ZERO LANDFILL FRAMEWORK FOR APPAREL INDUSTRY SOLID WASTE

K.L.A.K.T. Liyanage* and Nayanthara De Silva

Department of Building Economics, University of Moratuwa, Sri Lanka

ABSTRACT

Apparel industry being one of the key economic players, mass production of textile and apparel take place, resulting in a considerable amount of solid waste generation which ultimately ended up in landfills. Shortfalls in solid waste management has created several issues related to environmental, economic and social and thus it has become a burning issue. Therefore, innovative approaches are timely, needed to overcome this national problem. The Zero landfill concept has been identified as one of the innovative approach. Therefore, this research is focused to study the applicability of the Zero landfill concept to the Sri Lankan Apparel industry. For the study, conceptual framework for zero landfilling was developed and further three case studies were selected for the identification of suitability of the framework for the solid waste management in the apparel industry. Documentary evidences, interviews with experts were carried out to achieve the relevant data. The study revealed that industry generates main types of solid waste, such as, fabric, paper, cardboard, food waste and considerable amount of such waste can be managed through this proposed framework. A considerable amount of plastic and polythene waste ended up in landfills causing difficulties in achieving zero landfill concept for the apparel industry. With the expert opinions, it was confirmed that zero landfill concept can be achieved in the apparel industry by zero landfilling of plastic and polythene waste. Thus, the zero-landfilling concept can be implemented successfully in the country. Further, as landfilling has become a burning issue in the Sri Lankan context, the Zero landfilling concept is a vibrant solution to eliminate the solid waste landfilling.

Keywords: *Adaptability; Apparel Industry; Solid Waste Management; Zero Landfill.*

1. INTRODUCTION

The apparel industry has been one of the fast-growing industry in Sri Lanka, where the rapid generation of solid waste has taken place (Weerakoon et al., 1996). In the textile and apparel world, solid waste is produced at all the points in the manufacturing process (Larney & Aardt, 2010).Solid Waste (SW) is the portable objects that have been abandoned by the owners (Bilitewski et al., 1997). In the textile and apparel industry, major types of solid waste that get generated are, fabric, polythene, paper, plastic, glass, metals and cardboard (Larney & Aardt 2010; Weerakoon et al, 1996).

When disposing of SW, landfilling is the most common waste disposal method throughout the world and landfill is an area of land onto or into which SW is deposited (Fatemi, 2009; Manfredi et al., 2009).In developed countries such as United Kingdom (UK), United Stated of America (USA) nearly 40% to 60% of textile and apparel waste ended up in landfills (Fuchs, 2016).In, developing countries like in China 2.6 million of waste is landfilled while in South Africa, 62.1 % of apparel waste ended up in the landfills (Jordeva et al., 2015; Xue et al., 2014).If this situation continues, the availability of landfills will be decreased while the volume of SW continued to be increased (Domina & Koch, 1997).

At the same time, Bellezza (2003) said dumping of waste to landfill, causes aesthetical problems, health hazards, and environmental problems. Many waste management approaches, including Reduce, Reuse, Recycle (3R), green supply chain, lean manufacturing, and zero landfills have been suggested to overcome these problems (Bowen et al., 2001; Dissanayake & Sinha, 2012; Kaur et al., 2016; Franchetti, 2012).

*Corresponding Author: E-mail – kushiliyanage23@gmail.com

For the disposal of solid waste, huge lands are required. Thus, as per Franchetti (2012), the zero landfill concept has been identified as the most effective strategy to reduce the waste dumping into landfills. Gjetley and Pierre (2003) explained, zero landfill as the operation in which generated waste does not send into the landfill. But the problem here is, there is a lack of studies on the applicability of this concept to Sri Lanka. So this study focuses on how to adapt zero landfill to Sri Lankan apparel industry and to develop a framework for zero landfills using apparel waste along with the objectives to identify the types of waste generated in the apparel industry, to identify the waste management strategies, to study the adaptability of zero landfill concept to the apparel waste and to develop a framework for zero landfill to apparel industry.

2. LITERATURE REVIEW

2.1. SOLID WASTE IN THE APPAREL AND TEXTILE INDUSTRY

With the industrial revolution, apparel production has started to bloom. Bailey (1993) has explained the success of the apparel industry was based on mass production of low-cost styles. Hemachandra (2009) has identified apparel producer types as knitted, woven, weaving operators, and fabric producers, washing and dyeing operators. The production process of the apparel industry consists of pre-treatment, bleaching, dyeing, printing, sizing, de-sizing, and mercerization, washing, and finishing (Singh, 2014). Furthermore, Jayasinghe et al. (2010) stated that, annual fabric consumption of apparel and textile sector of Sri Lanka is nearly 19,000 to 38,000.Apparel and textile waste have given a greater concern in both developed and developing countries (Altun, 2012). Apparel and textile waste have categorized as post consumer waste and post industrial waste (Tomovska et al., 2016). Furthermore, Domina and Koch (1997) have identified paper, yard waste, metals, plastic, glass and post consumer textiles as waste types generated in textile and apparel industry. Moreover, Tomovska et al. (2016) have identified textile waste, paper, plastic, reels, and buttons as waste within the apparel and textile industry.

In the Sri Lankan context, fabric, paper, gunny bags, cardboard, and polythene have been identified as the apparel waste (Weerakoon et al., 1996) Similarly, Larney and Aardt (2010) have grouped apparel waste as paper, cardboard, metals, plastic while textile wastes such as fibers, yarn, and cutting waste. Not only that they have also identified that fabric cutting waste, thread waste, notion scraps, waste paper, yarn cones and tubes and packaging waste as apparel waste that are generated in the apparel industry. For the disposal of waste, landfills have been considered as the most common, economical and environmentally accepted method (El-Naqa, 2004). Even though there are different types of approaches used for waste management, a significant amount of waste still ended up in the landfills (El-Naqa, 2004).

2.2. SOLID WASTE MANAGEMENT STRATEGIES

The rapid increase in the purchase and disposal of textile and apparel products have resulted in the waste management (Dissanayake & Sinha, 2012). To manage solid waste, institutional regulatory reform and waste reduction technologies are used (Kansal, 2002). Further, Sakai et al. (1996) have stated that, to develop solid waste management strategies, most of the countries follow waste management heirachy which comprises of prevention, material recovery, incineration and landfilling.

2.2.1. 3R CONCEPT

Components of 3R concepts are Reduce, Reuse and Recycle (Aadal et al., 2013). Authors have defined reducing as the method used to decrease the waste production by choosing and utilizing factors. Moreover, they have identified recycling as the step in which waste is used as a resource. Use of the product for the same purpose along with resale and redistribution has defined as reuse (Fletcher, 2008).

2.2.2. GREEN SUPPLY CHAIN

Raj, Ma, Gam, and Banning (2017) defined apparel supply chain as the collaboration of a multiple number of channel members at different levels starting from raw material procurement to the finished good development. Purchase of materials for the organization to enhance environmental outputs by reducing material flow impacts through reuse, recycle, reduction in energy and material wastage have been defined as the green supply chain (Bowen et al., 2001).

2.2.3. LEAN MANUFACTURING

A lean manufacturing adaptation of the organization involves with cultural change, higher profits, and higher employee commitment (Kaur et al., 2016). The authors have explained when adapting lean to the textile and apparel industry, Key Performance Indicators (KPI), current activity measurement, improvement of figures have been considered. Through lean manufacturing, customers are supplied with the exact amount that is needed for them without creating any waste (Ali, 2012). Furthermore, Ali (2012) stated that, for the lean production, Just in Time (JIT) have contributed. When an organization adopts lean manufacturing strategy, employees can inspect their own products and can minimize the delivery of defect products (Chiromo et al., 2015).

2.2.4. EXTENDED PRODUCER RESPONSIBILITY

Extended Producer Responsibility (EPR) is another strategy that is being used in the process of recycling (Chavan, 2014). The author has said that through the EPR, the manufacturer is responsible for the entire life cycle of the product, where the manufacturer is liable for the take-back, recycle and final disposal. To reduce and to avoid major waste volumes during the production process of the product, EPR is an important tool (Lindhqvist, 2000). In order to encourage cleaner production process and to eliminate waste during the different stages of the product life cycle EPR has to be followed (Fatemi, 2009).

2.2.5. ZERO LANDFILLS

The operation in which generated waste does not send into the landfill is identified as the zero landfill (Gjetley & Pierre, 2003). Furthermore, Lombardi (2011) has identified zero landfills as the redesigning of the resource life cycle where no resource gets wasted to the landfill throughout the process. The excessive generation of wastes and the overuse of land for landfills create an increasing environmental burden for the society which causes more optimal use of land (Tan & Khoo, 2006). Therefore, by achieving zero landfill, it would help to overcome the harmful effects that take place due to waste dumping into the landfills.

2.3. BENEFITS OF ZERO LANDFILL

Waste dumping in landfills have led to the harmful effects of environment, land, air, and water (Gjetley & Pierre, 2003). Therefore, the authors have stated that achieving zero landfill would help to overcome the harmful effects that take place due to waste dumping into the landfills. Benefits of Zero Landfill concept can be discussed under ecological and economic benefits.

- **Ecological benefits**

Bartl and Haner (2009) have said that, more ecological benefits can be achieved with the improvement in fiber recycling technologies which have impacted on the higher recovery rate. For the ecological textile and apparel production, environmental demands have made a huge impact (Domina & Koch, 1997). Authors have further explained that, instead of waste disposal to landfills, apparel manufacturers are looking into number of recycling alternatives. Kavitha and Manimekalai (2014) have stated that, issues that can arise as a result of waste dumping to the landfills, can be reduced by avoiding synthetic product dumping in the landfills and by reducing the pressure on virgin resources. Through different alternatives such as, involvement of government, environmental policies, and awareness through media, waste dumping in the landfills can be controlled (Domina & Koch, 1997).

- **Economic benefits**

In order to achieve zero landfills, textile and apparel manufacturers have looked into alternative recycling methods. As a result of the improvement in fiber recycling technologies, economic benefits can be achieved (Bartl & Haner, 2009). Domina and Koch (1997) have said that, waste disposal to landfills is an inexpensive, easy method in which less commitment has to be paid for recycling programs. Authors have explained that, for products like paper, glass and aluminium cans recycling efforts are taken as it has a resale value.

3. RESEARCH METHOD

To identify the adaptability of Zero landfills to apparel waste, expert's attitude and experience have to be considered. Therefore, the qualitative approach is used for the study. Bloor and Wood (2006) stated that in-depth analysis and detailed understanding can be achieved through the case study. Hence,in order to identify the adaptability of Zero landfill concept to the apparel industry more cases needed to be studied. Therefore, for the study three cases were selected from the top three key players in the apparel industry where waste management practices are being followed to reduce waste generation.Selected factories are namedas case A, case B, and case C those who are into export of apparel products. Table 1 shows the details of the cases.

Table 1: Profile of the Cases

Criteria	Case A	Case B	Case C
Production category	Casual wear garments	Sample sportswear	Lingerie garment products
Production capacity (garments per month)	250000	1000	40000
Work force (Person)	3000	520	750
Respondent	Senior Maintenance Manager (A1)	Senior Executive Sustainable Engineer (B1)	Senior Executive Sustainability (C1)
Years of experience in the field of WM	4 ½ years	3 ½ years	1 ½ years

Data collection was carried out through semi structured interviews, document review and through observation to identify the types of solid waste, their management process and further expert personnel in the field of waste management were interviewed to identify the applicability of the zero landfill concept to the apparel industry. Moreover, to validate the proposed framework and collected data, five expert personnel were interviewed. Table 2 shows the profile of the interviewed experts to validate the proposed framework.

Table 2: Profile of the Experts

Respondent	Description	Experience
E1	Managing Director of Plas Techs (Pvt) Ltd	25 years
E2	Deputy General Manager in Compliance and Sustainability	10 ½ years
E3	Deputy Project director of construction of SW disposal facilities project in Central Environmental Authority (CEA)	30 years
E4	Director of Western Province Waste Management Authority	25 years
E5	Director of Environmental Division of Katunayake BOI zone	25years

Proposed conceptual framework to find the applicability of zero landfill concept to the apparel industry is shown in Figure 1.

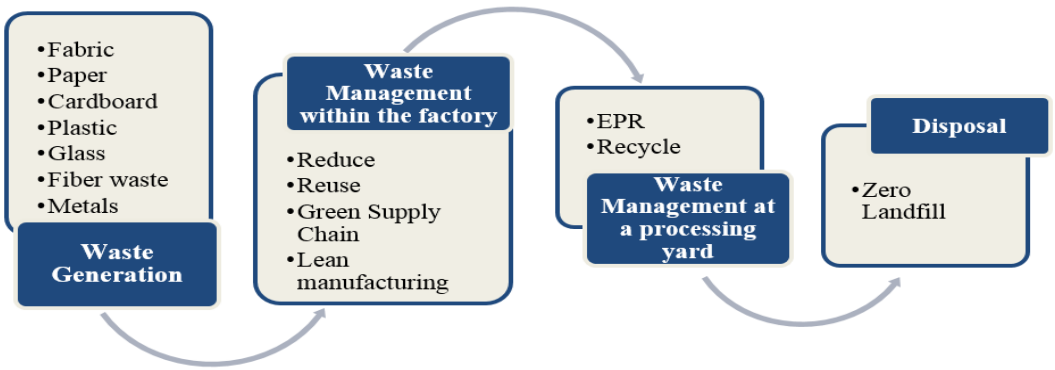

Figure 1: Conceptual Framework

4. RESEARCH FINDINGS AND ANALYSIS

The study of adaptability of zero landfill for Sri Lankan apparel industry had in depth study as this is a novel area for Sri Lanka. To achieve the ultimate aim of the study, three (03) case studies and five (05) expert interviews were carried out.

4.1. TYPES OF WASTE

Although SW types like fabric, paper, cardboard, plastic, glass, fiber and metal were identified as the textile and apparel waste types through literature findings, according to the case study findings, major types of SW that can be found in Sri Lankan textile and apparel industry are fabric, polythene, plastic, paper, cardboard and food. In all three cases, these SW waste types were identified. Quantities of waste in each case by weight for the year 2016 are shown in Table 3.

Table 3: Types of Waste and their Quantities

Type of waste	Waste by weight (in Kg/ per year)		
	Case A	**Case B**	**Case C**
Fabric	70000	15473.19	22679.6
Cotton Fabric	5000	-	-
Paper	7500	12827.45	2723.55
Cardboard	18000	4904.50	9628.74
Plastic/Polythene	3407.85	2981.61	1769.01
Food	30000	11302.05	21563.24
Glass	Very small quantity	Very small quantity	Very small quantity
Metals	Very small quantity	Very small quantity	Very small quantity
Sanitary waste	Very small quantity	Very small quantity	Very small quantity

4.2. WASTE MANAGEMENT PROCESS

In the apparel industry, once the SW gets generated, firstly, point wise waste segregation takes place. Depending on the nature of the SW type, SW are separated. Then those segregated SW are placed in the waste storage yards. From the waste storage yards, waste collectors collect SW for reuse and recycling purposes. Finally, through the waste collectors, residual SW those are unable to reuse or recycle, are disposed to landfills.

SW that are generated through the factories are, fabric, cotton waste paper, cardboard, plastic, polythene, food, glass, metals and sanitary waste. To handle waste within the factories, rather than the waste management procedure, colour coding bin arrangement system and 3R concept are being followed. When it comes to the colour code bin arrangement system, for the disposal of food waste, green colour bins are used while plastic and polythene are sorted into orange colour waste bins. Blue colour waste bins are used to collect paper and cardboard waste. For the waste collection, waste collection yards are available and they are divided as SW and hazardous waste. All the food waste are sent to a piggery farm on a daily basis. Once the waste gets collected in the waste yard, they are taken by the separate waste collectors. Factories that are within the Board Of Investment (BOI) zone, waste get collected in the BOI waste yard and from the waste yard, waste recyclers collect the waste. Separate waste collectors are available to collect plastic, polythene, fabric, cardboard and paper waste. After the recycling of SW, if there are any residuals, those residuals are discarded into landfills.

4.3. WASTE MANAGEMENT STRATEGIES TO SW HANDLING

To handle the SW generated within the factory, it was observed that different approaches are followed by the factories. In each case, waste management approaches like reduce, reuse, green supply chain, lean manufacturing are used to handle waste.

4.3.1. REDUCE

When considering about all 3 cases, different approaches have been followed to reduce the SW in each factory. Table 4 shows the reduce approaches used by apparel factories.

Table 4: Reduce Approaches in Factories

SW approach	Case A	Case B	Case C
Both side of the paper used for documentation activities	√	√	√
Elimination of PET water bottles	√	√	√
Use of poly bags	√		
Use of plastic tags	√		
Use of fabric bags to transport finish products	√		
"N-CING" computer aided method for production floor which helps for paperless production		√	
"View sticker", a 3D technique to check on samples		√	
Using email memos instead of leaving notes			√
Suppliers are asked to use less packaging			√

4.3.2. REUSE

Reuse of SW is another approach that helps to achieve zero landfilling in the long run. Apparel factories follow strategies shown in Table 5.

Table 5: Reuse Approaches in Factories

Approach	Case A	Case B	Case C
Use of water dispensers and glass water bottles	√	√	√
Fabric off cuts are used for handloom productions	√	√	√
Reusing of thread cones after rewinding		√	√
Reuse of cardboard boxes	√		
Paper used in sublimation printing are used in cutting section		√	
Paper in cutting section are used to prepare envelop		√	
Remaining trims in the production floor is collected by the stores and reused		√	
Fabric waste are reused as kitchen napkins and hand wipes in kitchen areas			√

4.3.3. GREEN SUPPLY CHAIN

While purchasing materials, environmental concerns can be seen. From the findings related to the three cases, it can be seen that the partnerships are made with the manufacturers those who are into sustainable approaches. Moreover, for the production of garments, organic cotton are being used. Organic cotton is the type of cotton in which chemicals are not being used during the manufacturing process. In order to minimize and to improve the productivity within the supply chain, cleaner production techniques are being used to facilitate the environmental performance of the industry. Cleaner production is the strategy that is used to reduce the impact of production on the environment by preventing at the source. Cleaner production techniques such as transformation of waste into useful products, reverse logistics, waste segregation have resulted in using environmental friendly technologies within the factory. Green productivity is considered to enhance the productivity and environmental performance.

4.3.4. LEAN MANUFACTURING

With the focus on waste reduction and non-value adding activities within the factory, lean manufacturing can be implemented. In all three cases, for the lean manufacturing practices, value stream mapping, marker efficiency for fabric cutting and lean manufacturing tools such as 5S, Just In Time (JIT) Kanban are followed within the factory. Excessive production of garments and waste generation have reduced as a result of lean manufacturing. In order to reduce fabric waste, design changes are carried out by discussing with the designers.

If the designed garment has curves which leads to wastages of fabric, after discussing with the designers, in order to minimize the damages, curves are turned into sharp edges. Complimentary products such as hair bands and hand bands are produced from the fabric off cuts.

4.4. WASTE MANAGEMENT APPROACHES TO TRANSFER WASTE

By using waste management approaches like reduce, reuse, green supply chain and lean manufacturing, SW can be managed to a certain extent. But those approaches cannot avoid SW ends up in the landfills. Therefore, to avoid SW ends in landfills, waste management approaches like EPR and recycle can be used.

4.4.1. EXTENDED PRODUCER RESPONSIBILITY (EPR)

When the producer take the responsibility for what he produce, then it helps to reduce the waste generation at the end as well as during the production of the product. Producers take the responsibility of the product by taking back their garment products at the end of the useful life. When the life cycle of the product is designed from the initial stage, it helps to reduce the waste at the end disposal.

4.4.2. RECYCLING

For the recycling of waste within the factory, factories have joined with 3rd parties those who have a license to do the recycling activities. To recycle fabric, paper, cardboard, plastic and paper there are separate waste collectors in each factory. For the recycling of plastic, paper, polythene and cardboard, 3rd party recyclers are registered under the Central Environment Authority (CEA).

4.5. WASTE DISPOSAL

From the findings, after following the waste management strategies, portion of waste get ended up in the landfills. Table 6 shows the weights of waste ending up in landfills.

Table 6: Weights of Waste Disposed to Landfills

Waste Type	Waste disposal from factory to the waste collectors (kg/per year)			Waste disposal to landfills from the waste collectors (kg/per year)		
	Case A	Case B	Case C	Case A	Case B	Case C
Fabric	70000	15473.19	70000	0	0	0
Cotton Fabric	5000	-	-	0	-	-
Paper	7500	12827.45	2723.55	0	0	0
Cardboard	18000	4904.50	9628.74	0	0	0
Plastic/Polythene	3407.85	2981.61	1769.01	165.35	125.24	65.28
Food	30000	11302.05	21563.24	0	0	0

According to the findings from the three cases, it can be observed that landfilling of waste take place only from plastic and polythene. Disposed SW in the factory is equal to the generated waste in the factory. It is because the generated waste is given to the waste collectors to reuse or recycling purposes. Waste collectors convert fabric waste into energy through waste recovery. Therefore, fabric waste does not end up in the landfills. Paper and cardboard waste that is generated in factories are recycled and paper and cardboard produced again. Hence, paper and cardboard waste also does not end up in the landfills. Food waste is sent to a piggery farm as food for pigs. Hence, it is clear that, fabric, paper, cardboard and food waste does not end in landfills. As per the findings of the case study, it is observed that portion of plastic and polythene waste end up in landfills and it is shown in Table 7.

Table 7: Weights of Polythene and Plastic Waste Disposed to Landfills

Case	Quantities of Plastic and Polythene waste		Waste disposal percentage to the landfill (%)
	Waste at generation (Kg/per year)	Waste sent to landfills (Kg/per year)	
Case A	3407.85	165.35	5
Case B	2981.61	125.24	4
Case C	1769.01	65.28	4
Total	8158.47	355.87	4

As per the findings, it was evident that 4% of polythene and plastic waste get ended up in the landfills. Main reason for this 4% of plastic and polythene waste landfilling is due to the difficulties in proper point wise segregation, high recycling cost, inadequacy of proper technology for recycling, lack of recycling capabilities of recyclers, food waste remains on lunch sheets, remaining polythene and plastic waste are not be compatible with the recycling purposes and poor planning of product life cycle. Experts stated that, zero landfill concept can be achieved by eliminating 4-5% of polythene and plastic waste. In order to eliminate the plastic and polythene ending up in landfills, their views were to follow proper waste hierarchy, proper point waste segregation, proper monitoring system to 3rd party vendors, maintain direct agreements with end disposer, use of new technology like pyrolysis, segregation of polythene waste according to the thicknesses and awareness on not to produce with mix polymers. Hence, it can be concluded that, zero landfill concept can be adapted to the Sri Lankan apparel industry. All the research findings were harmonised into one place and framework was developed to achieve zero landfill as shown in Figure 2.

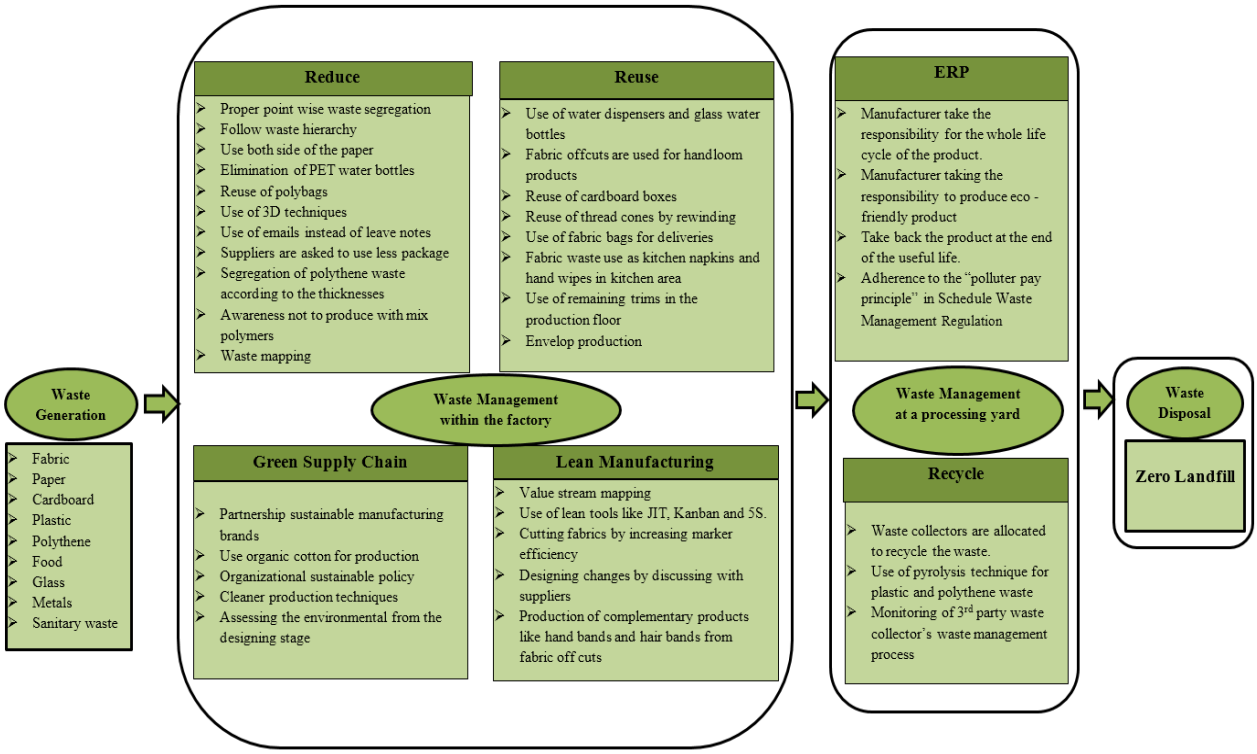

Figure 2: Framework for Zero Landfill of Apparel Waste

5. CONCLUSIONS

Apparel industry, being one of the key economic contributor with large scale textile production considerable amount of waste gets generated through the industry which ultimately end up in the landfills. Therefore, the applicability of the zero landfill concept to the apparel sector was the focus of the study. In apparel industry, types of solid waste generated are identified as fabric, cotton fabric, paper, cardboard, plastic, polythene, glass, metals, and sanitary waste. Waste management strategies like lean manufacturing, Extended Producer Responsibility (EPR), green supply chain, 3R concept can be followed to achieve zero landfill concept. The

process in which the generated waste does not send into the landfill can be defined as zero landfilling. Through the study it was observed that, for the solid waste management in the factories, point wise waste segregation, follow up of the waste hierarchy, use of both sides of the paper for documentation activities, PET water bottle elimination, use of fabric off cuts for handloom production, partnerships are made with sustainable manufacturers, and use of organic cottons for productions is being followed. By following up these practices, it was observed that solid waste types like fabric, paper, cardboard, food achieve the zero landfilling while nearly 4-5% of plastic and polythene waste get ended up in the landfills. With the expert opinion, it was confirmed that 4-5% of plastic and polythene waste too can be zero landfill. Therefore, by following up this framework, zero landfilling can be achieved. With the case study findings and expert interviews, adaptability of zero landfill concept to the apparel waste was accomplished. Finally, a framework was developed to elaborate the adaptability of zero landfill concept to the apparel industry.

6. LIMITATIONS AND PRACTICAL IMPLICATIONS

The research is limited to the factories in the western province. Moreover, there were difficulties in collecting data as the concept is novel in the Sri Lankan context. Further, the applicability of the concept is confirmed purely through expert views and there may be practical issues when implementing the concept into the practical scenario.

By implementing this concept, it will help to overcome from the social, environmental and health issues that arose as a result of waste dumping into landfills. Furthermore, waste authorities can use this as a positive study to find solutions for the solid waste landfilling issue. Based on the findings, authorities can look into adequate infrastructure to facilitate the proposed methods in an effective way.

7. RECOMMENDATIONS

As recommendations for industry practitioners, it is necessary to implement proper point wise segregation and awareness need to be given to employees on the importance of point wise segregation. Moreover, management commitment needs to be enhanced and strategies need to be formed to reduce waste generation in the apparel industry. Further, direct relationship with end disposer need to be maintain and end disposal activities need to be evaluated.

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