could be connected to different parts with help of different identified seam.

5.2.4 Implementation of connection

The implementation of connection is required after a determination of proper connection between two parts. During the implementation phase, the slight modification in the parts may be required to achieve implementation. The shape and size of two parts at each seam should be similar to become a pair. This can be achieved if attributes and value of attributes at the connection seam should be equal. This can be explained with help of below equation:

$$\begin{cases} t_i = t_j \\ V_{Ati} = V_{Btj} \end{cases}, \quad i = 1,2,3 \ldots . I; \quad j = 1,2,3 \ldots . J \tag{4}$$

Where t_i and t_j are elements of set the T_A and T_B. R and J are total number of elements of set. The attributes of two parts at junction is similar, this can be depicted by $t_i = t_j$. The value of variables at junction is equal can be indicated by $V_{Ati} = V_{Btj}$. Two parts at a junction are equal in terms of sizes, shape and value.

5.2.5 Application of re-modularization model in garments redesign

The process of redesign varies from one organization to other organization. A Sweden based redesign organization was selected to understand the application of re-modularization. This selected Swedish organization performs the process of redesign at a larger scale through separate redesign division. A dedicated team of designers carry out the redesign activities in the warehouse. The activities of the redesign are also carried out through satellite centers where local inhabitant volunteers redesign old textile or garments products. All the redesign products are sold under the 'Remake' brand name. The organization has launched new store to sale redesigned garments. The team has a standard operating procedure for the complete redesign activities.

However, at present, activities like parts extraction and identification, determination and implementation of connections are done based on the memory, intuition and experience of designers. Below figure demonstrate the steps followed for redesign at the selected organization.

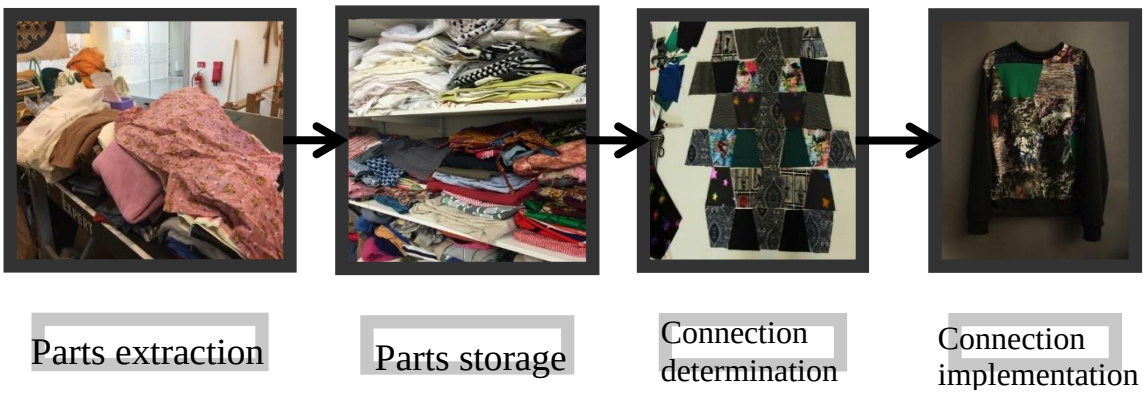

Figure 5-4: An illustration of redesign practice

However, the above re-modularizations model can be used for the redesign process. The steps can be elaborated as follows:

Selection of used clothes: Garments are selected on the basis of its aesthetic, functional qualities, perceived needs, labour saving and ease of reconstruction. Aesthetic qualities include style, the colour, material composition, visual appeal and prevalent demand. Functional qualities on the basis of which garments are selected vary from product to product. For example, denim jeans and jackets are selected on the basis of fabric sturdiness. Garments are generally discarded due to worn or washed out look. Interestingly, this feature of faded colour or wash outlook increases its attractiveness and considered more suitable for a redesign. Men and women t-shirts are also available in abundance in the used garment collections. T-shirts and tops generally have little variations in the form of size, fabric and constructions. Uniformity among the styles and ease of handling of fabrics make t-shirts and tops suitable for a redesign. Formal suit and long

ladies' dress are also considered for a redesign because of higher quality and quantity of usable fabrics. On the basis of the material usability and colour/style forecast/trends of upcoming seasons, a 'wish list' is prepared by the redesign team. The durability of the material and disassembly effort is also considered during preparation of material 'wish list'. Sorting team picks the material as per wish list, prepares a bag and gives it to the redesign team after regular intervals.

Extraction of parts from used garments: The redesign process begins by deconstructing and analyzing the used products and associated materials for the best use and utilization. The redesign team observes each of the products considering the scope of redesign and accordingly extracts designable part/patch after disassembly. Basic garments such as t-shirts and ladies' dresses are cut to extract fabrics while complex garments such as suit and jacket are converted to another form of garments. The product which is found suitable for the redesign is further sent for value addition processes such alteration, embroidery, printing etc. The current organization has in-house facilities for basic embroidery and screen printings. The part or patch of the fabrics and trims are stored separately on racks as per the concept of re-modularization. Each extracted parts are stored at different locations on the basis of their characteristics or future use. Presently, extraction and storage of parts are done manually. However, with the proposed re-modularization model the attributes information of extracted parts can be stored in the computerized system. The type of attributes and the value for each of the parts can be entered in the re-modularization system. Overall, each part can be physically categorized and stored on the basis its attributes.

Identification of parts for redesigning: Initial idea for redesigning of garments is developed based on demand forecast and available extracted parts. Designs are finalized with the technique of draping and/or flat pattern making. Subsequently, the parts search starts to achieve the desired

aesthetic look. Presently, this whole process of search is done manually and mainly on the basis of memory. The proposed re-modularization model can facilitate an ease of search of the required parts. The parts requirements are raised based upon the size and styles of intended redesigned garments. According to the design requirements for garments, the value of binary equation for each part can be used as follow:

$$\alpha \begin{cases} \alpha_{mj} = 1 & j = 1,2,3 \\ \alpha_{mj} = 0 & j = 8,9 \\ \alpha_{lj} = 1 & j = 1,2 \end{cases} \qquad (5)$$

On the basis of the above binary information, the re-modularization model will look for the parts from the database having a record of all the parts. Every garment requires unique binary identification number based on the type (important and less important) and attributes and its value. For example, some redesign garments may require pocket. Based upon the pocket requirement the attributes for the pocket will have value 1. Each required parts will be coded with specific value based on specific attributes. The parts can be searched on the basis of the attributes and its values. If a part with a particular attribute and value is not available in the parts database, then parts with similar characteristics can be selected to get desired output after modification.

Determination of connections: The next step in this process is a determination of connection for the selected parts. The selected parts are connected as per design prototype to achieve the desired look and draping. Presently, the redesign organization establishes connections on the trial basis by making several permutations and combinations. The manual process of connection establishment is time-consuming and a tedious process. Some modifications are also done if shape and size of the connecting seam are not similar. Feasibility of the transformations is also

considered during the modification and reconstruction processes. The process of this connection establishment can be simplified with the help of the proposed re-modularization model. The computerized re-modularization model system can suggest suitable parts for connections. The suitability of two parts for connections are decided based on attributes and its associated value. The attributes of two parts should be equal i.e. $t_i = t_j$ and the value associated $V_{Ati} = V_{Btj}$. The re-modularization system will keep on determining connections till the time suitable cona nection is not achieved.

Implementations of connections: Once parts are selected and connections are determined then the next step is to implement connection. A good design can be achieved by proper stitching of the parts with the help of garment design and production knowledge. Under a few circumstances, proper connection constraint can be also required. For example, if the composition of the fabrics is varying from each other it is not easy to implement connections even though the attributes and its value are same. Understanding these nuances related to production constraints are gradually developed with experience. The redesigned system will keep on doing the reconstruction process till the time the desired perfection is not achieved. At the later stage, modification or reconstruction can be repeated if the designer is not satisfied with design or fitting.

Further to understand the benefits of re-modularization model over the manual re-design process an analysis has been performed to compare the time consumed in each process. The time taken in the manual redesign process varies according to the complexity of garments. Simple or basic garments such as ladies knitted tops, t-shirts, shirts are relatively easy to re-design. Almost 1-2 hours are consumed to redesign basic garments. Whereas for medium complex garments, such as trousers, jeans the re-design process needs 6-8 hours. Jackets and ladies dresses are considered as high complex garments and re-design process require 10-18 hours (up to 2 working days). Most

of these times are incurred are during redesign ideation and connection determinations. The re-modularization model can be applied to shorten the time taken for re-design ideation and connections determination. The re-modularization model can perform ideation and connection determinations task in the fraction of minutes with the help of computerized information. The above discussion summarizes the benefits of re-modularization model over the manual redesign process. In other words, this can also be considered as a recommendation to improve the current redesign process.

5.3 Model to calculate clothes reuse times

Used clothes can undergo through reuse cycle multiple times based upon the reprocessing activities. Reuse of clothes as a product is only considered, reuse of raw material fibres and fabric is not taken into consideration for the current research. The principle of Markov chain is utilised to modelled the reuse-based closed loop value chain. In the reuse-based closed loop value chain, a clothing product can have three stages i.e. use, reuse and discard. At the beginning of the life cycle clothes will be with the customer and subsequently will be discarded after the end of life. In LCA, a trip number is an important concept which is number of the cycle a product can complete. Life cycle assessment (LCA) is an important tool for analysis of a product journey from birth (cradle) to end-of-life (grave). Cradle, gate and grave are important terminologies that are frequently used in LCA. Cradle is birth of a product that starts from raw material abstraction. Under this research, an attempt has been made to analyse the life of used clothes from the customer (gate) to the disposal (grave). In the reuse-based closed loop value chain, the trip (average) number for a clothing product has been calculated.

5.3.1 Model assumptions and formulation

Clothes can be discarded by the consumer after end-of-life but can be reused by another consumer after end-of-use by the first owner. Clothes purchase by the consumer can be used by the consumer or informally transferred to friends or family. Otherwise, the clothes can enter into formal reuse cycle through second hand markets. At the end-of-life, clothes can be discarded from use or reuse stage.

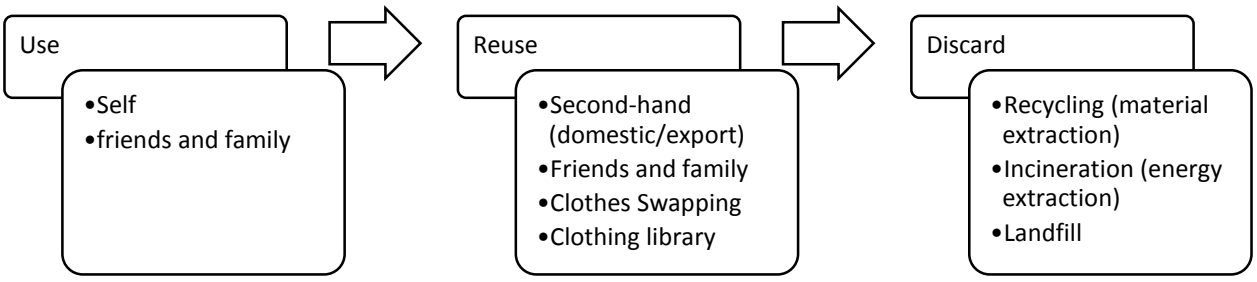

Figure 5-5: Stages of clothes reuse

Following assumption has been made to model clothes reuse as per Markov principle:

- Self and informal exchange are considered as use.
- Formal reuse such as second hand domestic and export, clothing library and clothes swapping at one stage.
- Landfill, material and energy extraction is considered as discard.
- All exchange of clothes happens at the fixed point in time.
- Exchange of part or parts of clothing products is not considered.
- Transitional stages are not considered.
- Clothes quality at every stage is deliberated non-deteriorating.
- Exported clothes will undergo more reuse cycle than originating countries.
- Discard is an absorbing stage; the product cannot have entered into reuse cycle once it reaches to discard stage.

Based on aforementioned assumption a model can be formulated to perform LCA for clothes reuse:

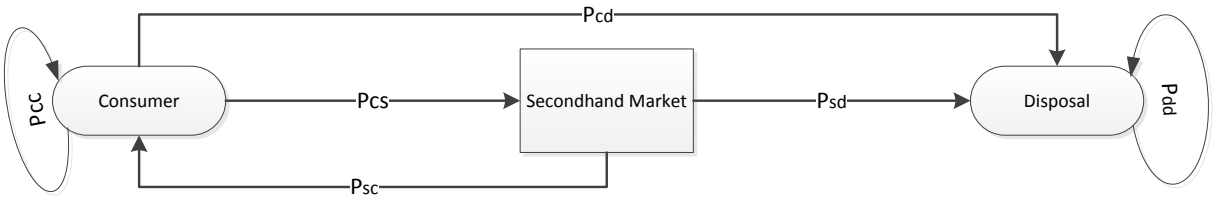

Figure 5-6: A Simplified model for reuse-based closed loop value chain

5.3.2 State matrix

The consumer purchases clothes and keep with themselves before end-of-use or end-of-life. At the initial stage, products are under use, so the probability of clothes to be available at 'use' stage will be 1. The probability of clothes to all other stages i.e. 'reuse' or 'discard' will be 0. The state probability matrix is $v^0 \in S$ can be written in matrix form as below:

$v^0 = [1,0,0]$

5.3.3 Transition Matrix

There is different probability through which clothes can move from use to reuse or discard stage. The quality of clothes determines the movement of clothes from one stage to another stage. The flow of material in different Nordic countries is depicted in below table.

Table 5-7: Transition of clothes in Kg. (Naoko Tojo et al. 2012; Palm et al. 2014)

Country 1: Denmark	**Use**	**Reuse**	**Discard**	**Total**
Use	5.3	6.3	4.4	16
Reuse	5.2	0	1.1	6.3
Discard	0	0	0	0

Country 2: Finland	**Use**	**Reuse**	**Discard**	**Total**
Use	1.3	4.7	7.6	13.5
Reuse	2.3	0	2.4	4.7
Discard	0	0	0	0

Country3: Iceland	**Use**	**Reuse**	**Discard**	**Total**
Use	0.5	4.5	10	15
Reuse	3.6	0	0.9	4.5
Discard	0	0	0	0

Country 4: Norway	**Use**	**Reuse**	**Discard**	**Total**
Use	4.4	4.6	5.4	14.4
Reuse	4.4	0	0.2	4.6
Discard	0	0	0	0

Country 5: Sweden	**Use**	**Reuse**	**Discard**	**Total**
Use	4.5	3	7.5	15
Reuse	2.5	0	0.5	3
Discard	0	0	0	0

Transition matrix based on the probability of clothes movement from one stage to other stage is calculated for different countries as below:

Country 1: Denmark – Per capita annual consumption of textile and clothing in Denmark is 16 Kg. therefore, initially, for a certain amount of time, 16 kg clothes will stay with the consumer. Once consumer fed up with same clothes then he or she pass on to friends and family. The data shows that on average 5.3 kg clothes are informally exchanged between friends and family. Whereas, 6.3 kg of clothes are collected by formal reuse player and entered the second hand market. Out of total 6.6 kg collection by second hand player for formal reuse, 5.2 kg of clothes goes to the second cycle of reuse while 1.1 kg is discarded. 4.4 kg of clothes is not found suitable to reuse and directly discarded out of 16kg new clothes purchased by the consumer. So there a probability for movement of clothes between use, reuse and discard. On the basis of this probability, below transition matrix can be defined for Denmark:

$$P = \begin{bmatrix} 0.33 & 0.83 & 0 \\ 0.39 & 0 & 0 \\ 0.28 & 0.17 & 1 \end{bmatrix}$$

In the similar fashion the transition matrix for other countries can be defined as follow:

Table 5-8: Transition matrix for clothes movement in Nordic countries

Case 2: Finland	**Case 3: Iceland**
$P = \begin{bmatrix} 0.10 & 0.49 & 0 \\ 0.35 & 0 & 0 \\ 0.55 & 0.51 & 1 \end{bmatrix}$	$P = \begin{bmatrix} 0.03 & 0.80 & 0 \\ 0.30 & 0 & 0 \\ 0.67 & 0.20 & 1 \end{bmatrix}$
Case 4: Norway	**Case 5: Sweden**
$P = \begin{bmatrix} 0.30 & 0.96 & 0 \\ 0.32 & 0 & 0 \\ 0.38 & 0.04 & 1 \end{bmatrix}$	$P = \begin{bmatrix} 0.30 & 0.83 & 0 \\ 0.20 & 0 & 0 \\ 0.50 & 0.17 & 1 \end{bmatrix}$

5.3.4 Numerical Analysis

Average number of times clothes reuse

Below equation can be used to calculate the trip number or an average number of time clothes can be reused:

$$v = v^0 T^n$$

Where initial state matrix v^0 at $= 0$:

$$v^0 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

The aim of our LCA is to calculate n so that at $= n$ state, the state matrix become:

$$v^n = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

At the end of the cycle all clothes will reach to discard stage, therefore, the probability of clothes to be found of other than discard stage will be 0. Initial state matrix v^0 will remain same for all countries calculation, while the transition matrix can be found in above table. After performing numerical analysis by using matrix multiplication technique, $(\boldsymbol{n})$ trip number for each of country can be calculated as follow:

Table 5-9: Average number of times clothes reuse (Paras and Pal 2018)

Countries	**Total number of the trip$(\boldsymbol{n})$**	**Reuse times$(\boldsymbol{n-1})$**
Country 1: Denmark	20	19
Country 2: Finland	08	07
Country 3: Iceland	08	07
Country 4: Norway	17	16
Country 5: Sweden	10	09

This can be derived from above table that in the Finland and Iceland, least number of times clothes can be reused. While in Denmark clothes reuse can be for a long time.

5.4 Chapter Summary

In this chapter the analytical tools such as AHP is used to make reverse logistics decision, the Genetic algorithm used to optimize the upcycling or redesigning process, and Markov principle is used to make life cycle assessment of clothes reuse. The findings from the case study is

strengthen with the help of three models develop in this chapter. The next chapter will discuss and comprehended the findings from the current and previous Chapter 4.

6 Chapter: Model Development for Reuse Based Value Chain for Apparel

This chapter will discuss empirical findings from the case studies and mathematical modeling. The literature highlighted that the reverse value chain of apparels comprised of collection, sorting and reprocessing for value creation process. The discussion regarding the findings from the case studies in chapter 4 and mathematical modeling in Chapter 5 will be broadly based on collection, sorting and value creation processes involved in reverse value chain. At the end of case study analysis, an empirical model for resource and economical efficient reverse value chain for apparels will be proposed.

6.1 The Reverse value chain in the clothing industry

Rogers and Tibben-Lembke (2001) have emphasized that the purpose of the reverse value chain is to recapture or to recreate value from discarded products. The clothing products are discarded much before their end-of-life and hence, it is important to recover maximum value from donated clothes. The findings of this research also supported this notion. Due to the fast changing fashion, the consumers easily get tired of wearing same clothes for a longer time and want to get rid-off apparels. In the absence of appropriate reverse value channel, the apparels are disposed-off along with other solid wastes and increase the overall volume. Textile and clothing products are widely attributed for their negative environmental impacts (Cumming 2017). Recapturing the unutilized value from the discarded products is resource efficient as well as environment-friendly process. The incineration process for energy extraction is the least preferred method among all the alternatives (Carter and Ellram, 1998). There are cost associated with each process in reverse value chain. This cost can be for primary and supportive activities. Profit is the difference between value created and cost incurred in the creation of value (Porter 1985). The primary and supportive activities of the reverse value chain are depicted in below figure:

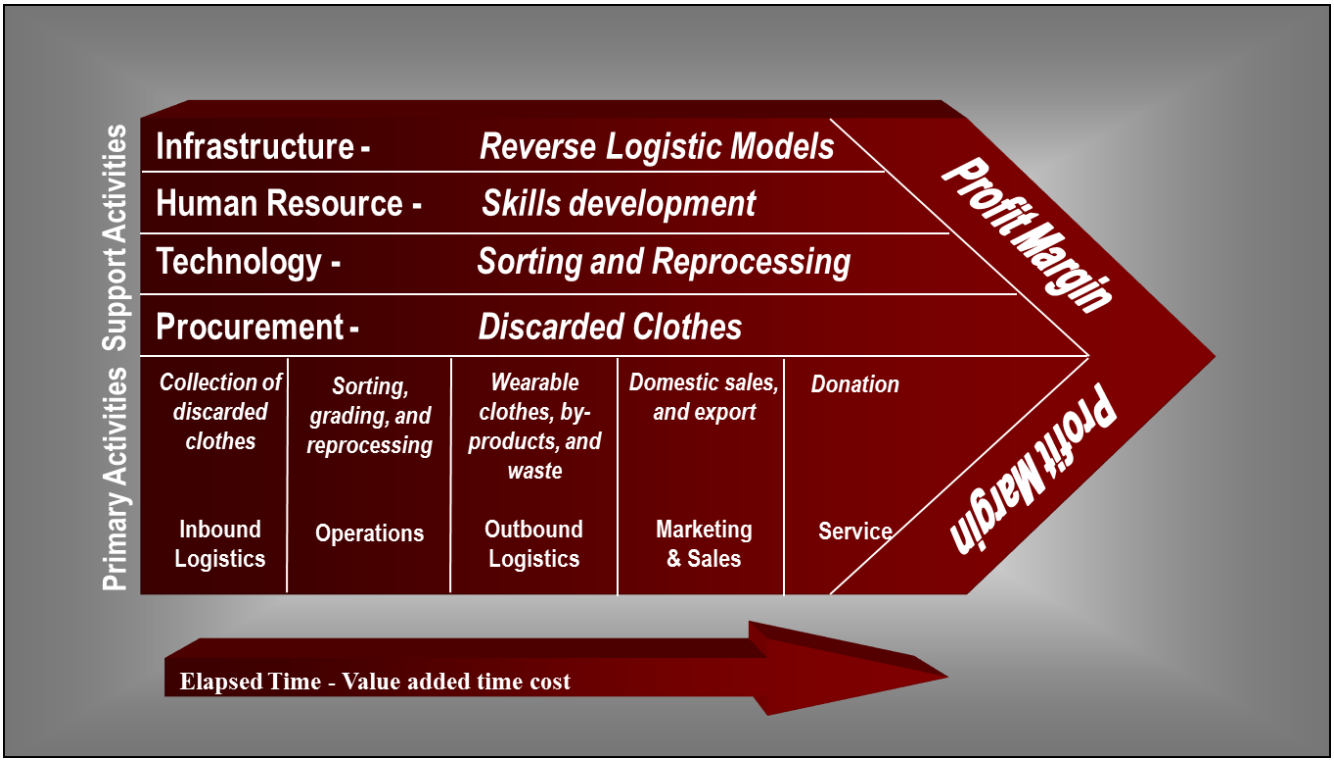

Figure 6-1: Value creation in the reuse-based reverse value chain for apparel (Porter 1985)

In the reverse value chain, reuse is found to be more resource efficient than recycling for material extraction. This has been found in the European case study as well as Indian case study. In other words, the organizations are trying to maximize the fraction of used apparels for direct reuse, considering its economic benefits over recycling. This has been found from European multinational charity organization case stsudy that organization in Europe need to pay around 200 Euros per ton for disposing unsold stocks at the district heating centre. In the present situation even in western Europe, it is a big challenge to get back products from the consumers (Morana and Seuring 2007). (Pal and Gander 2018) advocated the direct reuse of clothing products over other recovery options. In the case of multinational charity organizations study, this has been found that the organizations are utilizing different methods to collect used clothes. Companies are innovating new methods to do an effective collection to extract the highest value

from the discarded clothes. The product return and recovery highly depends upon the availability of return channel. The facilities such as collection boxes, return offers, repair and redesign services accelerate the product return (O'Reilly and Kumar 2016). This is important to collect clothes and bring it to the reverse cycle of use. Next subsections discuss collection, sorting, and reprocessing methods for value creation in details.

6.1.1 Collection

The reverse logistics of clothing industry is predominantly propelled by charity organizations (Pal 2018). This is also evident from the case study findings. Most of the organizations (except E3, E5, E7 and S5) engaged in the collection of clothes are not-for-profit in nature.

E5 is a 30 years old for-profit establishment located in the London, UK while E3 is Stockholm based recycling company and recently entered into textile collection and recycling. E7 and S5 are owned by local municipalities where the clothes are mainly collected through collection box and direct handovers in the shop (Shen 2014). Similar ways of collection are also found in the Swedish local charities organization. As all charity organizations i.e., S1-S5 are accepting collection of used apparel at the shop, whereas organization S2 has also installed a collection box in the city. S5 has collaborated with E1 to receive a collection from the textile collection box owned by E1. Some unique and innovative approaches of the collection were found in this research, particularly in the case of a multinational charity organization as mentioned in the Table below:

Table 6-1: Unique ways of the collection to recapture value from used clothes

S.No	Collection method	Supporting cases	Remarks
1	On shop	S1-S5 and E1-E10	1. Most common method to accept the donation
2	Collection bin/box	S2, S5 and E1-E10 (except E8)	1. S1, S3, and S4 are local charities organisation, so don't have a collection box 2. E8 believe good quality of collection can't be received in box
3	Collection container (large size)	E1-E10 (except E8)	1. The large container is placed near energy station to receive a collection
4	Collection events	E1, E2, E3, E6, E7, E8*, E9, and E10	1. E8 collect used clothes through only through collection events organised at a shopping mall and another place 2. Other organisation organised collection events mostly at the shop and some time in a shopping mall during the festival
5	Leftovers from garment factories	S1 and S2	1. Leftover trims and fabrics
6	Unsold clothes from retailers	S4, E1, E2, E4, E6, E9 and E10	1. Unsold stocks of online and shops retailers are donated after the end of a season. In most of the cases, new clothes are donated on the condition of not selling clothes in domestic markets.
7	Office, banks, and housing agencies	E2, E3, E4, and E6	1. E3 is in favour for the quality of the collection and so planning to collaborate with housing agencies to collect directly from consumers. 2. E6 reported quantity issue in office and bank collection
8	Collection through school	E5, E9, and E10	1. Organization in the UK are collecting from school as an outgrown student generally donated their smaller clothes.
9	Collection through retailer	E2, E4, and E6	1. Collaborate with the retailer to collect clothes from retailer shop
10	Postal collection	E2	2. E2 has collaborated with national postal agencies for collection by post
11	Collaboration with local agencies	E1, E2, and E4	1. E1 collaborated with private agencies for remote location collection 2. E2 and E4 collaborate with municipal agencies for collection

From the table above, it is evident that there are different ways to collect clothes. European multinational organizations have figured out innovative ways of collection as evident in the case of E2, E4, and E6 which are collecting in collaboration with retailers. (Shen 2014) has also highlighted, fashion brand such as H&M collaborate with charities or commercial companies to manage product return. The commercial collection companies ensure to process the collected clothes according to their conditions. Retailers have also launched different kinds of schemes to promote the collection of textile material (Naoko Tojo et al. 2012). (Ekstrom and Salomonson 2014b) emphasized that the charities organizations can also collaborate with retailers to collect clothing from people's home or workplace. Charities organizations E2, E3, E4, and E6 are collecting from office, banks, and housing agencies. E3 thinks that good quality of clothes can be collected from consumers and in most of the cases clothes are picked up by local charities. However, E6 believes that this is not economical to collect from banks and offices as the volume of the collection is very low. Some of the textile collectors in the UK has placed textiles bank in the schools and periodically visit schools and brief students about environmental benefits of textile reuse (Morgan and Birtwistle 2009). This is apparent from the E5, E9, and E10 collection methods.

Farrant, Olsen, and Wangel (2010) suggested that good quality of clothes collection can't be done through collection boxes. This is mainly because people dispose textile scrap in the boxes and take back quality clothes to donate at second hand shop. Local charities organizations like S1 and S2 are able to collect relatively better quality of used-apparels as compared to the collection bins. E1 and E3 have also shown that for good quality of clothes the collector needs to reach close to the consumer. Charities are collecting clothes for donations but in reality, they make money from second hand clothes sales. The collected clothes are sold at secondhand shop and

exported to commercial recyclers and are not freely distributed in most of the cases (Brooks 2013). This demoralizes public trust and can reduce the volume of textile and clothing collection (Ekstrom and Salomonson 2014b). The charities organization in the UK has started faceing this problem because of too many collecting organisations. Now consumers and government in the UK consider second hand clothing as a profitable business. This has attracted too many private players in the trade of second hand clothes becoming very competitive and complex with the entry of commercial collectors (Norris 2012). Local government and municipality in the UK allocate place for collection bins at the public place through competitive bidding process.

6.1.2 Sorting

The sorting decision is influenced by potential markets and product demands. For example, a basic t-shirt of fair quality may be considered of lesser value in the European market as compared to the developing economies like Africa or India. The collected clothes are segregated based upon the degree of usefulness and acceptability in the market. Generally, the operation of sorting by large charities or commercial sorters is performed with the help of conveyer belt. Further, the operation of sorting is divided into primary and secondary sorting. Primary sorting is performed to broadly filter out acceptable and unacceptable items. The secondary sorting operation is performed to separate useful items on the basis of specific categories such as men, women and children. Each of these categories is further divided into garment type i.e., shirts, dresses, blouses, pants and lingerie. Below table clearly depicts the criteria and sub-criteria employed during sorting process:

Table 6-2: Sorting criteria and sub-criteria

Basis	**Subcriteria**
Potential Market	Consumer purchasing power, taste, fit, climate, trade law, the relation between Importer and exporter.
Degree of Dirt	Soiled, Clean etc.
Expected Value	Best, useful, Waste
Product Category	Shirt, Blouse, t-shirts, Jeans etc.
Target Consumer	Men's wear, Ladies wear, kids etc.
Fibre Contents	Cotton, Silk, polyester
Colour	Red, black, Blue , white etc (to avoid dying and bleaching during recycling process)
Condition	Amount of reconditioning required-Missing button, tear etc.
Brand Type	Levies, Gap, Esprit etc.
Level of sorting	Crude/Refined, Primary/Secondary etc.
Quality Grade	A-Europe, B-Africa, C-Asia, G-Recycle

The sorting process is critical in nature because it is crucial for capturing unutilized value from the used clothes. The discarded clothes collected from the consumers are not considered as valuable in the unsorted condition. However, this depends upon the ability of the person involved in sorting (Botticello 2012) to extract value from the discarded clothes and this was evident in case of I6. The general manager of I6 told that due to a small mistake or negligence by the sorter, the valuable clothes are sent to the garbage. Therefore, it is important to sort clothes efficiently (productivity) as well as effectively (quality). Used clothes are sorted and graded in almost 200-300 categories, therefore it is important to employ a skilled employee for performing the sorting process. H&M collection partner grouped the collected textiles broadly into four categories i.e., re-wear (clothes that can be re-worn), reuse (as rags and wipers) and recycle

(generate fibres to make insulating materials) (Shen 2014). Further, the clothes under these four categories are subdivided into multiple subcategories based on the usage. For the recycling purpose, collected textiles are segregated according to their material composition, colour, size and recyclable suitability (Mo, Wen, and Chen 2009). It has been found that at I3, the used clothes are sorted based upon colour for rags and recycling. Generally, white rags and waste fabrics for recycling have better market value as compared to the coloured fabrics. This is also found at I1 because the multicoloured fabrics are required to be bleached, re-dyed, and it is hard to achieve good quality yarn from mixed used clothes. Sorting of clothes on the basis of colour means no re-dying is required and consequently, there will be saving of energy and water. Sorting process is considered as one of the critical steps in reverse value chain and requires the intervention of technology (Alkazam 2013). Below table represents the characteristics of sorting problem:

Table 6-3: Characteristics and description of sorting

Characteristics	Description
Subjective	No standard defined parameter
Huge Category	Due to different type and condition of cloths almost 150-400 categories are made during sorting
Individualistic	Good and Band quality depends upon individual Judgement
Expertise	In the absence of standardization need an expert to execute
Manual	The toilsome & tedious process to extract useful from bulk waste
Automation	Technology intervention is required

On similar lines, the European multinational charity organizations E2 and E4 have emphasized the importance of technology in sorting of the discarded clothes. E2 is in the process of

developing single-touch floor for sorting process in which the discarded clothes (sorted for export) will be touched only once throughout the process whereas E4 is planning to install infra-red based technology for automatic sorting. In contrast, the organization E5 is rolling back to manual process to improve quality of sorting because in the automatic process the accountability of the person involved in sorting will reduce to some extent. Hence, the quality of sorted clothes is expected to improve with the automation. The reputation of exporter involved in the used clothing exports depends upon the judgment of clothes quality. Therefore, the companies are employing knowledgeable and skilled sorters to gain and retain reputation (Norris 2014). The similar opinion is also found in the interview with the founder of I5 where he explained that due to large number of sellers of used clothes, it is important to establish a good reputation by offering good quality graded goods. Inefficient methods of sorting result in high cost as they are unable to extract maximum value from the discarded clothes (Carter and Ellram, 1998). This is quite apparent from the cross-case analysis of Swedish local charity organization, European multinational charity organization, and Indian sorting and grading companies. Swedish local charity organizations are able to extract the least value. For example, the organization S1 has a huge inventory of unsold clothes. European multinational is extracting relatively better value by networking with international traders and buyers whereas Indian sorting and grading companies derive optimum value from the used clothes. Indian organizations such as I3 and I5 are relatively better in capturing value by routing different fraction of clothes for the different purposes.

6.1.3 Value creation through reprocessing

The second hand clothes donated are generally considered as a gift or waste with no or very less value to the donor. This is quite evident from all the case studies; the consumers take pain to drive to donate the clothes to the second hand shops or textile collection bins. The Indian sorting

and grading companies I7 is able to receive the used clothes from the USA on the payments of the freight charge only. However, in most of the cases, the donated clothes have an unutilized value that can be properly realized through reverse value chain activities (Brook 2012). The Swedish charities organizations i.e., S1-S5 are not able to extract value from used clothes. Indian sorting and grading companies i.e., I1-I10 are able to retrieve maximum value from the imported second hand clothes. The collected clothes gain significant value after sorting and reprocessing (if required). The product can undergo various reprocessing steps depending on the condition of the discarded clothes. This has been found that the reasonable qualities of clothes are sold in the second hand shops. The clothes which are in bad condition can be washed and repaired to fix broken stitches and buttons to restore the basic functionality of the garment (Sandberg, Pal, and Hemilä 2016). Theoretically, it is possible to perform repair and redesign processes but practically organizations are not able to perform cleaning and washing. Indian organizations are able to perform basic repair due to the availability of cheap labour. European organizations such as E1, S1, S2, and S5 rarely repair and wash. Sometimes value addition activities such as redesign or upcycling are used to improve the condition or functionality of the existing clothes. Romanian organizations such as R1 and R3 are able to upcycle. This may be due to relatively lower wages in Eastern Europe as compared to Western Europe. In addition, the Romanian organizations are able to receive better quality products and hence, are capable to do upcycling. However, for the Indian organizations downcycling is the value capture opportunity. Downcycling could be an alternative to capture existing value if clothes are not suitable for direct reuse or upcycling (Paras and Curteza 2018). The waste clothes can be converted to new clothes ranging from high-value vintage clothes to the low-value rags and wipers (Pal 2017). European organizations E2 and E5 are also able to make wipers from the unwearable clothes.

Hawley (2006) presented a pyramid model for volume-to-value creation ratio in the used clothing. Overall, all the organizations are trying to maximize the value that can be retrieved from the used clothes. The table below demonstrates the broad categories of value capture in reprocessing and missed by different organization studied.

Table 6-4: Capture and missed reprocessing value in reverse value chain of apparel

S.No	Value creation through reprocessing	organization capture value	organization missed value
1	Retail of second hand clothes	S1-S5, E1- E10, and R1-R4	I1-I10, and R5-R6
2	Export of second hand clothes	S1-S2, E1-E10, I1-10, and R6	S3-S4, and R1-R5
3	Redesign and upcycling	R1, R3, E7, and E8	Remaining all organization
4	Downcycling (rags, and wipers)	E2, E5, and I1- I8	Remaining all organization
5	Downcycling (fibres)	I1 and I8	Remaining all organization
6	Denim cut shorts	I1-I8	Remaining all organization
7	Mutilation for domestic sales	I2-I7	Remaining all organization

The maximum amount of clothes (approximately 48%) is used in the domestic markets or exported to the developing countries. Unique or branded garments are very rare and hence, are considered as Cherrie or diamond in the used clothing business. Rags and wipers for cleaning and recycling for fibres have captured a significant attention from practitioners. The European flammability legislation has mandated to use products with high wool content in upholstery and protective clothing (Hawley 2006). This indeed increased the requirements of recycled woolen fabric. From Table 6-4, it is visible that the organizations are engaged in the reverse value chain where they are trying to capture value through different reprocessing methods. However, in a

few situations, the value is lost due to lack of knowledge and other geographical legislations. For example, the Indian sorting organizations are not permitted to sale sorted and graded clothes in domestic markets because the Indian government has categorized wearable used clothes as a prohibited item to protect local textile and garment manufacturing companies. The mutilated used clothes are allowed to import for recycling purpose. Recycled woollen fibres are also used for making blankets in India and wall-filling materials in western countries (Norris). The recycling of used clothes is not feasible for the European companies, because the labour cost is high. This was clearly observed at Swedish local charity organization S1, where high value woollen clothes are disposed-off to waste and treated as unwearable whereas woollen clothes in the mutilated form are in high demand in Indian recycling markets.

Value creation from used apparels also varies among the organization to organisation in the same geographical location. For instance, I1 and I8 have their own recycling facilities to generate yarn from unwearable clothes while other Indian organizations do not have this facility. European organization E2 has established his own sister company to manage export activities. The other organizations such E6 and E8 also take help of E2's sister companies to export unwearable clothes. The amount of value created by an organization gives a competitive advantage to that organization over others (Pal 2018). The organization can exploit available resources and processes to create new value in form of a product or service (Cova et al., 2011). However, the reverse value chain activities are labour intensive, therefore, the outsourcing or offshoring could be a suitable option to achieve cost efficiency (Skinner et al., 2008; Bernon et al., 2011). The reprocessing in the form of minor or major deformation depends on the requirement of new products (Abraham 2011). Reconstructing denim jeans to denim cut shorts is a good approach to make high demand products with the little amount of deconstruction. This also creates huge

employment opportunity as clearly visible from the sorting and grading organization located in India. The reprocessing of used clothes generate a significant amount of employment in handling, cleaning, restyling and redistribution process (Bigsten and Wicks 1996)

6.1.4 Upcycling and Redesign

A few designers and second hand clothing companies are making efforts to turn textile wastes into cutting edge designs. For example, in the current study, R1, R3, E7 and E8 are engaged in the redesign process. However, the total amount of redesign clothes are limited in the amount (Tojo et al. 2012). Redesigning can be performed to turn clothing products into cushions, pillow or reconstructed apparel. For example, the sweater can be turned into a pair of pants for the child. Fabrics of jeans and trousers have a long life and hence, this can be re-cut and re-stitched into other products (Abraham 2011). In the current study, organization R1 is performing redesign to convert used clothes into another form of wearable clothes or different accessories. Most of the redesigned products are made by R1 on the basis of bulk orders or demand from the own shops. E8 has a separate redesign section and satellite centre to perform redesigning activity. Useful parts from the used clothes are extracted and stored for future redesign. R3 and E7 are engaged in the redesign process for few particular products. The redesign process to a product of higher value i.e., upcycling can be a product, process or demand based. Redesign could add values to the existing clothes and avoid production of new clothes (Farrant, Olsen, and Wangel 2010). The figure below depicts a different kind of upcycling process

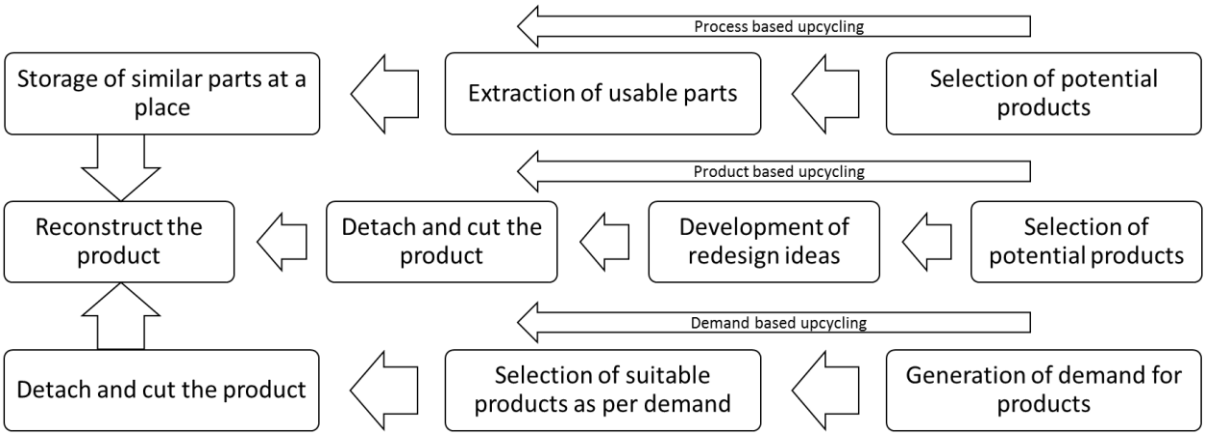

Figure 6-2: Approach to upcycling process

Altering, remaking and refashioning clothes are other ways through which the life of clothes can be extended. Specifically, the quality, price and appearance of the used clothes in the second hand clothing market get improved (Imo and Maiyo 2012). The charities from Nordic countries send materials to east Europe for recycling. It is not financially viable to set up recycling units in the developed countries (Ekstrom and Salomonson 2014a). This is apparent from the cases of Romanian organizations.

6.2 Modelling reverse value chain

In this section, an empirical model has been developed and analyzed to enhance the understanding of reuse-based reverse value chain for the apparel industry. Dervojeda, Verzijl, and Rouwmaat (2014) have highlighted the importance of smaller loops to save energy and effort to extend the life of the product. In reverse value chain in apparel industry can be incorporated by three different ways or loop. Firstly, retailers and distributors can redesign the leftover stock of products to make them saleable. Secondly, consumers can extend the life of self-used clothes by getting it redesigned. Thirdly, route of reuse can be adopted. Based on the qualitative analysis and above discussion from the case study findings, a model for reuse-based reverse value chain is proposed as follow:

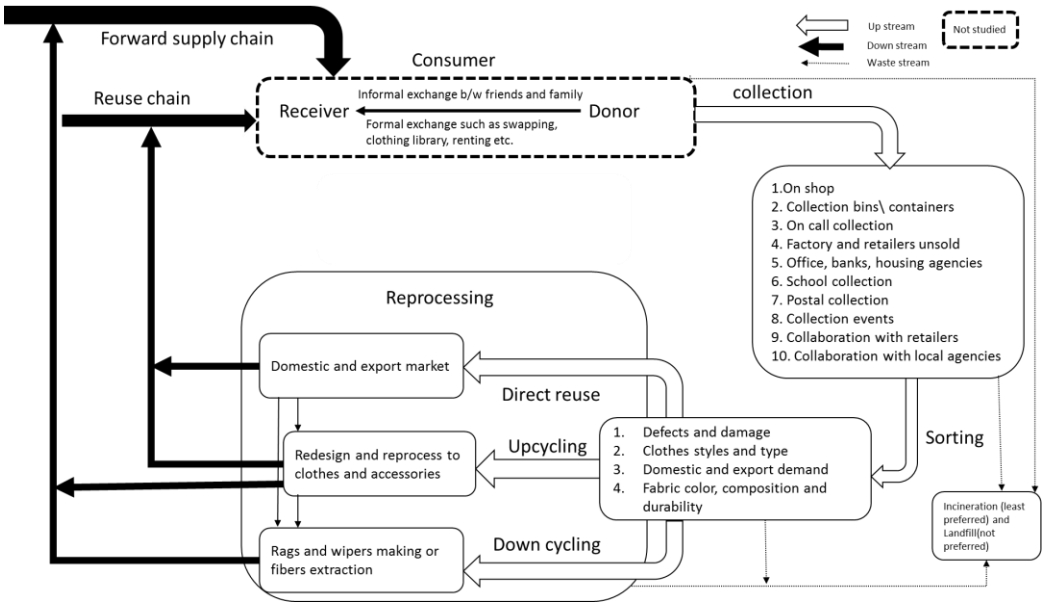

Figure 6-3: Model for reuse based reverse value chain

Further, the model is analyzed with a different analytical technique such as AHP, Genetic algorithm and Markov principle in below subsection.

6.2.1 Reverse value chain decision

The impact of reverse value chain factors can be understood with the help of ranking and weight of each of the closed loop alternatives. Ranking and weight of the closed loop alternatives are based on the material, economy and technology factors. The up-cycling alternative is ranked first depicting that the up-cycling process is the most efficient phenomenon. This was also highlighted by the designer of R1 in her interview. The cost incurred in the process of reverse logistics and the market potential decide the future direction of clothes (Metta and Badurdeen 2013). This was also apparent in the case of Romanian charity organisation in the Iasi region. The firm is able to up-cycle reasonable quality of products if there is demand for a set of skill. At the same time, the founder of the Romanian charity organisation has highlighted that there is not much demand for up-cycling and the process is expensive. The economic feasibility is a major driving force for closed loop chain (Badri Ahmadi, Hashemi Petrudi, and Wang 2016). In below Figure 6-4 alternative's weights are given and sum of all normal weights will be 1. This can be interpreted that direct reuse and up-cycling alternatives are preferred 30.9% and 48.2% respectively. Down-cycling and incineration/landfill are preferred 13.4% and 7.2% respectively. The physical interpretation of ideal weight of an alternative could be studied as compared to other alternatives. Direct use is 0.3 times suitable in comparison to up-cycling alternatives whereas down-cycling and incineration are 0.13 and 0.07 times important in comparison to the up-cycling. Based on the ideal weight, a ranking of up-cycling, direct reuse, down-cycling and incineration are one, two, three and four respectively.

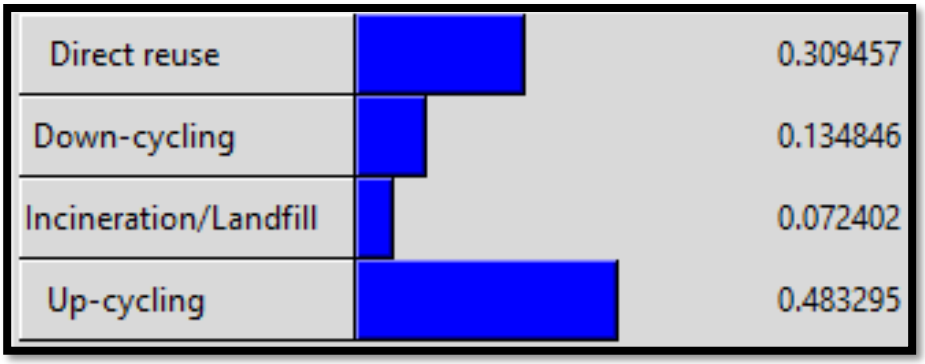

Figure 6-4: **Weight and ranking of alternatives**

The experts have highlighted that in the absence of technical skills, the product is reused as it is. However, incineration or landfill is preferred over other alternatives, if the material is of poor quality (Gam et al. 2011). This is in line with the findings from an interview with the manager of the distributor located in the Bacau region. Manager of R1 during her Interviewee has also emphasised on up-cycling. She has explained that the top quality of products is sorted for the upcycling process. If the product is made up of good quality material but it is in torn or dirty condition, then down-cycling is preferred. The same has been demonstrated by the Romanian designers and also supported by Zhao et al. (2013).

6.2.2 Optimizing redesign process

In the re-modularization model for garments re-design, the parts are extracted from the used or discarded garments based on the redesign requirements. The extracted parts are divided into the 'important' and 'less important' group. There are eight kinds of parts under the important category while four kinds of parts are considered under the less important category. Each part has a different set of attributes and characteristics that differentiate one part from the others. The proposed mathematical definition can be used to quantify the attributes and characteristics of the extracted parts. Information for each part is saved in the part database on the basis of the mathematical definition of parts. The stored parts can be identified for the redesign on the basis of design requirements. A binary decision variable can be used for the identification of the parts from the database. Value of the binary variable for the important part can be set as 1 for the apparel re-design and 0 for accessories re-design.

The mathematical symbol has been used to define parts junction and parts associated with the junction. Mathematical notation is used to clearly describe part attributes, the value of its attributes and requirements of the junction. The system could finish redesign on the basis of domain knowledge of garment design and production. The attribute and value of the attribute of two parts should be equal for implementation of a connection. The feasibility of implementation of redesign system is checked with a re-design company based in Sweden. The result shows that application of model could simplify the existing process of re-design. In the present scenario, all the processes right from parts extraction to reconstruction are done manually on the basis of expertise and skill of the designers. Application of modularized model could enable others also to perform redesign activities based on the re-design history. In the current study, this has been found that application of re-modularization model can save up to 75% time over the manual process.

6.2.3 Life cycle assessment of reuse value chain

The value from the used clothes can be captured through different methods i.e., direct reuse, upcycling, downcycling or incineration (Harris, Roby, and Dibb 2016; Bell, Mollenkopf, and Stolze 2013b; Goggin and Browne 2000). Direct reuse has received a significant amount of attention from the research and practice (Jayaraman and Luo 2007). Life cycle assessment has been done with help of Markov principle to calculate number of times the clothes can move (trip number) in reuse cycle before final disposal to the garbage. If clothes can complete n trips then the number of time it can be used will be $n-1$. Redesign is found a hotspot as a good redesign process, significantly influences $n-1$ i.e., number of times, a clothes can be reused (Schrijvers, Loubet, and Sonnemann 2016). For example, in case of Denmark the trip number ($n=20$) illustrates that in Denmark 19 times a cloth can be reused before reaching to the final disposal.

This may be due to high percentage of clothes exported from Denmark (Tojo and Nordic Council of 2012) and this has been assumed that number of times a clothes used is higher in the country where they are exported as compared to the country of origin. This is also in accordance with the fact that people with lower income use clothes till the threadbare (Lambert 2004).

For Finland the value of n is 8 hence number of times a cloth can be reused i.e., $n-1$ will be 7. There is a good recycling and reuse percentage in the Finland. The recycling percentage of Finnish clothes is 30% and a very small percentage of clothes are incinerated. This happens due to relatively better infrastructure and mechanisms to handle the post-consumer apparels. The recycling companies are facing economic crisis and may need the help of the government to sustain for long (Guide, Jayaraman, and Linton 2003). Post-consumer clothes collected in Iceland are mainly exported to developing nations in the absence of domestic second hand market (Palm et al. 2014). The value of n is 8 hence number of times a cloth can be reused i.e., $n-1$ will be 7 in Iceland. The reverse values chain of clothes in Norway is mainly carried out by non-government firm such as charity organization. The number of times a cloth can be used in Norway is 16. The current reuse practice can be improved in the presence of proper infrastructure to recycle and reuse (Laitala and Klepp 2014). In Sweden almost three fourth clothes are exported to the developing countries and 10% are used by Swedish people and remaining 10% of clothes are incinerated for heating (Naoko Tojo et al. 2012). Based on LCA, total number of times a cloth can be reused in Sweden is found to be 7.

6.3 Chapter summary

The chapter discussed empirical findings from the cases and the mathematical models. The existing theoretical knowledge was the context of discussion to build new theoretical knowledge as well as knowledge for the practice. A novel model has been proposed for the reuse base

reverse value chain. The model provides an insight into the value creation stages of the reverse value chain of the clothing industry. The model has summarized different and unique ways to capture value in the reverse value chain across all process. Local charities organizations are connected to the community and therefore able to recover good quality of collections. Multinational charity organization are in better position to understand the business and implement technology, therefore these organization has achieved expertise in sorting process. Indian organization has the competitive advantage of location and low wages, therefore able to capture value from almost each fraction of used clothes. Subsequently, develop empirical model is analyzed with the help of mathematical techniques. MCDM technique is used to make reverse logistic decisions. A genetic algorithm is used to optimize upcycling or redesign process. Finally, the Markov principal is used to count a number of times, a cloth can be used. The next chapter is the conclusion that will comprehend the contributions, implications and future directions of this research work.

7 Chapter: Conclusions

This chapter answers the research questions based on the empirical findings from the case studies and the mathematical models. Next, theoretical contribution and implications of this research will be discussed. The current chapter concludes with research limitations and future research avenues in the area of the reuse-based reverse value chain for the apparel industry.

7.1 Revisiting Research Objectives

The objective of the research outlined in the introduction section will be revisited in this section. The overall aim of the thesis is to develop a reuse-based value chain model for the apparel industry. The aim of the research was subdivided into three objectives. The first objective was to figure out the theoretical underpinnings for this research and was addressed in Chapter 2 based on the state of art literature review. The second objective is empirical in nature and is examined with the help of case studies. The response to the third objective is achieved by formulating a mathematical model for reuse based reverse value chain. The objectives of the research are explored in order to enhance an overall understanding of the reuse-based reverse value chain for the apparel industry.

7.1.1 Objective I: To develop a theoretical framework for the reuse-based reverse value chain for the apparel industry.

The first objective of the research was addressed in Chapter 2 through a systematic review of existing literature. The need for the exploring theoretical foundations was primarily to figure out the processes and factors influencing reverse value chain for the clothing industry and to design a framework based on the identified factors. System, prices, design, information, awareness and legislation emerged as important factors influencing collection, sorting and reprocessing of used apparels. The findings are unique and provided a deeper understanding of the reverse value chain

of apparel because earlier studies were mainly focused on the consumer behaviour and environmental impact of apparel reuse.

7.1.2 Objective II: *To empirically investigate the business of used apparel in the different charities and organizations.*

The empirical findings from the cases in Chapter 4, suggested that the companies engaged in apparel reuse business have different approaches and different levels of value creation. The Swedish local charity organizations are able to create the lower amount of value, while the multinational charity organizations are able to recover more resources. The findings further suggest that offshoring reverse value chain activities to the developing countries can be a cost-effective solution. Thus, the thesis proposes different ways to collect, sort, and reprocess the used or discarded apparels to maximize value creation based upon the findings from Europe and India.

7.1.3 Objective III: *To apply mathematical tools and techniques to analyze reverse value chain model of the apparel industry.*

Various mathematical tool and techniques such as analytical hierarchy process, genetic algorithms, and Markov chain are applied in Chapter 5 to strengthen the case study analysis. Analytical hierarchy process is applied to select the most appropriate reverse value chain alternatives among direct reuse, down-cycling, upcycling, and incineration. Direct reuse was found to be one of the best alternatives based on the analysis of data collected from Romanian used apparel experts. A genetic algorithm is used to optimize the apparel redesign and upcycling process. While the Markovian principle is used to perform life cycle assessment of apparel by calculating the number of the trips that clothes can make in a reuse cycle. Thus, the analytical

analysis strengthens the case study findings and improves the understanding of reuse-based reverse value chain.

The overall aim of the research was addressed by developing an empirical model of the reuse-based reverse value chain for the apparel industry in Chapter 6. The model is specific to used apparel and limited to the phenomenological context of the studied companies. The developed model is different from the previous models proposed in the literature in terms of value creation during collection, sorting, and reprocessing. The model also unveils that the resource efficient value creation can be done at each of the steps i.e., collection, sorting, and reprocessing. Even though reprocessing is one of the crucial steps in maximizing the value creation in the reverse chain. Therefore, the value optimization in reverse value chain should not be limited to the reprocessing stage, but a proper attention is also required at an earlier stage to differentiate valuable and waste product to save logistic cost. Furthermore, with the help of mathematical model proposed in the thesis, an optimal decision can be made in the reverse value chain. This is important as the recent literature in the area of operation and supply chain has observed increased discussion on resource efficiency and value creations.

Based on the investigations to figure out responses to the research aim and objectives, the next section provides the theoretical contribution of the present work.

7.2 Contribution to theory

The elusiveness in the reuse-based reverse value chain concept has stimulated us to contribute in this domain. The thesis enhances the current understanding of reuse-based reverse value chain across three processes i.e. collection, sorting, and reprocessing. The current research is considered to be unique to study the apparel reuse business across different socioeconomic regions such as West Europe, East Europe and India. The inter and intra analysis of each cases

provides different findings to strengthen the current research knowledge. Another theoretical contribution of the thesis is signified by the application of mathematical models in the reverse value chain. The applied models are further validated with the primary or secondary data of reverse value chain. The current thesis builds on the mix method approach i.e., qualitative (case study) and quantitative (mathematical modeling). Most of the previous works in the area of apparel reuse were qualitative in nature and hence, this thesis applied a novel methodological approach to comprehend reuse base reverse value chain. Value creation in the reuse-based reverse value chain is highly determined by the design and strategy of reverse value chain (Savaskan, Bhattacharya, and Van Wassenhove 2004; Bernon, Rossi, and Cullen 2011). Differences in value creation are clearly visible from the study of European multinational and Swedish local charity organizations. Swedish local charities have limited access to the market and know how to create perform value addition activities. For example, torn woolen apparels are incinerated by Swedish local charities, whereas the mutilated woolen clothes are of great value for Indian sorting and grading companies. The multinational charities are able to generate higher income from the used apparels by exporting unsold apparel to Asia and Africa. The organizations gain higher economic value through multiple value-added activities and multiple sales channel (Pal 2017). The value generated out of used apparel also depends upon the quality of apparel collected from the end consumers. Organizations were involved in the collaboration and partnership with government and non-government agencies to reach close to consumer. The findings highlighted the importance of right collection system and strategy for the success of reverse value chain (Jayaraman and Luo 2007).

This thesis presents a distinct view of reverse value process and value creation across the collection, sorting and reprocessing. Proper utilization of each portion of the collected apparels

can optimize overall value creation of reverse value chain of apparel. The existing knowledge of reverse value chain of apparel is enhanced by the development of a model for reverse value chain for the apparel industry. So far most of the research works have focused on consumers only, whereas this thesis has created knowledge from a wider or overall reverse value chain perspective. Therefore, the reverse logistics knowledge and literature strengthened meaningfully.

7.3 Implication to practice

The discussion in Chapter 6 suggests different ways to collect, sort, and reprocess used apparels. Thus, the secondhand clothing organizations can learn from the findings of the current research to effectively collect, sort, and reprocess discarded clothes. Practically the findings are important for the organizations that are struggling for the economic sustainability. The findings provide suggestions on maximizing the benefits from used apparels through understanding how to categorize and increase the utilization of each category. Based on the cases, the thesis provided specific implications for the organizations that have participated in the present research.

The findings can be used to develop strategic and collaborative collection and reprocessing system, and optimization of sorting and grading categories to maximize use of each fraction of used apparel. The design of reverse value chain varies from one industry/region to other industry/region (Jayaraman and Luo 2007), therefore it is important for the practitioners to appreciate the factors influencing value creation process carefully while designing reverse value chain. In the current study, it has been found that the second hand clothing business is at developing stage. Hence, the organizations are attempting to explore new innovative methods. It is crucial to undertake a proper analysis of reverse value chain to avoid low or no value creation. The absence of strategic collaboration or a high degree of fragmentation leads to low-value creation in the reverse value chain (Ekstrom and Salomonson 2014b). In this context, the current

study emphasizes certain reverse value chain design strategy such as collaborative value creation.

Waste management is formidable challenge for the society and government. Therefore, current research provides an insight for the policy makers as well as community to minimize the textile waste through improved collection system. Society and community could also be get motivated and participate in the reverse value chain of apparel and textile as active members. The finding from the some of the case study has also demonstrated the involvement of charities into other social activities like apart from environment and waste management. UK based charity organization periodically visit schools and conduct quizzes and workshops that can significantly improve the knowledge of students. Swedish charities organizations are providing meeting place for homeless people, inviting local resident for the volunteer service, and providing jobs to homeless, alcoholic, and disabled persons. Therefore, charities organization could also learn from each other and could improve their social contribution.

7.4 Research Limitations

The empirical study in the current research are based on the findings from three cases. The organization selected for the study is based on convenience and snowball sampling. So other organisations are required to be explored generalize the findings. Most of the representatives of the organisations were not fluent in the local languages and thus, the language was found to be one of constraints. However, with the help of native speakers, the effort has been made to translate the collected data effectively to minimize the loss of data. Majority of the evidences for the current research are collected from Sweden, Romania, and India.

Furthermore, the current study does not take into consideration other value aspects such as consumers and brand image. The end consumer and retailer or fashion brand perspectives are

exempted from the current study. However, the current study presented the process of value creation and shows the influence of multiple design aspects towards a particular type of value creation. The current work is informed basic research and exploratory in nature and partly suffers from in-depth analysis such as collaborative and action research for the higher value manifestation. This limits the scope of generalization as the value manifestation, process; legislation will differ considerably for other industries. Other external factors such as legislation and product directives have not been explored in details.

7.5 Future Research

The current research is the outcome of the mobility based joint doctoral programme. Therefore, the researcher was not able to implement the findings as the research duration at each location was not sufficient to implement the findings. Thus, the application of the thesis findings could be a major avenue for the future research. Therefore, future researchers are encouraged to do collaborative and action research for in-depth analysis of reuse-based reverse value chain. The qualitative model of the current thesis could also be validated with simulation techniques such as system dynamics and/or agent-based modeling. The statistics based quantitative models can also be useful for in-depth investigation of social business model like charities. The empirical model developed for reverse value chain for the apparel industry in the current research is universal and could be applied to the other reverse value chain of other location. The context of the current research is apparel; future researchers could test the same in the other industry scenario. Furthermore, the evidence of product-process design from the current study could be extended to product, process and supply chain design using three dimensional concurrent engineering for higher value creation and its manifestations.

References

Abdallah, Tarek, Ali Diabat, and David Simchi-Levi. 2012. 'Sustainable supply chain design: a closed-loop formulation and sensitivity analysis', *Production Planning & Control*, 23: 120-33.

Abdulrahman, Muhammad D., Angappa Gunasekaran, and Nachiappan Subramanian. 2014. 'Critical barriers in implementing reverse logistics in the Chinese manufacturing sectors', *International Journal of Production Economics*, 147: 460-71.

Abimbola, O. 2012. 'The international trade in secondhand clothing: Managing information asymmetry between west African and British traders', *Textile: The Journal of Cloth and Culture*, 10: 184-99.

Abraham, N. 2011. 'The apparel aftermarket in India - a case study focusing on reverse logistics', *Journal of Fashion Marketing and Management*, 15: 211-27.

Alkazam. 2013. 'Textile Science & Engineering Automated Sorting Technology from T4T Can Help Improve Recovery and Efficiency', *J Textile Sci Eng*, 3: 3-5.

Asemi, Adeleh, MS Baba, R Haji Abdullah, and N Idris. 2014. 'Fuzzy multi criteria decision making applications: a review study'.

Atasu, Atalay, V. Daniel R. Guide, Jr., and Luk N. Van Wassenhove. 2008. 'Product reuse economics in closed-loop supply chain research', *Production and Operations Management*, 17: 483-96.

Badri Ahmadi, Hadi, Seyed Hamid Hashemi Petrudi, and Xuping Wang. 2016. 'Integrating sustainability into supplier selection with analytical hierarchy process and improved grey relational analysis: a case of telecom industry', *The International Journal of Advanced Manufacturing Technology*, 90: 2413-27.

Barley, Stephen R, and Gideon Kunda. 2001. 'Bringing work back in', *Organization science*, 12: 76-95.

Beamon, B. M., and C. Fernandes. 2004. 'Supply-chain network configuration for product recovery', *Production Planning & Control*, 15: 270-81.

Bell, John E., Diane A. Mollenkopf, and Hannah J. Stolze. 2013a. 'Natural resource scarcity and the closed-loop supply chain: a resource-advantage view', *International Journal of Physical Distribution & Logistics Management*, 43: 351-79.

Bellman, Richard E, and Lotfi Asker Zadeh. 1970. 'Decision-making in a fuzzy environment', *Management Science*, 17: B-141-B-64.

Bernon, Michael, Silvia Rossi, and John Cullen. 2011. 'Retail reverse logistics: a call and grounding framework for research', *International Journal of Physical Distribution & Logistics Management*, 41: 484-510.

Besiou, Maria, Patroklos Georgiadis, and Luk N. Van Wassenhove. 2012. 'Official recycling and scavengers: Symbiotic or conflicting?', *European Journal of Operational Research*, 218: 563-76.

Bianchi, Constanza, and Grete Birtwistle. 2010. 'Sell, give away, or donate: an exploratory study of fashion clothing disposal behaviour in two countries', *The International Review of Retail, Distribution and Consumer Research*, 20: 353-68.

Bianchi, Constanza, and Grete Birtwistle. 2012. 'Consumer clothing disposal behaviour: A comparative study', *International Journal of Consumer Studies*, 36: 335-41.

Bigsten, A., and R. Wicks. 1996. 'Used-clothes exports to the third world: Economic considerations', *Development Policy Review*, 14: 379-90.

Botticello, J. 2012. 'Between classification, objectification, and perception: Processing secondhand clothing for recycling and reuse', *Textile: The Journal of Cloth and Culture*, 10: 164-83.

Brander, James A. 2007. 'sustainability: Malthus revisited?', *Canadian Journal of Economics/Revue canadienne d'économique*, 40: 1-38.

Braun, Virginia, and Victoria Clarke. 2006. 'Using thematic analysis in psychology', *Qualitative research in psychology*, 3: 77-101.

Braungart, M. 2006. 'Cradle to cradle', *Textiles Magazine*, 33: 8-11.

Brinkmann, Svend. 2012. *Qualitative inquiry in everyday life: Working with everyday life materials* (Sage).

Brooks, Andrew. 2013. 'Stretching global production networks: The international second-hand clothing trade', *Geoforum*, 44: 10-22.

Brown, Barry AT, Abigail J Sellen, and Kenton P O'hara. 2000. "A diary study of information capture in working life." In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, 438-45. ACM.

Bruce, Margaret, Lucy Daly, and Neil Towers. 2004. 'Lean or agile: A solution for supply chain management in the textiles and clothing industry?', *International Journal of Operations & Production Management*, 24: 151-70.

BÜYÜKaslan, Evrim. 2015. 'A Sustainable Approach To Collect Post-Consumer Textile Waste In Developing Countries', *Marmara University Journal of Science*, 27.

Carlsson, Christer, and Robert Fullér. 1996. 'Fuzzy multiple criteria decision making: Recent developments', *Fuzzy sets and Systems*, 78: 139-53.

Carlsson, Jan, Håkan Torstensson, Rudrajeet Pal, and Manoj K Paras. 2015. "Re: Textile–Planning a Swedish Collection and Sorting Plant for Used Textiles." In.

Cervellon, M. C., L. Carey, and T. Harms. 2012. 'Something old, something used: Determinants of women's purchase of vintage fashion vs second-hand fashion', *International Journal of Retail and Distribution Management*, 40: 956-74.

Charmaz, Kathy. 2006. 'Constructing grounded theory: A practical guide through qualitative research', *SagePublications Ltd, London*.

Chen, Hsiou-Lien, and Leslie Davis Burns. 2006. 'Environmental analysis of textile products', *Clothing and Textiles Research Journal*, 24: 248-61.

Cho, Jeasik, and Allen Trent. 2006. 'Validity in qualitative research revisited', *Qualitative research*, 6: 319-40.

Collier, John, and Malcolm Collier. 1986. *Visual anthropology: Photography as a research method* (UNM Press).

Cova, Bernard, Daniele Dalli, and Detlev Zwick. 2011. 'Critical perspectives on consumers' role as 'producers': Broadening the debate on value co-creation in marketing processes', *Marketing Theory*, 11: 231-41.

Cumming, Deb. 2017. 'A Case Study Engaging Design for Textile Upcycling', *Journal of Textile Design Research and Practice*, 4: 113-28.

Czarniawska, B. 2014. *Social Science Research: From Field to Desk* (SAGE Publications).

Czarniawska, Barbara. 1997. *Narrating the organization: Dramas of institutional identity* (University of Chicago Press).

Czarniawska, Barbara. 2007. *Shadowing: and other techniques for doing fieldwork in modern societies* (Copenhagen Business School Press DK).

Czerwinski, Mary, Eric Horvitz, and Susan Wilhite. 2004. "A diary study of task switching and interruptions." In *Proceedings of the SIGCHI conference on Human factors in computing systems*, 175-82. ACM.

Das, Debabrata, and Pankaj Dutta. 2015. 'Design and analysis of a closed-loop supply chain in presence of promotional offer', *International Journal of Production Research*, 53: 141-65.

Das, Kanchan, and Abdul H. Chowdhury. 2012. 'Designing a reverse logistics network for optimal collection, recovery and quality-based product-mix planning', *International Journal of Production Economics*, 135: 209-21.

Davis, Evan, and John Kay. 2013. 'Think Again: Adding Value', *London Business School Review*, 24: 74-75.

De Brito, Marisa P, and Rommert Dekker. 2004. *A framework for reverse logistics* (Springer).

Defee, C. Clifford, Terry Esper, and Diane Mollenkopf. 2009. 'Leveraging closed-loop orientation and leadership for environmental sustainability', *Supply Chain Management-an International Journal*, 14: 87-98.

DeLong, M., B. Heinemann, and K. Reiley. 2005. 'Hooked on vintage!', *Fashion Theory - Journal of Dress Body and Culture*, 9: 23-42.

Denzin, Norman K, and Yvonna S Lincoln. 2011. *The SAGE handbook of qualitative research* (Sage).

Dervojeda, Kristina , Diederik Verzijl, and Elco Rouwmaat. 2014. 'EU-circular-supply-chains', *Business Innovation Observatory*.

Diabat, Ali, Devika Kannan, and K Mathiyazhagan. 2014. 'Analysis of enablers for implementation of sustainable supply chain management–A textile case', *Journal of Cleaner Production*, 83: 391-403.

Domina, Tanya, and Kathryn Koch. 1999. 'Consumer reuse and recycling of post-consumer textile waste', *Journal of Fashion Marketing and Management: An International Journal*, 3: 346-59.

Dururu, John, Craig Anderson, Margaret Bates, Waleed Montasser, and Terry Tudor. 2015. 'Enhancing engagement with community sector organisations working in sustainable waste management: A case study', *Waste management & research : the journal of the International Solid Wastes and Public Cleansing Association, ISWA*, 33: 284-90.

Eisenhardt, Kathleen M. 1989. 'Building theories from case study research', *Academy of management review*, 14: 532-50.

Eisenhardt, Kathleen M, and Melissa E Graebner. 2007. 'Theory building from cases: Opportunities and challenges', *Academy of management journal*, 50: 25-32.

Ekstrom, K M, and N Salomonson. 2014a. 'Reuse and Recycling of Clothing and Textiles--A Network Approach', *Journal of Macromarketing*, 34: 383-99.

Ekstrom, K. M., and N. Salomonson. 2014b. 'Reuse and Recycling of Clothing and Textiles--A Network Approach', *Journal of Macromarketing*, 34: 383-99.

Elkington, John, and Ian H Rowlands. 1999. 'Cannibals with forks: the triple bottom line of 21st century business', *Alternatives Journal*, 25: 42.

Ellram, Lisa M. 1996. 'The use of the case study method in logistics research', *Journal of Business Logistics*, 17: 93.

Eriksson-Zetterquist, Ulla. 2009. *Institutionell teori–idéer, moden, förändring* (Liber).

Farrant, Laura, Stig Irving Olsen, and Arne Wangel. 2010. 'Environmental benefits from reusing clothes', *International Journal of Life Cycle Assessment*, 15: 726-36.

Ferguson, N., and J. Browne. 2001. 'Issues in end-of-life product recovery and reverse logistics', *Production Planning & Control*, 12: 534-47.

Fernández, Isabel. 2004. "Reverse logistics implementation in manufacturing companies." In.: University of Vaasa.

Fischer, Amber D, and Cihan H Dagli. 2004. 'Employing subgroup evolution for irregular-shape nesting', *Journal of Intelligent Manufacturing*, 15: 187-99.

Fleischmann, Moritz. 2001. 'Reverse logistics network structures and design'.

Fleischmann, Moritz, Jacqueline M Bloemhof-Ruwaard, Patrick Beullens, and Rommert Dekker. 2004. 'Reverse logistics network design.' in, *Reverse Logistics* (Springer).

Fleischmann, Mortiz, Hans Ronald Krikke, Rommert Dekker, and Simme Douwe P Flapper. 2000. 'A characterisation of logistics networks for product recovery', *Omega*, 28: 653-66.

Fletcher, Kate, and Lynda Grose. 2012. *Fashion & sustainability: design for change* (Laurence King Publishing: London).

Gallo, Mose, Elpidio Romano, and Liberatina C. Santillo. 2011. 'A METHODOLOGICAL APPROACH TO MANAGE WEEE RECOVERY SYSTEMS IN A PUSH/PULL LOGIC', *Proceedings of the 2011 Winter Simulation Conference (Wsc)*: 1035-47.

Gam, H. J., H. Cao, J. Bennett, C. Helmkamp, and C. Farr. 2011. 'Application of design for disassembly in men's jacket: A study on sustainable apparel design', *International Journal of Clothing Science and Technology*, 23: 83-94.

Genchev, Stefan E., R. Glenn Richey, and Colin B. Gabler. 2011. 'Evaluating reverse logistics programs: a suggested process formalization', *International Journal of Logistics Management*, 22: 242-63.

Glaser, Barney G. 1978. *Theoretical sensitivity: Advances in the methodology of grounded theory* (Sociology Pr).

Glaser, Barney G, and Anselm L Strauss. 1967. 'The discovery of grounded theory: Strategies for qualitative research. Piscataway', *NJ: Transaction*.

Gobbi, Chiara. 2011. 'Designing the reverse supply chain: the impact of the product residual value', *International Journal of Physical Distribution & Logistics Management*, 41: 768-96.

Goggin, Kate, and Jim Browne. 2000. 'The resource recovery level decision for end-of-life products', *Production Planning & Control*, 11: 628-40.

Gold, Stefan, Stefan Seuring, and Philip Beske. 2010. 'The constructs of sustainable supply chain management–a content analysis based on published case studies', *Progress in Industrial Ecology, an International Journal*, 7: 114-37.

Govindan, Kannan, Joseph Sarkis, and Murugesan Palaniappan. 2013. 'An analytic network process-based multicriteria decision making model for a reverse supply chain', *The International Journal of Advanced Manufacturing Technology*, 68: 863-80.

Govindan, Kannan, Hamed Soleimani, and Devika Kannan. 2015. 'Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future', *European Journal of Operational Research*, 240: 603-26.

Goworek, H. 2011. 'Social and environmental sustainability in the clothing industry: A case study of a fair trade retailer', *Social Responsibility Journal*, 7: 74-86.

Goworek, Helen, Tom Fisher, Tim Cooper, Sophie Woodward, and Alex Hiller. 2012. 'The sustainable clothing market: an evaluation of potential strategies for UK retailers', *International Journal of Retail & Distribution Management*, 40: 935-55.

Greimas, Algirdas Julien, Joseph Courtés, Larry Crist, and Daniel Patte. 1982. *Semiotics and language: An analytical dictionary* (Cambridge Univ Press).

Guide, V. D. R., V. Jayaraman, and J. D. Linton. 2003. 'Building contingency planning for closed-loop supply chains with product recovery', *Journal of Operations Management*, 21: 259-79.

Guide, V. Daniel R., Jr., and Luk N. Van Wassenhove. 2009. 'The Evolution of Closed-Loop Supply Chain Research', *Operations Research*, 57: 10-18.

Guiot, Denis, and Dominique Roux. 2010. 'A Second-hand Shoppers' Motivation Scale: Antecedents, Consequences, and Implications for Retailers', *Journal of Retailing*, 86: 383-99.

Handfield, Robert B, and Ernest L Nichols. 1999. *Introduction to supply chain management* (prentice Hall Upper Saddle River, NJ).

Harris, F., H. Roby, and S. Dibb. 2016. 'Sustainable clothing: Challenges, barriers and interventions for encouraging more sustainable consumer behaviour', *International Journal of Consumer Studies*, 40: 309-18.

Hart, Stuart L., Jay B. Barney, David J. Ketchen, Mike Wright, and Glen Dowell. 2010. 'Invited Editorial: A Natural-Resource-Based View of the Firm', *Journal of Management*, 37: 1464-79.

Hawley, J. M. 2006. 'Digging for Diamonds: A Conceptual Framework for Understanding Reclaimed Textile Products', *Clothing and Textiles Research Journal*, 24: 262-75.

Herriott, R. E., and W. A. Firestone. 1983. 'Multisite Qualitative Policy Research: Optimizing Description and Generalizability', *Educational Researcher*, 12: 14-19.

Hiller Connell, Kim Y. 2011. 'Exploring consumers' perceptions of eco-conscious apparel acquisition behaviors', *Social Responsibility Journal*, 7: 61-73.

Horne, Suzanne. 1998. 'Charity shops in the UK', *International Journal of Retail & Distribution Management*, 26: 155.

Horvath, P. A., C. W. Autry, and W. E. Wilcox. 2005. 'Liquidity implications of reverse logistics for retailers: A Markov chain approach', *Journal of Retailing*, 81: 191-203.

Hsu, Hy Sonya, Christine A. Alexander, and Zhiwei Zhu. 2009. 'Understanding the reverse logistics operations of a retailer: a pilot study', *Industrial Management & Data Systems*, 109: 515-31.

Huang, Min, Min Song, Loo Hay Lee, and Wai Ki Ching. 2013. 'Analysis for strategy of closed-loop supply chain with dual recycling channel', *International Journal of Production Economics*, 144: 510-20.

Husserl, Edmund. 1970. *The crisis of European sciences and transcendental phenomenology: An introduction to phenomenological philosophy* (Northwestern University Press).

Imo, Beatrice E., and Rael C. Maiyo. 2012. 'Lessons from Thriving Second-Hand Clothing Businesses for Kenya's Fashion Industry', *Journal of Emerging Trends in Economics and Management Sciences*, 3: 32-37.

Jack, Eric P., Thomas L. Powers, and Lauren Skinner. 2010. 'Reverse logistics capabilities: antecedents and cost savings', *International Journal of Physical Distribution & Logistics Management*, 40: 228-46.

Jaligot, Remi, David C Wilson, Christopher R Cheeseman, Berti Shaker, and Joachim Stretz. 2016. 'Applying value chain analysis to informal sector recycling: A case study of the Zabaleen', *Resources, Conservation and Recycling*, 114: 80-91.

Jayaraman, Vaidyanathan, and Yadong Luo. 2007. 'Creating competitive advantages through new value creation: A reverse logistics perspective', *Academy of Management Perspectives*, 21: 56-73.

Ji, Guojun. 2007. *Virtual enterprise and performance evaluation by using exergoeconomics in closed-loop supply chain*.

Jindal, Anil, and Kuldip Singh Sangwan. 2014. 'Closed loop supply chain network design and optimisation using fuzzy mixed integer linear programming model', *International Journal of Production Research*, 52: 4156-73.

Jose, Alberto, and Michel Tollenaere. 2005. 'Modular and platform methods for product family design: literature analysis', *Journal of Intelligent Manufacturing*, 16: 371-90.

Junior, Bonfim A., Plácido R. Pinheiro, and Rommel D. Saraiva. 2013. 'A Hybrid Methodology for Nesting Irregular Shapes: Case Study on a Textile Industry*', *IFAC Proceedings Volumes*, 46: 15-20.

Kannan, G., A. Noorul Haq, and M. Devika. 2009. 'Analysis of closed loop supply chain using genetic algorithm and particle swarm optimisation', *International Journal of Production Research*, 47: 1175-200.

Kaplinsky, Raphael, and Mike Morris. 2001. *A handbook for value chain research* (IDRC Ottawa).

kargar, motahareh, and pedram payvandy. 2015. 'optimization of fabric layout by using imperialist competitive algorithm'.

Keiser, Sandra J, and Myrna B Garner. 2008. "Beyond design." In.: New York: Fairchild Publications.

Kim, Hee-Su, and Sung-Bae Cho. 2000. 'Application of interactive genetic algorithm to fashion design', *Engineering Applications of Artificial Intelligence*, 13: 635-44.

Klassen, Robert D. 2009. "Comment on “The Evolution of Closed–Loop Supply Chain Research” by V. Daniel R. Guide, Jr. and Luk N. Van Wassenhove." In *Operations Research (online forum commentary)*, 1.

Kleindorfer, Paul R, Kalyan Singhal, and Luk N Wassenhove. 2005. 'Sustainable operations management', *Production and Operations Management*, 14: 482-92.

Krikke, H., J. Bloemhof-Ruwaard, and L. N. Van Wassenhove. 2003. 'Concurrent product and closed-loop supply chain design with an application to refrigerators', *International Journal of Production Research*, 41: 3689-719.

Krikke, Harold, Dianne Hofenk, and Yacan Wang. 2013. 'Revealing an invisible giant: A comprehensive survey into return practices within original (closed-loop) supply chains', *Resources Conservation and Recycling*, 73: 239-50.

Kumar, R. 2005. "Research methodology: A step-by-step guide for beginners Frenchs Forest: Pearson Education." In.: ISSN.

Kumar, Sameer, and P. Malegeant. 2006. 'Strategic alliance in a closed-loop supply chain, a case of manufacturer and eco-non-profit organization', *Technovation*, 26: 1127-35.

Kumar, Sameer, and Valora Putnam. 2008. 'Cradle to cradle: Reverse logistics strategies and opportunities across three industry sectors', *International Journal of Production Economics*, 115: 305-15.

Kuo, Tsai-Chi, Chia-Wei Hsu, Samuel H. Huang, and Dah-Chuan Gong. 2014. 'Data sharing: a collaborative model for a green textile/clothing supply chain', *International Journal of Computer Integrated Manufacturing*, 27: 266-80.

Kurniawan, Harwin, Tanika D Sofianti, Aditya Tirta Pratama, and Prianggada Indra Tanaya. 2014. 'Optimizing Production Scheduling Using Genetic Algorithm in Textile Factory', *Journal of System and Management Sciences*, 4: 27-44.

Laitala, Kirsi, and Ingun Grimstad Klepp. 2014. 'Consumers ' Clothing Reuse : P otential in Informal Exchange', *Journal of Consumer Policy*: 1-26.

Lambert, M. 2004. ''Cast off wearing apparell': The consumption and distribution of second-hand clothing in northern England during the long eighteenth century', *Textile History*, 35: 1-26.

Lehr, Christian B., Joern-Henrik Thun, and Peter M. Milling. 2013. 'From waste to value - a system dynamics model for strategic decision-making in closed-loop supply chains', *International Journal of Production Research*, 51: 4105-16.

Leo Ho Wai, Yeung, and K. S. Tang Wallace. 2003. 'A hybrid genetic approach for garment cutting in the clothing industry', *IEEE Transactions on Industrial Electronics*, 50: 449-55.

Lepak, David P, Ken G Smith, and M Susan Taylor. 2007. 'Value creation and value capture: a multilevel perspective', *Academy of management review*, 32: 180-94.

Lim, Weng Marc, Ding Hooi Ting, Wei Yi Wong, and Pei Theng Khoo. 2012. 'Apparel acquisition: Why more is less?', *Management & Marketing*, 7: 437-48.

Lopes, Diana Mery Messias, Márcio de Almeida D'Agosto, Amanda Fernandes Ferreira, and Cintia Machado de Oliveira. 2014. 'Improving post-sale reverse logistics in department stores: a Brazilian case study', *Journal of Transport Literature*, 8: 325-48.

Lu, Jun-Ming, Mao-Jiun J. Wang, Chien-Wen Chen, and Jyi-Hua Wu. 2010. 'The development of an intelligent system for customized clothing making', *Expert Systems with Applications*, 37: 799-803.

Ma, Junfeng, and Gül E. Okudan Kremer. 2015. 'A sustainable modular product design approach with key components and uncertain end-of-life strategy consideration', *The International Journal of Advanced Manufacturing Technology*, 85: 741-63.

Mandler, Jean Matter. 2014. *Stories, scripts, and scenes: Aspects of schema theory* (Psychology Press).

Megens, Hellen, and Brian Martin. 2003. 'Cybermethods: an assessment', *First Monday*, 8.

Meho, Lokman I. 2006. 'E-mail interviewing in qualitative research: A methodological discussion', *Journal of the American society for information science and technology*, 57: 1284-95.

Melo, M Teresa, Stefan Nickel, and Francisco Saldanha-Da-Gama. 2009. 'Facility location and supply chain management–A review', *European Journal of Operational Research*, 196: 401-12.

Merton, Robert K. 1965. *On the shoulders of giants: The post-Italianate edition* (University of Chicago Press).

Metta, Haritha, and Fazleena Badurdeen. 2013. 'Integrating Sustainable Product and Supply Chain Design: Modeling Issues and Challenges', *Ieee Transactions on Engineering Management*, 60: 438-46.

Mills, C Wright. 1959. '2000', *The sociological imagination*.

Mo, Hongpin, Zongguo Wen, and Jining Chen. 2009. 'China's recyclable resources recycling system and policy: A case study in Suzhou', *Resources, Conservation and Recycling*, 53: 409-19.

Moise, Mihaela. 2008. 'The importance of reverse logistics for retail activity', *Amfiteatru Economic*, 10: 192-209.

Mol, Annemarie. 2002. *The body multiple: Ontology in medical practice* (Duke University Press).

Morana, R., and S. Seuring. 2007. 'End-of-life returns of long-lived products from end customer - insights from an ideally set up closed-loop supply chain', *International Journal of Production Research*, 45: 4423-37.

Morgan, Louise R., and Grete Birtwistle. 2009. 'An investigation of young fashion consumers ' disposal habits', *Europe*, 33: 190-98.

Naoko Tojo, Beatrice Kogg , Nikola Kiørboe , Birgitte Kjær, and Kristiina Aalto. 2012. *Prevention of Textile Waste*.

Naoko Tojo, Beatrice Kogg Nikola Kiørboe Birgitte Kjær and Kristiina Aalto. 2012. 'Prevention of Textile Waste', *Nordic Report*, Nordic Report.

Norris, Lucy. 2012. 'Trade and transformations of secondhand clothing: Introduction', *Textile*, 10: 128-43.

Norris, Lucy. 2014. 'Tracking Globalization : Global Contexts of Reuse and Value.' in, *Recycling Indian Clothing*

O'Reilly, Seamus, and Anita Kumar. 2016. 'Closing the loop', *The International Journal of Logistics Management*, 27: 486-510.

Oldenziel, Ruth, and Heike Weber. 2013. 'Introduction: Reconsidering Recycling', *Contemporary European History*, 22: 347-70.

Ozceylan, Eren, Turan Paksoy, and Tolga Bektas. 2014. 'Modeling and optimizing the integrated problem of closed-loop supply chain network design and disassembly line balancing', *Transportation Research Part E-Logistics and Transportation Review*, 61: 142-64.

Ozkir, Vildan, and Huseyin Basligil. 2012. 'Modelling product-recovery processes in closed-loop supply-chain network design', *International Journal of Production Research*, 50: 2218-33.

Paksoy, Turan, Tolga Bektas, and Eren Ozceylan. 2011. 'Operational and environmental performance measures in a multi-product closed-loop supply chain', *Transportation Research Part E-Logistics and Transportation Review*, 47: 532-46.

Pal, Rudrajeet. 2014. *Sustainable Business Development Through Designing Approaches for Fashion Value Chains Design for sustainability*.

Pal, Rudrajeet. 2017. 'Value creation through reverse logistics in used clothing networks', *The International Journal of Logistics Management*, 28: 864-906.

Pal, Rudrajeet, and Jonathan Gander. 2018. 'Modelling environmental value: An examination of sustainable business models within the fashion industry', *Journal of Cleaner Production*, 184: 251-63.

Palm, David, Maria Elander, David Watson, Nikola Kiørboe, Hanna Salmenperä, Helena Dahlbo, Katja Moliis, Kari-Anne Lyng, Clara Valente, and Stefán Gíslason. 2014. *Towards a Nordic textile strategy: Collection, sorting, reuse and recycling of textiles* (Nordic Council of Ministers).

Paras, Manoj Kumar, and Antonela Curteza. 2018. 'Revisiting upcycling phenomena: a concept in clothing industry', *Research Journal of Textile and Apparel*, 22: 46-58.

Paras, Manoj Kumar, and Rudrajeet Pal. 2018. 'Application of Markov chain for LCA: a study on the clothes 'reuse'in Nordic countries', *The International Journal of Advanced Manufacturing Technology*, 94: 191-201.

Paras, Manoj Kumar, Rudrajeet Pal, and Daniel Ekwall. 2017. 'Systematic literature review to develop a conceptual framework for a reuse-based clothing value chain', *The International Review of Retail, Distribution and Consumer Research*: 1-28.

Parsons, Elizabeth. 2002. 'Charity retail: Past, present and future', *International Journal of Retail & Distribution Management*, 30: 586-94.

Polkinghorne, Donald E. 1988. *Narrative knowing and the human sciences* (Suny Press).

Porter, Michael E. 1985. "Competitive advantage: creating and sustaining superior performance. 1985." In.: New York: Free Press.

Prothero, R Mansell, and Murray Chapman. 2011. *Circulation in third world countries* (Routledge).

Qiang, Qiang, Ke Ke, Trisha Anderson, and June Dung. 2013. 'The closed-loop supply chain network with competition, distribution channel investment, and uncertainties', *Omega-International Journal of Management Science*, 41: 186-94.

Rahman, Shams, and Nachiappan Subramanian. 2012. 'Factors for implementing end-of-life computer recycling operations in reverse supply chains', *International Journal of Production Economics*, 140: 239-48.

Rogers, Dale S., Benjamin Melamed, and Ronald S. Lembke. 2012. 'Modeling and Analysis of Reverse Logistics', *Journal of Business Logistics*, 33: 107-17.

Rogers, Dale S., and Ronald Tibben-Lembke. 2001. 'An examination of reverse logistics practices', *Journal of Business Logistics*, 22: 129.

Rosen, Michael. 2000. *Turning words, spinning worlds: Chapters in organizational ethnography* (Psychology Press).

Rosenberg, Nathan. 1973. 'Innovative responses to materials shortages', *The American Economic Review*, 63: 111-18.

Ruiz-Torres, a J., J. H. Ablanedo-Rosas, and S. Mukhopadhyay. 2013. 'Supplier allocation model for textile recycling operations', *International Journal of Logistics Systems and Management*, 15: 108-24.

Saaty, Thomas L. 2008. 'Decision making with the analytic hierarchy process', *International journal of services sciences*, 1: 83-98.

Saaty, TL. "The analytical hierarchy process: planning, priority setting, resource allocation, 1980." In.: McGraw-Hill, New York.

Sandberg, Erik, Rudrajeet Pal, and Jukka Hemilä. 2016. 'Exploring value creation and appropriation in the reverse clothing supply chain', *International Journal of Logistics Management, The*: 00-00.

Sanderson, E. C. 1997. 'Nearly new: The second-hand clothing trade in eighteenth-century Edinburgh', *Costume*: 38-48.

Saphores, Jean-Daniel M., and Hilary Nixon. 2014. 'How effective are current household recycling policies? Results from a national survey of U.S. households', *Resources, Conservation and Recycling*, 92: 1-10.

Sasikumar, P., and A. Noorul Haq. 2011. 'Integration of closed loop distribution supply chain network and 3PRLP selection for the case of battery recycling', *International Journal of Production Research*, 49: 3363-85.

Savaskan, R. C., S. Bhattacharya, and L. N. Van Wassenhove. 2004. 'Closed-loop supply chain models with product remanufacturing', *Management Science*, 50: 239-52.

Schenkel, Maren, Marjolein CJ Caniëls, Harold Krikke, and Erwin van der Laan. 2015. 'Understanding value creation in closed loop supply chains–Past findings and future directions', *Journal of Manufacturing Systems*, 37: 729-45.

Schrijvers, Dieuwertje L., Philippe Loubet, and Guido Sonnemann. 2016. 'Critical review of guidelines against a systematic framework with regard to consistency on allocation procedures for recycling in LCA', *The International Journal of Life Cycle Assessment*, 21: 994-1008.

Schultmann, F., M. Zumkeller, and O. Rentz. 2006. 'Modeling reverse logistic tasks within closed-loop supply chains: An example from the automotive industry', *European Journal of Operational Research*, 171: 1033-50.

Serfozo, Richard. 2009. *Basics of applied stochastic processes* (Springer Science & Business Media).

Seuring, Stefan, and Martin Müller. 2008. 'From a literature review to a conceptual framework for sustainable supply chain management', *Journal of Cleaner Production*, 16: 1699-710.

Shen, Bin. 2014. 'Fashion Supply Chain: Lessons from H&M', *Sustainability*: 6236-49.

Shulman, Jeffrey D., Anne T. Coughlan, and R. Canan Savaskan. 2010. 'Optimal Reverse Channel Structure for Consumer Product Returns', *Marketing Science*, 29: 1071-85.

Silverman, David. 2015. *Interpreting qualitative data* (Sage).

Staikos, T., and S. Rahimifard. 2007. 'A decision-making model for waste management in the footwear industry', *International Journal of Production Research*, 45: 4403-22.

Steinar, Kvale. 1996. 'Interviews: An introduction to qualitative research interviewing', *Studentlitteratur, Lund*, 8.

Subie, A., A. Mouritz, and O. Troynikov. 2009. 'Sustainable design and environmental impact of materials in sports products', *Leisure/ Loisir*, 2: 67-79.

Thierry, Martijn, Marc Salomon, Jo Van Nunen, and Luk Van Wassenhove. 1995. 'Strategic issues in product recovery management', *California Management Review*, 37: 114-36.

Tibben-Lembke, Ronald S. 2002. 'Life after death: reverse logistics and the product life cycle', *International Journal of Physical Distribution & Logistics Management*, 32: 223-44.

Tipper, Matthew J., Ioannis Drivas, Stephen J. Russell, Garth D. Ward, and Nick Morley. 2010. 'Principles of the recovery and reuse of corporate clothing', *Proceedings of the ICE - Waste and Resource Management*, 163: 165-72.

Todorov, Tzvetan. 1977. '77je Poetics of Prose', *Trans. Richard Howard. Oxford: Blackwell*.

Tojo, Naoko, Beatrice Kogg, Nikola Kiørboe, Birgitte Kjær, Kristiina Aalto, activities Special, miljöinstitutet Internationella, Economics The International Institute for Industrial Environmental, universitet Lunds, University Lund, and verksamheter Särskilda. 2012. 'Prevention of Textile Waste. Material flows of textiles in three Nordic countries and suggestions on policy instruments'.

Tojo, Naoko, and Ministers Nordic Council of. 2012. *Prevention of textile waste: material flows of textiles in three Nordic countries and suggestions on policy instruments* (Nordic Council of Ministers: Copenhagen, [Denmark]).

Tomasic, Dubravko, Goran Dukic, and Mario Safran. 2013. 'INVENTORY MANAGEMENT IN REVERSE LOGISTICS - ANALYSIS OF CROATIAN AUTOMOTIVE INDUSTRY POSTSALE PRACTICES', *Tehnicki Vjesnik-Technical Gazette*, 20: 541-47.

Triantafyllou, Maria K., and Tom J. Cherrett. 2010. 'The logistics of managing hazardous waste: a case study analysis in the UK retail sector', *International Journal of Logistics-Research and Applications*, 13: 373-94.

Tseng, H., C. Chang, and J. Li. 2008. 'Modular design to support green life-cycle engineering', *Expert Systems with Applications*, 34: 2524-37.

van Nunen, Jaee, and R. A. Zuidwijk. 2004. 'E-enabled closed-loop supply chains', *California Management Review*, 46: 40-+.

Vlajic, Jelena V., Radomir Mijailovic, and Mariana Bogdanova. 2018. 'Creating loops with value recovery: empirical study of fresh food supply chains', *Production Planning & Control*, 29: 522-38.

Wadhwa, S., Bibhushan, K. S. Bhoon, and F. T. S. Chan. 2006. 'Postponement strategies for re-engineering of automotive manufacturing: knowledge-management implications', *The International Journal of Advanced Manufacturing Technology*, 39: 367-87.

Wang, Hsiao-Fan, and Hsin-Wei Hsu. 2010. 'A closed-loop logistic model with a spanning-tree based genetic algorithm', *Computers & Operations Research*, 37: 376-89.

Wang, Yacan, Vincent Wiegerinck, Harold Krikke, and Hongdan Zhang. 2013. 'Understanding the purchase intention towards remanufactured product in closed-loop supply chains An empirical study in China', *International Journal of Physical Distribution & Logistics Management*, 43: 866-88.

Wong, W. K., and S. Y. S. Leung. 2009. 'A Hybrid Planning Process for Improving Fabric Utilization', *Textile Research Journal*, 79: 1680-95.

Yang, Hsu-Hao, and Chien-Li Lin. 2009. 'On genetic algorithms for shoe making nesting – A Taiwan case', *Expert Systems with Applications*, 36: 1134-41.

Yang, P. C., S. L. Chung, H. M. Wee, E. Zahara, and C. Y. Peng. 2013. 'Collaboration for a closed-loop deteriorating inventory supply chain with multi-retailer and price-sensitive demand', *International Journal of Production Economics*, 143: 557-66.

Yin, Robert K. 2013. *Case study research: Design and methods* (Sage publications).

Yuan, Kai Fu, Shi Hua Ma, Bo He, and Yang Gao. 2015. 'Inventory decision-making models for a closed-loop supply chain system with different decision-making structures', *International Journal of Production Research*, 53: 183-219.

Zaarour, Nizar, Emanuel Melachrinoudis, Marius M. Solomon, and Hokey Min. 2014. 'The optimal determination of the collection period for returned products in the sustainable supply chain', *International Journal of Logistics-Research and Applications*, 17: 35-45.

Zhang, Y., and J. K. Gershenson. 2003. 'An Initial Study of Direct Relationships between Life-Cycle Modularity and Life-Cycle Cost', *Concurrent Engineering*, 11: 121-28.

Zhang, Zhi-Hai, Gemma Berenguer, and Zuo-Jun Shen. 2015. 'A Capacitated Facility Location Model with Bidirectional Flows', *Transportation Science*, 49: 114-29.

Zhao, Jing, Weiyu Liu, and Jie Wei. 2013. 'Pricing and Remanufacturing Decisions of a Decentralized Fuzzy Supply Chain', *Discrete Dynamics in Nature and Society*.

Zhou, Haimei, Yanni Xu, Lichuan Wang, and Yan Chen. 2016. 'A garment design method based on modularization', *Textile Research Journal*, 86: 1710-15.

Zimmerman, Don H, and D Lawrence Wieder. 1977. 'The Diary:" Diary-Interview Method"', *Journal of Contemporary Ethnography*, 5: 479.

List of Appendix

Appendix I: Protocols for study of Swedish and European charity organization

A. Overview of the case Study

1. Objective is to develop conceptual framework and validate same in Swedish contest.
2. Research question has been asked to fill current theoretical gap.
3. Different proposition has been derived to develop conceptual framework.
4. Validation of conceptual framework and proposition with empirical evidences.

B. Data Collection Procedure

1. From Charity based organization involved in closed loop clothing business.
2. Interviewing founder and senior manager of the organization.
3. Formal visit of organization prior to conduct interview.

C. Data Collection Question

1. General company information and current practice:
    a. Briefly explain about your organization including mission and vision?
    b. How many employee and volunteer are working in the organization?
    c. Describe the current practice of organizations?
    d. What are the different ways to collect used clothes?
    e. How sorting are done? and what are the different categories and criteria?
    f. What are the different repair and reprocessing activities done by your organization?
2. General company information and current practice:
    a. Do you think proper system effect the current practice?
    b. What is the total area you have for organization?
    c. Do you have your own transportation facilities for collection?
    d. How design of cloths affects the business?
    e. Is price is important criteria for customer to make purchase decision?

f. How Information and awareness about your organization effects the collection and sales?

g. Are you getting support from government and its aided agencies?

h. How consumer attitude affects you?

D. Guide for the case study report

1. This case study will add knowledge in the current field and useful for academician, researcher and person from industry.
2. Government agencies can also use to enact supportive legislation.

Appendix II: Protocol for study of Indian sorting and grading organization

Briefly explain about your company?

- Year of Start
- Business volume (Qty/Financial)
- Area of factory
- Employee Strength
- Number of units
- Any other unique feature

1.What are the reason to engage with used clothing network: What are your business logic?

- Why you are involved in this business (as there is no domestic market)?
- Why you are located in Kandla SEZ, India?
- How you maintain lower production cost with quality?

2. How you are engaged with the used clothing network; who are your partner?

- Why you have special relationship with your suppliers?
- How you search new Supplier/Buyer?
- Why and how you develop partnership?
- How you negotiate with Supplier/Buyer?
- What experience you have in past with Supplier/Buyer?

3. What do you offer (to your customer)?

- What are the different sorting categories you have?
- What are different activities of repair/redesign performed?

- How you develop reputation & trust among Buyer?

4. What are your activities? What are major costs you incur?

- How you access to raw materials?
- How you manage process in organization?
- What are the infrastructures you have to perform activities?
- How you find skilled and efficient manpower to perform activities?

5. Who are main competitors and in what ways?

- How you perform activities better than competitors?
- How many companies perform work similar to you?
- How easy it is for other company to get import license and goods?
- Why new companies are trying to do similar business in near future?
- How new company entry will affect you?

6. What are the major challenges that you face in your used clothing business? What effects do these challenges have?

- How you manage to employ skilled manpower?
- Why worn clothes processing is complex (due to smuggling problem)?
- How difficult it is to repair or redesign used clothes?
- What are the different sorting and repair problem and how you manage with?
- What are the different risk involved in logistics and financial transaction?
- How much threat you have with partner after contract?

7. How do you gain money through your used clothing business (How do you get paid and who pay for it & at what rate)

- How frequently you have transaction with buyer/supplier?

- What are hidden costs and benefits in this business?
- Which kind of economic planning you have?

8. What are the other incentives (you get) by engaging with used clothing business?

- How you motivate yourself in the business (any certification, award)?
- How much license of import protect you?
- How much satisfied you are with your current business?
- What are the competitive advantages you have (over your competitor)?

Appendix III: Questionnaire for AHP analysis

Respondent Details:	
Name:	**Date:**
Position:	
Organisation:	

Introduction: There are different criteria and sub-criteria on the basis of which future directions (i.e. Direct reuse, Upcycling, Down-cycling or Incineration/ landfill) of discarded clothes are determined. Kindly rate/compare those criteria/sub-criteria on the scale of 1-9.

1a)

Criteria's comparison with respect to **closed loop clothing value chain Goal** Rating/Comparison of one factor over other																		
Economy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Material
Economy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Technology
Material	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Technology

1b)

Sub-criteria's comparison within Material criteria Rating/Comparison of one factor over other																		
Brand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric colour
Brand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric quality
Brand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric size
Brand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric type
Brand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Smell/Odour
Brand	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social association
Fabric colour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric quality
Fabric colour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric size
Fabric colour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric type
Fabric colour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Smell/Odour
Fabric colour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social association
Fabric quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric size
Fabric quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric type
Fabric quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Smell/Odour

Fabric quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social association
Fabric size	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fabric type
Fabric size	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Smell/Odour
Fabric size	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social association
Fabric type	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Smell/Odour
Fabric type	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social association
Smell/Odour	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social association

1c)

Sub-criteria's comparison within Economy criteria Rating/Comparison of one factor over other																		
Government incentive	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Labour cost
Government incentive	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Market value
Government incentive	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Processing cost
Government incentive	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation cost
Labour cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Market value
Labour cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Processing cost
Labour cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation cost
Market value	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Processing cost
Market value	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation cost
Processing cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation cost

1d)

Sub-criteria's comparison within Technology criteria Rating/Comparison of one factor over other																		
Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Craftsmanship
Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Disassembly complexity
Availability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation
Craftsmanship	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Disassembly complexity
Craftsmanship	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation
Disassembly complexity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation

Alternatives decision on the basis of material criteria

2a)

Alternative comparison within Material criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

2b)

Alternative comparison within Fabric size sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

2c)

Alternative comparison within Fabric type sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

2d)

Alternative comparison within Fabric colour sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

2e)

Alternative comparison within Fabric quality sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

2f)

Alternative comparison within Brand sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

2g)

Alternative comparison within Social association sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

2h)

Alternative comparison within Smell/Odour sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

<u>Alternatives decision on the basis of economy criteria</u>

3a)

Alternative comparison within Economy criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

3b)

Alternative comparison within Market value sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

3c)

Alternative comparison within Labour cost sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

3d)

Alternative comparison within Processing cost sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

3e)

Alternative comparison within Transportation cost sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

3f)

Alternative comparison within Government incentive sub-criteria

Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

Alternatives decision on the basis of technology criteria

4a)

Alternative comparison within Technology criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

4b)

Alternative comparison within Availability sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

4c)

Alternative comparison within Craftsmanship sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

4d)

Alternative comparison within Innovation sub-criteria

Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

4e)

Alternative comparison within Disassembly complexity sub-criteria Rating/Comparison of one factor over other																		
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Downcycling
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Direct reuse	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Incineration/Landfill
Downcycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling
Incineration/Landfill	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Upcycling

Thank you

Appendix IV: List of Publication

Published in Journal:

1. **Paras, M.K**., Ekwall, D., Pal, R., Curteza, a., Chen, Y. and Wang. L., 2018. An exploratory study of Swedish charities to develop a model for reuse-based clothing value chain. Sustainability.
2. **Paras, M.K.** and Pal, R., 2018. Application of Markov chain for LCA: a study on the clothes 'reuse'in Nordic countries. The International Journal of Advanced Manufacturing Technology, pp.1-11.
3. **Paras, M.K.** and Curteza, A., 2018. Application of Fuzzy technique to make closed loop decision in clothing value chain. International Journal of Value Chain Management.
4. **Paras, M.K.** and Curteza, A., 2018. Revisiting upcycling phenomena- A concept in clothing industry. Research Journal of Textile and Apparel.
5. **Paras, M.K.,** Pal, R. and Ekwall, D., 2017. Systematic literature review to develop a conceptual framework for a reuse-based clothing value chain. The International Review of Retail, Distribution and Consumer Research.
6. **Paras, M.K.,** Curteza, A., Pal, R., Wang, L., and Chen Y. A Romanian case study of clothes and accessories upcycling. *Indistria Textila*. (**Accepted for publication**)
7. **Paras, M.K.,** Curteza, A., Pal, R., Ekwall, D., Wang, L., and Chen Y. The study of 3rs – reuse, repair, and redesign at swedish recycling mall. *Indistria Textila*.(**Accepted for publication**)

Under review in Journal:

1. **Paras, M.K.,** Ekwall, & D., Pal, R. Offshoring reverse value chain activities: An evidence from Indian sorting and grading firms of used clothing. Revise and re-submitted at *Journal of Global Operations and Strategic Sourcing*.
2. **Paras, M.K.,** Wang, L., Chen Y., Curteza, A., Ekwall, D., and Pal, R. Development of a Sustainable Re-Modularization Method Based on Genetic Algorithm for Garment Re-Design Process. Under review at *Textile Research journal*.
3. **Paras, M.K.** Curteza, A., and Wang, L. An exploratory study to investigate redesign and upcycling practice in clothing industry. Under review at *Fashion Practice.*
4. **Paras, M.K.** and Curteza, A., A qualitative and quantitative study of Romanian used clothing industry. Under review at *Journal of Fashion Marketing and Management.*
5. **Paras, M.K.,** Wang, L., Chen Y., Curteza, A., Ekwall, D., and Pal, R. Application of genetic algorithm to optimize redesign process. Under review at *Design Studies.*

International Conference:

1. **Paras, M.K.,** Curteza, A., Burlacu A. and Pal, R., 2017. Upcycling decision in the Closed Loop Clothing Value Chain Using an Analytical Hierarchy Process. In POMS 28th Annual Conference, Seattle, WA, USA, May 5-8, 2017.
2. **Paras, M.K.,** Curteza, A. and Pal, R., 2017. Application of Absorbing Markov Chain for Life Cycle Assessment of clothes reuse in Nordic Countries. In POMS 28th Annual Conference, Seattle, WA, USA, May 5-8, 2017.

3. **Paras, M.K.,** Ekwall, D. and Pal, R., 2015. Testing a conceptual model of circular clothing value chain with product reuse in Swedish contest. In Global Cleaner Production & Sustainable Consumption Conference.
4. **Paras, M.K.,** Pal, R., Ekwall, D. and Curteza, A., 2016. Reuse based Closed Loop Clothing Value Chain: An Empirical investigation into Multinational Charities and Organizations of Norway, Sweden and UK. In 3rd International Conference on Green Supply Chain 2016 (GSC'16).
5. **Paras, M.K.,** Hedegård, L. and Curteza, A., 2016. ReTuna Recycling Mall: Reuse based Circular Fashion Supply Chain Management. In Inventica 2016.
6. Pal, R.; Hemilä, J.; **Paras, M. K.;** Sandberg, E., 2016. "A value perspective in multi-echelon retail reverse value chain: a case of take-back scheme in used clothing network" in the International Symposium on Logistics (ISL) 2016, Taiwan.
7. Hedegård, L., **Paras, M.K.,** and Gustafsson, E. 2016. Contradictions In Reuse-based Fashion Retail-the ReTuna Mall Case. In Global Fashion, Stockholm, October 20-21, 2016.

National Conference:

1. **Paras, M.K.,** Curteza, A. and Pal, R., 2016. A state-of-the-art Literature Review of Upcycling: A Clothing Industry Perspective. In 16th Romanian Textiles and Leather Conference, Romania, October 27-29, 2016. (p. 121). Editura Acreditata de Cncsis Bucuresti.