Ban on Polythene Bags and Lunch Sheets in Sri Lanka: Impact, Challenges and Alternatives

Sangeeth Prasad Fernando
G.V. Norica Aiome
Virajith Kuruppu
P.C.J. De Silva
S.M.A. Samarakoon
H.M.J.K. Herath

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Hector Kobbekaduwa Agrarian Research and Training Institute
114, Wijerama Mawatha
Colombo 7
Sri Lanka

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FOREWORD

Polythene is the most common plastic and with multiple use in our daily life. Despite its user friendly character, it has a huge negative impact on the global environment and the agricultural sector per se. Recycling of polythene remains a grave issue that pushed nations towards restricting the use.

The present study comes in the wake of a ban imposed by the Sri Lankan government to identify the perception and difficulties faced by various stakeholders following the ban. Moreover, it also scrutinizes on the prevailing use of polythene and potential alternatives and stakeholders' perception on them, degradability of prevailing shopping bags and lunch sheets in Sri Lanka. Besides, positive and negative qualities of certain plastic products, prevailing laws regarding the polythene products and solid waste management in Sri Lanka have also been in focus.

I believe the study is a timely academic venture as it collects the sample from the Western Province where the higher usage of polythene is reported. Considering its broad spectrum of objectives and respondents, I hope the findings would augur well for future action towards polythene products and stir further debate on this issue to evolve much plausible solutions. I highly appreciate the great commitment shown by the members of research team and congratulate them on publishing this report.

W.H. Duminda Priyadarshana
Director/CEO (Acting)

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Research Team

EXECUTIVE SUMMARY

Following the ban on polythene bags and lunch sheets/food wrappers (PBLS) imposed in September 2017, the topic on the detrimental effects of polythene waste on the environment came to the fore stirring up debate and criticism over the pros and cons of the move. The ban came in the back drop of lack of alternatives and it also dealt a blow to livelihoods of many who were centred on the industry.

When analysing the problems surrounding the polythene ban the study focused on many aspects, considering the significance of the topic to the present day Sri Lanka. Hence the study intended to identify the perception and difficulties faced by various stakeholders, identify the potential alternatives for the banned items, exploring the nature of degradability of PBLS in the market. Further, it also aimed at identifying positive and negative attributes of PBLS as per the stakeholder perception, examining the existing laws with regard to polythene products and solid waste in Sri Lanka and finding evolving sustainable remedies to manage plastic waste in the country.

In achieving the above ends, the study was conducted in the Western Province covering the three districts- Colombo, Gampaha and Kalutara- selecting 1400 persons as the sample. That included government institutions, non-governmental organisations, material researchers, major foodstuff producers, polythene manufacturers, supermarket chains, grocery shops, food vendors, entrepreneurs, plastic collectors and recyclers as well as the general public in the province. Here, Key Informant Interviews, Focus Group Discussions and Questionnaire Surveys were used to obtain primary data and sources of Central Environmental Authority (CEA) and Department of Customs, details of research reports, journals and newspaper articles were employed as secondary data. Choice experimental technique was deployed to elicit responses from the respondents.

According to the 2017 law on PBLS, all lunch sheets used in Sri Lanka should be made of a non-polythene biodegradable material, while grocery bags must be manufactured using low-density polyethylene (LDPE) or other (preferably biodegradable) substance. Even though, manufacturers had apparently shifted to producing starch based lunch sheets; that naturally decompose within a relatively short period after disposal, the main shift in grocery bag production was from high-density polyethylene (HDPE) to an equally non-degradable LDPE. It was widely reported that the grocery bags available following the ban, were of inferior strength, requiring the use of double bagging to do the task of a single HDPE bag used before. They were not only of lower strength, but also incurred a higher production cost while also being more difficult to recycle after use. A similar issue was raised with regard to the new lunch sheets by 74% of the food vendors surveyed. They complained that these lunch sheets were easily damaged, leading to leaking of wrapped food while also making the wrapping process more difficult compared to the polythene sheets used before. Basically, the ban appeared to have resulted in the exact opposite of what was intended. Therefore, it is not surprising that 60% of those interviewed in this

study considered the “polythene ban” to be a failure. Only 20% was of the opinion that it was effective. Another aspect uncovered in the study was the prevalence of “black market” polythene lunch sheets which sometimes pass off as biodegradable ones. This was a major concern raised by manufacturers of biodegradable lunch sheets, as they have to compete with lower priced fakes that undermine the environmental benefits of the imposed regulations.

Enforcement of the law by the government would play a major role in making the “polythene ban” effective. According to the CEA an increasing number of inspections and raids had been carried out at retail shops, supermarkets and manufacturing facilities to detect illegal polythene products. These have resulted in a large number of confiscations, issuance of fines and prosecutions on those found to be in possession of unauthorised grocery bags and lunch sheets. Yet, the researchers found quite a few limitations in the processes used in the detection of illegal products. The government has to rely on the importation certificates confirming legitimacy of the raw materials used in the manufacturing process, while having only limited resources and methods to check for banned substances in the finished products. It was also identified that the government sector, at present, has no laboratory facilities to test for degradability of material, so as to confirm that the ultimate aim is fulfilled by the manufacturer.

Another dimension of polythene waste is the recycling process. Collection and recycling of plastics (including polythene) is a business that has the potential to minimise environmental damage while leading to income generation for many. The study was able to find that the amount of plastic waste generated per year by a single Sri Lankan on average is around 11 kilograms. Not only does this point to the immensity of its possible environmental impact, but also of its potential to become an abundant raw material source for the recycling industry. When attempting to interview plastic collectors and recyclers registered at the Central Environmental Authority, it was found that 42% of those contacted had given up the business. Of those who were still functioning 86% complained that there was minimal assistance or encouragement by the authorities for continuing and improving their industry.

The new laws may have expected to push the consumers towards more environmentally friendly alternatives for grocery bags and lunch sheets. With entrepreneurs that have introduced and attempted to promote material and products as substitutes have expressed their disappointment with authorities who have done little in terms of providing support. This was clear with what was observed in the study, where very few alternative products were found to be available and in use. When attempting to identify most favoured alternative for polythene shopping bags, the study found that cloth bags were rated higher than others due to its physical qualities while the high price acted as the main limit for its popularity.

An interesting finding prominently pointed out in this research was the presence of an act (Consumer Affairs Authority Act, No. 9) that would have been a major contributor to the

excessive use of polythene grocery bags and lunch sheets over the years. Even though some supermarkets in Sri Lanka has already introduced commendable steps such as providing loyalty card points and discounts for bringing own reusable bag, the study suggests taking it a step further to bring in a points system for reusing old plastic bags as well. If the government could intervene and negotiate the use of such incentive programmes across all supermarket chains in Sri Lanka, it could go a long way in limiting the consumption of plastic bags in the country. Further, the study recommends a slogan hailed by other countries is ‘polluter pays, by way of extended producer responsibility’.

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LIST OF ABBREVIATIONS

CEA	Central Environmental Authority
CV	Contingent Valuation
DSs	Divisional Secretariats
EDB	Export Development Board
FAO	Food and Agriculture Organization
HDPE	High Density Polyethylene
IEB	Integrated Environmental Body
ITI	Industrial Technical Institute
JICA	*Japan International Cooperation Agency*
LAs	Local Authorities
LDPE/LDP	Low Density Polyethylene
NERDC	National Engineering Research & Development Centre
PBLS	Polythene Bags and Lunch Sheets/Food Wrappers
PET	Polyethylene Terephthalate
PPP	Public Private Partnership
PVC	Polyvinyl Chloride
SLIC	Sri Lanka Inventors Commission
SLSI	Sri Lanka Standards Institute
SPSS	Statistical Package for the Social Sciences
SWM	Solid Waste Management
UN	United Nations

CHAPTER ONE

Introduction

1.1 Background of the Study

Plastic products including polyethylene bags and lunch sheets/food wrappers (PBLS) have become indispensable today for various reasons such as convenience, low-cost, impregnability to water, versatility, ease of manufacture and availability. In Sri Lanka, as per the statistics of the Central Environmental Authority (CEA) 200,000 Metric tons of raw materials are imported currently to manufacture these items and 70 percent of it is used for local consumption while the rest is exported. According to the statistics of the Sri Lanka Export Development Board (EDB), for over four decades this procedure has been continuing with an annual average growth rate of around 10–12 percent. Presently over 400 companies are engaged in plastic processing in Sri Lanka with Rs.15 billion investments. Nearly, half of the investment has been derived from foreign direct investments and of this 69 percent of total investment is exclusively for processing of plastic products for the export market. Further, according to the data collected by Japan International Cooperation Agency (JICA) in Sri Lanka, per capita generation rates of solid waste roughly range between 0.46 kg and 0.52 kg (Wijedasa, 2017). As an average value, that is around 0.49 kg. When reviewing the literature regarding the plastic waste in Colombo Municipal Council (CMC) and most other places in Sri Lanka, it shows that there are around six percent to seven percent (Wipulasena, 2018) plastic out of total. Thus, per capita plastic generation quantity in Sri Lanka per annum is around 10.73 kg to 12.52 kg (Data Generated through the HARTI Survey, 2018). Besides, a recent survey carried out by CEA has shown that over 20,000,000 polythene bags and about 15,000,000 lunch sheets are used daily (HARTI Survey Information of this Study, 2018). An alarming number of these synthetic material is in use and disposed every day to the environment in Sri Lanka.

Notwithstanding their multipurpose use of plastic products including single use PBLS added to the environment pose a huge threat. Due to long lasting effect in the environment, it causes environmental pollution, threatens agriculture, wildlife and human health. Owing to this, several countries have either executed bans or regulated the use of it. However, some countries are reluctant to come hard on production and use of polythene bags owing to the undue exerted on the respective governments. As a result, polythene bag usage and production is rampant in those countries (Karliner, 1997).

Despite Sri Lanka's commitment to limit polythene use and production by stipulating the quality parameters the dangerous presence of the material has triggered many a disasters concerning the environment such as the landslide of the Meethotamulla garbage dump and the deadly effects are more visible in the urban areas. In the meanwhile, new laws came into gazetted effect on September 01st 2017 aiming at minimising the above issues

prior to a full ban on PBLS in September 2017, which led to a huge uproar within the society. While some applauded the step, pointing at the sunny side of the ban on the environment; others protested, for the lack of alternatives and the economic blow it may have on their livelihood. The All Ceylon Polythene Manufactures and Recyclers Association and All Ceylon Canteen Owners' Association accused the authorities for their impractical approach and not offering plausible replacements. Almost two years on, has Sri Lanka successfully overcome its reliance on polythene? Still no study had been conducted in Sri Lanka to find the answers for questions arising following this major step.

- What are the difficulties experienced by various stakeholders due to PBLS ban?
- What are the prevailing and potential eco-friendly alternatives for PBLS in Sri Lanka?
- Are single use PBLS available in the market biodegradable?
- What are the positive and negative qualities of PBLS and their alternatives?
- What are the prevailing laws regarding polythene products and solid waste in Sri Lanka?
- Is a total ban on PBLS sustainable in Sri Lanka?
- Are the supermarkets, vendors and consumers capable of adapting to alternatives for PBLS?
- What is the level of functioning of the polythene collectors and recyclers in Sri Lanka?

Hence, the study came in the wake of gap existing with regard to the above issues and attempts to address those aspects.

1.2 Objectives

The main objective of this study is to identify the current situation on PBLS in Sri Lanka and evaluate the possible path forward.

The research objectives are;

i. Identifying the perception and difficulties faced by various stakeholders in our society regarding PBLS ban with effect from September 1st 2017 by the government.
ii. Identifying the prevailing and potential alternatives for PBLS and different stakeholders' perception on them.
iii. Identifying the nature of degradability of PBLS available in the market.

iv. Identifying the positive and negative qualities of PBLS according to relevant stakeholders.
v. Examining the prevailing laws regarding polythene products and solid waste in Sri Lanka.
vi. Identifying sustainable remedies that can be followed to manage plastic waste in Sri Lanka.

1.3 Organization of the Report

The report is organized as follows: The first chapter presents the research background and the objectives. The second chapter reviews the literature on PBLS and their effects, alternatives available for polythene products, remedies for plastic related problems, solid waste management in Sri Lanka, legislations related to plastics in Sri Lanka and future trends of plastic recycling in Sri Lanka. Chapter three presents the research methodology including selection of study location, methods of data collection, sample selection in questionnaire surveys and the data analysis. Chapter four outlines the results and discussion of the research. Finally, chapter five relates the conclusion and recommendations of the study in order to going forward.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Plastic

Over the past decades the consumption of plastic polymers increased vastly all over the world due to their physical character such as low-cost, ease of manufacture, versatility and impregnability to water (López-Rubio et al., 2004). Hans Von Penchmann, a German chemist is the first person who invented polythene accidentally in 1898 while investigating diamethane nearly a decade before Leo Baekeland contrived plastics. There are different categories of polymers used in common plastics. Such materials have different properties and therefore appropriate for different uses. However, there are concerns with regard to plastic use and Table 2.1 illustrates the type of plastic products and their impact on human health.

Each of these plastic type has its own risks, but some are more hazardous. For example, German researchers have discovered back in 2009 that PET plastic is much like the infamous bisphenol-A (BPA) chemical in that it can interfere with proper hormone expression and production and can increase one's risk of developing cancer. Further, polystyrene under category 6 may create human carcinogen and reproductive health problems. The Harvard University has revealed through research that polystyrene may cause abnormal pulmonary function, chromosomal damage and various types of cancer (Bollinger, 2015).

In 1977, supermarkets began to offer plastic grocery bags as an alternative to paper bags. By 1996, out of every five-grocery bags four were plastic. 1996 onwards over 80 percent of all bags are plastic. It is estimated that somewhere between 500 billion and one trillion plastic bags are consumed throughout the world each year. Approximately 53 percent of plastic bags are distributed from supermarket outlets, while 47 percent come from other retail outlets such as fast food shops, liquor stores and general merchandising (Gogte, 2009).

Table 2.1: Characteristics and Effects of Plastic as per Class

Source: http://myhealthmaven.com/numbers-plastic-bottles-mean/

2.2 Plastic Bags and Their Effects

There are two types of plastic shopping bags. They are the lighter, filmy bags get from supermarkets and other food outlets, and the heavier bags get from other retail outlets, like clothing stores. HDPE or high density polyethylene bags are stiff, thin and not transparent or opaque. HDPE (Ethylene polymer with densities ranging from 0.941 to 0.965 grams per cubic centimetre/>=0.94) is normally used in grocery or t-shirt bags. Low Density Polyethylene-LDPE (0.916 to 0.925 grams per cubic centimetre/<0.94mm) or low density polyethylene bags are thick and soft and can be transparent and glossy in appearance. LDPE is used in shopping bags usually with attached handles. Unlike HDPE, LDPE cannot be recycled.

The Danish Environmental Protection Agency in a study found that a number of times a grocery bag would have to be reused to have as low an environmental impact as a standard LDPE single-use plastic bag. For example, value of 5 indicates a bag would have to be reused five times to equal the environmental impact of a standard single-use plastic bag. The results show that certain plastic bag alternatives have high environmental impact and would require many reuses to make them worthwhile as a substitute. For example, an organic cotton bag would have to be reused 149 times to equal a LDPE's greenhouse gas emissions and 20,000 when impacts such as eutrophication, water and ecosystem are included. This presents a complex decision: plastic tends to have lower environmental impact for most metrics with the exception of its non-degradability and marine pollution. However, the biggest problem with plastic bags is that they do not readily break down in the environment. The time it takes them to decompose range from 400 to 1000 years (Bell and Cave, 2011). Further, plastic bags are not biodegradable, but do photo degrade. The sun breaks down the plastic into smaller and smaller toxic particles. The degradation releases toxic waste into the environment, polluting land, air, and water (Bashir, 2013). High consumption rates of plastic bags have led to increased inappropriate disposal of bags. It can also seriously harm or kill wildlife and domestic animals (Gogte, 2009). According to a study by Joseph et al., (2016), plastic bags caused choking the drains and the littered plastic bags are breeding ground for mosquitoes. Plastic bag packaging for hot edible items causes migration of harmful chemicals to food items. These include Styrene which is carcinogenic, Phthalates and Bisphenol-A which causes diabetes and diseases of the heart and liver.

2.3 Packaging Materials and Their Effects

Across many low to middle income countries, lack of packaging is an important issue for food security. The UN Food and Agriculture Organization (FAO) in 2012 have emphasized that lack of packaging and storage leads to significant post-harvest losses. Studies have shown that when distinguishing the environmental impacts such as greenhouse gas emissions, energy, water and resource use, plastic packaging tends to have a net positive impact. According to the experts, the impact of plastic production and handling is lower

than the impacts which would result from food waste without packaging. Reducing of packaging where it is used in abundant is useful, however, abandoning packaging completely would have serious implications on food security, safety ultimately leading to large enhances in the environment impact of food.

According to Song et al., (2009), packaging waste creates an exceptional part of municipal solid waste and has caused increasing environmental perturbs, resulting in a strengthening of assorted regulations aimed at reducing the amounts provoked. A wide range of oil-based polymers is currently used in packaging industries. These are almost non-biodegradable, and some are difficult to recycle or reuse owing to being complex composites having varying levels of contamination and sometimes they will take over 500 years to decompose. Defra (2004) and Thompson et al., (2009) have mentioned that the disposal of packaging materials from a certain society has been timely in terms of waste management. Even in 2009, plastic of cast packaging has been creating major waste management issues across the world (Barnes et al., 2009; Gregory, 2009; Oehlmann et al., 2009; Ryan et al., 2009; Teuten et al., 2009; Thompson et al., 2009a, b).

2.4 Alternatives for Polythene Bags

There is a range of alternatives to plastic bags. Supermarkets in Australia introduced biodegradable bags made from tapioca starch since 2003. According to Gogte (2009), though these bags closely resemble polythene bags those decompose within three months. According to a study by Athukorala et al., (2017) in Sri Lanka, cement paper bag with corn husk as the bottom, cement paper bag with oil paper layering and cement paper bag with banana tree bark at the bottom are also feasible alternatives for polythene bags. According to a study by Camann (2010) in the United States canvas bags are as popular as paper bags. The study also has demonstrated that a fair amount of the consumers would be willing to pay a small fee for alternative bags if such a system was introduced. The amount of participants willing to pay for alternatives is larger than the amount of participant willing to pay for current plastic bags.

2.5 Alternative Plastic Production

2.5.1 Degradable Plastics

There are two types of degradable plastic: bio-degradable plastics, which contain a small percentage of non-oil-based material, such as corn starch; and photodegradable plastics, which break down when exposed to sunlight. There are a number of concerns over the use of degradable plastics. First, these plastics only degrade if disposed of in appropriate conditions. For an example, a photodegradable plastic product does not degrade if it is buried in a landfill site where there is no light. Second, they may cause an increase in emissions of the greenhouse gas Methane, as Methane is released when materials biodegrade anaerobically (Bell and Cave, 2011). According to Khabbaz et al., (1998); Erlandsson et al., (1997); Akaranta and Oku (1997); Arvanitoyannis et al., (1998),

biodegradable plastics have been commercialized in manufacturing of various types of products such as garbage bags, compost bags, poly bags and agricultural mulch films.

According to Camann (2010), biodegradation is a natural process of degrading complex organic compounds by micro-organisms (such as bacteria) into simpler and smaller organic compounds. Biodegradable plastic bags can degrade in under two years. Thermoplastic starch (TPS) biodegradable plastics are starch-based plastics. Starch based polymers typically have starch contents ranging from 10 percent to 90 percent. Higher starch content will result in a more biodegradable plastic. It is 100 percent biodegradable and compostable. Normally, they decompose in compost in 10-45 days. Another starch-based biodegradable plastic used to make plastic bags is the starch synthetic aliphatic polyester blend. These bags are made up of 50 percent synthetic polyester and 50 percent starch. They are completely buried in soil within eight weeks. Organic bags made from materials such as cotton and hemp is also good options. They cost more than LDPE bags, but they last longer and are more stylish. They are also biodegrading within five to six months. LDPE bags are a relatively inexpensive option compared to most biodegradable bags on the market.

Debeaufort et al., (1998) and Guilbert et al., (1996) inferred that the use of biodegradable mulch film or photodegradable plastics can meet the growing needs to find alternatives to petroleum based products and to reduce the cost of labour for producing mulch film after use. Polyethylene has become a major contributor to waste plastics in whole world due to material is widely used in enormous fields. Farmers have got used to apply many discarded plastic materials consist of poly bags for sowing seeds and mulch films. LDPE, linear LDPE and HDPE are normally used for mulch films and poly bags (Fleck-Arnold, 2000).

According to Yrikou and Briassoulis (2007), though the process of recycling plastic is a good technology to mitigate the plastic waste in the environment, there are a lot of issues encountered during this process. Here recycling costs may be higher than the cost of production of new plastic. Hence, they can prevail last for hundreds of years due to their non-biodegradability. They are inert to micro-organisms, ultraviolet, heat and water. In another instance, plastic not only cause disposal problems but also affect marine life. Moreover, Land filling is the most common and frequently used method to dispose of municipal solid waste. When the things are so on, nowadays a lot of synthetic polymers that are resistant to chemical and physical degradation are disposed of together with other waste. Therefore, biodegradable polymers should be used as an alternative method in agriculture for the agricultural plastic waste.

In recent decades improving of environmental awareness has invigorated the enhancement of biodegradable materials from renewable resources to replace synthetic non-biodegradable materials in many applications. Among them polysaccharides like starches result several benefits for the replacement of conventional polymers in plastic industries because they are low cost, non-toxicity, biodegradability and availability.

Moreover, corn has been the main source of starch commercially available while rice, wheat, potato, cassava, yams, peas and lentils are other minor sources (Bergthaller, 2005). Biodegradable plastic packaging made from renewable raw materials such as crops instead of crude oil can be eradicated from the environment by composting or anaerobic digestion to reduce land filling (Murphy & Bartle 2004; Halley et al., 2001).

But according to Souza et al., (2010), there are some failures for producing starch based products since they present poor tensile characters and high water vapour permeability when compared to synthetic packaging generated from crude oil. However, using of biodegradable films as packaging materials is a fascinating approach, since it provides a substitute to non-biodegradable products making from by-products of petrochemical and enhances income in the agricultural sector. That being the case, biodegradable polymers are able to make outstanding contributions to material recovery, reduction of landfill and utilization of renewable resources (Davis and Song, 2006). Because of the difficulty in redeeming the conventional polyethylene mulching film after its use, biodegradable films have been enlarged and commercialized. These films usually made from bio-based stuff can be buried in the soil along after the usage of them in order to be decomposed by micro-organisms (Briassoulis et al., 2013).

Bio-plastics from Waste Newspapers

According to Agyeman (2014), with the aid of research and technology, the eco-friendly bags such as jute bags, cloth bags, paper bags and many other varieties have been initiated as the alternatives to plastic bags. Further he mentioned that these bags are recyclable, reusable and have no harmful effects on the environment. According to a past study by Goswami et al., (2014), the solution to this problem is biodegradable bioplastics. In that study they have dealt with the making of bioplastics from waste.

Because of newspapers possesses cellulose, they have extracted cellulose from the waste newspapers by decomposing them. When decomposing happens cellulose is crumbled into starch/glucose by process called Cellulolysis which is done with the help of enzymes. Finally, bioplastics has been prepared in lab by starch/glucose. Moreover, they have mentioned that although bioplastics are generally derived from renewable biomass sources, such as vegetable fats and oils, starch or micro biota, there is a variety of materials that bioplastics can be composed of, including: starches, cellulose, or other biopolymers. Besides, bioplastics can be used for packaging materials, dining utensils, food packaging, and insulation.

Due to many countries and states like China, Ireland, South Africa, Uganda and San Francisco are banning the plastic grocery bags responsible for so much so-called “white pollution” around the world, PLA is poised to play a big role as a viable, biodegradable replacement. According to Goswami et al., (2014), bio-plastics are made by corn starch, potatoes starch or banana starch which is used by humans and animals for their living. So his suggestion is that instead of using starch that are excreted from eatable things, waste

newspaper which are mainly made up of cellulose and these newspapers are dumped into oceans for disposal should be used for producing bio-plastics. The followed way by them has been included in **Annexure-1**. The production of bioplastics or biodegradable plastics is currently very low and it is estimated at around 4 million tonnes per year.

2.5.2 Recycled Plastic Bottles in Concrete Blocks

Safinia and Alkalbani (2016) conducted a study to scrutinize the possibility of using plastic bottles in concrete block in Oman. Accordingly, they revealed that in comparison to Omani hollow concrete blocks the concrete blocks with plastic bottles are 57 percent higher compressive robustness. Similarly, they expressed certain statements emphasized by Maroliya (2012) and appropriately hollow concrete blocks may be used, as substitutes to bricks and traditional stones in construction field. Furthermore, they impart an advantage of uniform quality as well as speeding in construction and the largest longevity. Maroliya (2012) further revealed that they are less expensive, consuming less cement and less involvement of labourers so on. Additionally, they can be employed in various locales such as the interior walls, exterior wall bearings and columns, the compound walls, and retaining walls etc.

2.5.3 Recycled Plastic Waste to Plastic Cement

Jassim (2017) administered a research to peruse the possibility of producing plastic cement mixed with Portland cement and the effect of replacing sand by fine polyethylene waste with different percentage on the properties of product. Here he conducted the experiments with the help of the waste of polyethylene packages including bottle and food crates in the range of 10 percent to 80 percent by volume as a short fortification edifice. Thus, results infer that there is a possibility to fabricate plastic cement from polyethylene waste and Portland cement by using 60 percent and 40 percent, respectively. But, their density has decreased while ductility and the workability has enhanced, which lead to produce lightweight stuff.

Further Rai et al., (2012) found that the workability and compressive strength were reduced due to partially replacement of sand by waste plastic flakes in varying percentages by volume to produce waste plastic mix concrete with plasticizer. Pezzi et al., (2006) found that the addition of polymeric material in fraction less than 10 percent in volume inside of cement matrix does not imply a significant variation of the concrete mechanical features. Binici et al., (2012) successfully used polyethylene bottle wastes in cement production and found that the ductility of concrete was improved. However, Marzouk et al., (2007) found that density and compressive strength of concrete decreased when the polyethylene terephthalate aggregate exceeded 50 percent by volume of sand. According to Dinesh et al., (2016), high strength bricks that possess thermal and sound insulation properties can be manufactured with the help of HDPE and polyethylene bags while mitigating the environmental pollution.

2.5.4 Plastic Waste for Road Construction

Kashiyani et al., (2013) launched a study to find the use of plastic waste in road construction along with utilizing process. Accordingly, 60 percent of the plastic-waste collected in India has been recycled back into the materials for further processing into consumer products, while the balance is left unutilized before year 2000. Afterwards plastic waste has been used by India in the construction of flexible road pavement. According to them, plastic would increase the melting point of the bitumen. As well with the help of the innovative technology, strengthens of the construction road can be enhanced while mitigating the damage to be happened on the environment. They further disclosed that plastic roads would be a blessing for India at hot and extremely humid where durable and eco-friendly roads which will relive the earth from all types of plastic debris. In India, 52,000 tons of plastic waste is produced per year and several roads have been built in this manner using polymer-coated–bitumen aggregate.

The Asset Group of Companies in Sri Lanka followed a new technology to incorporate the plastic waste to produce asphalt for road surfacing. The new material has been tested via a pilot project, where a strip of road spanning 500 meters (Pilot section-300 m and Control section – 200 m) from Ratmalana to Borupana. The company has collected and sorted non-recyclable plastic bags from municipal waste. Next, these has been cleaned, shredded to a permissible size and mixed with aggregates at 165° C temperature, within the asphalt batching chamber. Then, it has been applied for surfacing of roads less than 150 °C temperatures (Ada Derana, 2018). Nowadays, UK, Canada, Netherlands, Philippines and Indonesia like countries are also practicing this technology and with the aid of that issue has been arisen due to plastic waste can be managed while greatly reduce the cost of road construction by making the asphalt pavements more durable.

2.5.5 Management of Plastic Bags and Packaging

Globally, an ever-growing number of countries are introducing laws and policies to reduce, discourage, or ban the use of certain types of packaging materials. Bashir (2013) in a study explored the plastic problem in Africa and according to that, 90 percent of garbage in Africa has rotten in public areas. Certain African countries such as Rwanda, Tanzania and Uganda have passed laws, banning or restricting the use of the ordinary plastic grocery bag. They have taken several actions to reduce exposure to plastic toxins. Further, African governments encourage people to refrain from plastic packages and storage different items in containers such as reusable glass. Moreover, they are encouraged to use reusable bags or containers brought from home when marketing.

In the United Kingdom, people are encouraged to purchase reusable bags for life. Under a campaign, titled “Saving the Planet One Bag at a Time and Encourage Consumers to Reuse Them”. A three-part plan was launched to encourage more people to change their bag usage habits (Camann, 2010). It aimed at gradual elimination of polythene bag usage at supermarkets.

The first part is called 'Remind' that involves displays throughout the stores reminding people to reuse bags and buy reusable ones, sometimes called "Bags for Life." Furthermore, thousands of cashiers have been trained to offer 'Bags for Life' for those who did not bring their own. The second part is called 'Reward,' in which customers are given points called 'Nectar Points' for buying reusable bags and reusing old plastic bags through the 'Nectar Point' Reward Programme. Since its beginning, over 300 million points have rewarded. These points resemble electronic money that may be spent on an online Nectar store for various household items, entertainment, and even vacations. The final particular of the programme is called 'Remove.' In October 2008, Sainsbury's stopped providing free Polyethylene bags in all of its supermarkets (Camann, 2010).

Hence, Tesco, a British supermarket and merchandise giant introduced its 'Green Club-card Points' programme, which rewards customers for reusing bags. As a result of this programme over three billion bags saved within three years. Waitrose was one other supermarket in the United Kingdom also implemented a programme to encourage reusable bag use. Accordingly, they hid polyethylene bags from view and offer cheap "Bags for Life" to customers, and asked if customers need bags. Waitrose noticed about a 1100 percent increase in sales of 'Bags for Life', followed by a decline as customers started reusing them. At the same time, polyethylene bag usage has dropped by around 45-50 percent as customers used alternative bags (Camann, 2010).

In another instance, Ireland introduced a "Plas Tax"; a mandatory 20 cent tax on all polythene bags used in purchases. Consequently, Ireland's plastic bag consumption per person per year has dropped by 95 percent in less than a year. The initiative has changed consumers' habits and helped reduce the number of polythene bags used. Afterwards, the Australian government in 2008 has also imposed a tax on all polythene bags which resulted in a 90 percent decrease in polythene bag usage in the country in less than a year. Similarly, South Australia imposed its official plastic bag ban in May 2009. It has been the first state of Australia to do so. A progress report after six months of the ban and by late 2009, 200 million polythene bags had already been saved from use. Nearly 90 percent shoppers bring reusable bags with them to stores/shops, which is 60 percent increase than before the ban. Further retailers in Australia may be charged a $5,000 fine for offering polythene bags and suppliers a $20,000 fine for selling of polythene bags (Camann, 2010).

Denmark has also instituted a tax on bags and different approach has been followed here than Ireland. In 1994 Denmark has put a tax of 22 Danish Krone per kilo of plastic bags. This tax has included in the price charged to retailers and has cut plastic bag usage by 66 percent. Since, unlike Ireland, the tax has not been levied on consumers and it did not change consumer behaviour by as much as the Irish tax. The Danish market has collected around 170 million of Danish Krone so far and has used that money to fund many environmental projects (Gogte, 2009).

According to Camann (2010), San Francisco was the first city in the United States to ban plastic bags. The government introduced three options for supermarkets: biodegradability, reusability/recyclability concurrently fines were imposed on violating the above. It was reported that approximately 127 million plastic bags were saved following the ban.

In the subcontinent India Government prohibited manufacture, stocking, distribution or sale of carry bags made of virgin or recycled plastic and littering of plastic items. But consumer preferences revealed that a large population does not value the environmental aspect. Thus the ban of plastic bag usage is largely ineffective in India. Plastic bags have been used widely by small business owners such as vendors, retail shops and in shopping malls. A study revealed that majority of the sample were aware of at least one health hazard of plastic. Nevertheless, practices with respect to usage of alternative bags or reuse of already used plastic bags were found poor among majority of the participants (Joseph et al., 2016).

Additionally, many countries have remarkably responded by enforcing taxes to restrict their production and discourage buyers.

- Europe and the US: Various regulations and voluntary initiatives to prevent and reduce disposable packaging waste from, for example, coffee cups
- Kenya: Severe penalties for non-compliance with the plastic-bag ban
- UK: Ambitions to achieve “Zero percent avoidable plastic packaging waste”
- EU: Ambitions to ensure that 100 percent of plastic packaging is either recycled/recyclable or re-used
- China: Bans and imposes restrictions on import of certain types of waste as input for packaging material production

2.6 Specifications of Compostable Plastics in Sri Lanka

This international standard specifies procedures and requirements for the identification and labelling of plastics and products made from plastics suitable for recovery through aerobic composting. The following aspects are addressed.

a) Biodegradation
b) Disintegration during composting
c) Negative effects on the composting process and facility
d) Negative effects on the quality of the resulting compost, including the presence of high levels of regulated metals and other harmful components
e) This specification is intended to establish the requirements for the labelling of plastic products and materials, including packaging made from plastics, as “compostable” or “compostable in municipal and industrial composting facilities” or “biodegradable during composting” (for the purposes of this International

Standard, these three expressions are considered equivalent). The labelling will, in addition, have to conform to all international, regional, national or local regulations (e.g. European Directive 94/62/EC)

Source: Sri Lanka Standard Institute, 2016

2.6.1 The Principle

The purpose of this specification is to establish standards for identifying and labelling plastic products and materials that compost satisfactorily in well managed composting facilities where the typical conditions of composting can be consistently obtained (i.e. a long thermophilic phase, aerobic conditions, sufficient water content, a suitable Carbon/Nitrogen ratio etc.). Products meeting the requirements outlined below are appropriate for being labelled as “compostable”, “compostable in municipal and commercial facilities” or “biodegradable during composting”.

2.6.2 Basic Requirements

In order to compost satisfactorily, a plastic product or material shall demonstrate each of the characteristics given below.

1. Disintegration during composting
   The plastic product or material shall disintegrate during composting such that any remaining plastic is not readily distinguishable from the other organic materials in the finished compost. Additionally, the plastic product or material shall not be found in significant quantities during screening prior to final distribution of the compost.

2. Ultimate aerobic biodegradation
   The ultimate level of aerobic biodegradation shall be established by testing under controlled conditions.

3. No adverse effect on ability of compost to support plant growth
   The plastic product or material tested shall have no adverse effect on the ability of the compost to support plant growth, when compared to blank composts to which no test or reference substance has been added at the start of testing.

4. Compliance with national regulations
   Based on the relevant national and/or regional regulations, the plastic product or material shall not upon decomposition, release unacceptably high levels of regulated metals or other toxic substances into the environment. It is the responsibility of the user to conform to the applicable national and/or regional regulations dealing with metals, other elements and toxic substances in the environment.

Source: Sri Lanka Standard Institute, 2016

2.6.3 Detailed Requirements

ISO 16929: Plastic - Determination of the degree of disintegration of plastic materials under defined composting conditions in a pilot scale test.

ISO 20200: Plastic - Determination of the degree of disintegration of plastic materials under defined composting conditions in a laboratory-scale test.

ISO 14855-1: Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions-method by analysis of evolved Carbon dioxide-part 1: General method.

ISO 14855-2: Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions-method by analysis of evolved Carbon dioxide-part 2: Gravimetric measurement of Carbon dioxide evolved in a laboratory-scale test.

ASTM D5338: Standard test method for determining aerobic bio degradation of plastic materials under controlled composting conditions, including thermophilic temperatures.

In order to be identified as compostable, products and materials shall meet the requirements up below.

1. **Disintegration during composting**
   A plastic product is considered to have demonstrated satisfactory disintegration if after 84 days in a controlled composting test, no more than 10 percent of its original dry mass remains after sieving through a 2 mm sieve. The test shall be carried out in accordance with ISO 16929, ISO 20200, ISO 14855-1 or ASTM D5338 under thermophilic composting conditions without the CO_2 trapping equipment.

2. **Ultimate aerobic biodegradation**

   A plastic product is considered to have demonstrated satisfactory rate and level of biodegradation if when tested in accordance with ISO 14855-1, ISO 14855-2 or ASTM D5338, it achieves the ratio of conversion to Carbon dioxide.

   The ultimate aerobic biodegradability shall be determined for the whole material for each organic constituent. The level of biodegradation shall be determined separately for organic constituents which are present in the material at a concentration between one percent and 10 percent (by dry mass).

   Constituents which are present at concentrations of less than one percent do not need to demonstrate biodegradability. However, the sum of constituents shall not exceed five percent.

For all polymers, 90 percent of the organic carbon (relative to a positive control reference material) shall have been converted to Carbon dioxide by the end of the test period which shall be no longer than 180 days. Both the positive control and the test sample shall be composted for the same length of time and the results compared at the same point in time after the activity of both has reached a plateau. The positive control used shall be microcrystalline cellulose. As an alternative, 90 percent (in absolute terms) of the organic carbon shall have been converted to carbon dioxide by the end of the test period.

3. **No adverse effect on ability of compost to support plant growth and compliance with regional and/or national regulations**

   In order to ensure that the composting of plastic products or materials does not have any harmful effects on the finished compost or on the environment and complies with appropriate regional and national regulation mentioned below.

   The concentrations of regulated metals and other toxic substances in the plastic product or material shall be less than 50 percent of those prescribed for sludge, fertilizers and composts in the country where the final product will be placed on the market or disposed of. The plastic product or material shall contain a minimum 50 percent of volatile solids. The seedling germination rate of the finished compost and the plant biomass in the compost shall be no less than 90 percent of that of corresponding blank composts to which no test or reference material was added at the start of testing, determined in accordance with Organization for Economic Co-operation and Development (OCED) Guidelines 208 with the modification specified.

Source: Sri Lanka Standard Institute, 2016

2.6.4 Marking and Labelled

Plastic products or materials meeting all the requirements specified in above may be labelled “compostable” or “biodegradable during compost”. The labelling shall conform to international, regional, national and local regulations. The name of the country where the plastic product or material is to be marketed or recycled by composting shall be indicated.

Source: Sri Lanka Standard Institute, 2016

2.6.5 Test Report

The test report shall provide all pertinent information, including:

a) All information necessary to identify and describe the product or material tested;
b) References to all standards, guidelines and regulations that are relevant to the content of regulated metals and other toxic substances (a table of regulated metals and other toxic substances shall be presented, specifying each such reference and stating the prescribed limit for each metal the concentration determined in the test and the percentage of the prescribed limit);

c) A description of other relevant requirements in the referenced documents and a statement for each such requirement, as to whether the test result was in conformity with the requirement or not.

Source: Sri Lanka Standard Institute, 2016

2.7 Solid Waste Management (SWM) in Sri Lanka

According to the Asian Regional Research Programme on Environmental Technology in 2004, illegitimate management of solid waste has caused to create serious environmental and health consequences in Sri Lanka. Hence, proper environmental planning is needed to reinforce the environmental efforts and cooperation between municipalities, private sector, and both civil society and the communities of the particular localities. As Parvez (2019) expressed, SWM is a leading issue in most of the developing countries since it needs an integrated approach which includes waste generation, pre-collection and storage, collection, transportation, treatment (incineration, recycling, composting etc.) and up to final disposal.

Kuruparan et al., (2004) expressed that public and certain local authority bodies of developing countries such as Sri Lanka dump the solid waste on roadsides as well as in marshlands, wet lands or reservations. The situation has further been aggravated by inadequate financial resources, inadequate management and technical skills within municipalities and government authorities.

A study by Karunasena and Amarathunga (2010) reveals that lack of positive attitude, poor attention to raise community awareness, absence of community participation in strategy planning and development, rigid legal framework are the major ills in solid waste management in Sri Lanka. The National Solid Waste Management Support Centre's Annual Report in 2007 states that a huge gap exists between waste generation and collection in local authorities (LAs) of Sri Lanka.

2.7.1 Case Study on Solid Waste Management in Kelaniya Pradeshiya Sabha Area

Senanayake et al., (2017) in a study explored the municipal solid waste management system in the Kelaniya Pradeshiya Sabha, as a key area in the Gampaha district to identify best practices and gaps. The study reported lack of infrastructure and financial resources, poor public participation in the waste management process and less enthusiasm of government representatives as reasons for the sluggish the progress. It further found that although the institutional capacity has been developed to a certain extent, further attention and implementation of new policies are vital to overcome the prevailing circumstances.

2.7.2 Important Laws and Regulations Related to Solid Waste Management

The National Environmental Act No. 47 of 1980 can mitigate the emission of waste materials into the environment and states the responsibilities and powers of the CEA. Moreover, it has been amended time to time under the Act, No. 56 of 1988 and Act, No. 53 of 2000. Thereby, authorities have been able to give more concern towards the waste. And also, a new rule regarding the thickness of the polythene has been introduced by the Government under the Gazette No. 1466/5 published in October 10, 2006. Additionally, there is a gazette published by the Ministry of Environment and Natural Resources (Presently the Ministry of Environment and Mahaweli Development) under the No. 1627/19 (2009) on the municipal solid waste in Sri Lanka.

Moreover, Pradeshiya Sabha Act No. 15 of 1987, Urban Council No. 61 of 1939 and Municipal Council Ordinance No. 16 of 1947 are also vital to manage the solid waste. These Acts and Ordinances have stated that the local authorities are responsible for proper removal of non-industrial solid waste and dispensing suitable dumpsites. Hence, the Ministry of Environment has formulated the National Strategy for SWM in 2000, which recognized the need for SWM from generation to final disposal through a range of strategies, based on the 3-R principle. This has been supplanted by a National Policy for Solid Waste Management prepared in 2007 in order to ensure integrated, economically feasible and environmentally sound SWM practices for the country at national, provincial and local authority level.

Moreover, CEA in 2008 initiated a 10-year expansion waste management project known as ‘Pilisaru Project’ on March 24, 2008 to manage the solid waste at the national level under the concept of reusing the resources available in the collected garbage to the maximum before final disposal. The main objective was to achieve a waste free Sri Lanka by 2018. For achieving this, below specific objectives were to be obtained under the Pilisaru Programme and they are,

1. Development of a National Policy on SWM
2. Development of a National Strategy on SWM

3. Effective education and awareness for all stakeholders on SWM including training and capacity building
4. Facilitation for LAs for implementation of SWM projects / programmes
5. Legal reforms to strengthen effective law enforcement

According to Dasanayaka (2009), these objectives have been formulated considering the existing solid waste related problems and issues faced by the stakeholders and to improve the overall solid waste management system in the country, emphasizing particularly the crucial issues such as intermediate treatments and environmentally friendly final disposal of residues.

Further, he has noted down as the Ministry of Environment and Natural Resources is the main policy making body for the environmental sector in Sri Lanka. Under this Ministry, CEA has been contrived as a regulatory body for environmental management in the country. He has further revealed that lack of systematic systems on waste collection, waste transport and intermediate treatment systems and suitable waste disposal have led to the solid waste dilemma in Sri Lanka. Indiscriminate waste disposal practices in Sri Lanka have generated many environmental complications and innumerable embarrassments on general public. Therefore, Pilisaru is a successful Integrated Urban Planning Approach to SWM in Sri Lanka. Under the project technical and financial assistance has been extended to a certain extent on SWM to the local authorities while imposing legal action against those local authorities that were not managing their solid waste properly.

2.7.3 Pilisaru Project for Waste Management

Dasanayaka (2009) has mentioned in his report about a project called 'Pilisaru' by the Central Environmental Authority in 2008 with the participation of other government organizations, especially the Urban Development Authority, private institutions, NGOs and experts in this field to find solutions to solid waste in Sri Lanka.

Furthermore, the purview of the Pilisaru Project predominantly encloses the following key tasks.

i. Collection of information on disposal of solid waste by LAs

   Information on current waste disposal methods, projects and programmes abandoned by LAs and the resources available is collected for planning purposes. In the process of collecting data the assistance of the divisional environmental officers of the CEA is obtained through the network of the CEAs provincial and district offices.

ii. Evaluation of project proposals

Evaluation of proposals put forward by LAs is carried out and necessary assistance is provided to implement them on the ground. An evaluation procedure is formulated and assistance is sought from various technical experts for the successful implementation of the proposals.

iii. Establishment of waste recycling banking system

The Pilisaru Project negotiates with the SANASA Development Bank with regard to the possibility of implementing a waste banking system. The Bank collects the recyclable waste, particularly the plastics and polythene from the account holders and an amount equal to the value of the waste handed over is credited in the account of the account holder. The collected waste is sold by the bank to recyclers regularly to recover the money paid to the account holders with a nominal profit to cover the bank expenses. This is an innovative approach introduced by the Pilisaru Project with the 'SANASA Bank'.

iv. Establishment of waste collecting centres

v. Technical support, institutional strengthening and capacity building

vi. Strengthening recycling by establishing collection network for metal, plastic, glass, and paper wastes

Waste plastic, metal, glass, papers are preferable items used for recycling. An increasing number of private sector organizations are now providing plastics and paper collection services. One of the main activities of the Pilisaru project is establishment of proper collection network system for paper and plastic wastes. Especially education and awareness programmes are launched through schools, community organizations, women societies and local authorities to encourage recycling of such waste material.

vii. Establishment of compost plants at LA level.

In an effort to find a scientifically acceptable and reasonable solution for the problem of haphazard dumping of solid waste in open lands and water bodies, Pilisaru project takes an initiative to assist the establishment of a composting plants and an environmentally safe waste disposal facility with appropriate technologies utilizing the expert knowledge of members of the technical committee established under the national committee on SWM.

viii. Construction of low cost sanitary landfills for disposing residual waste.

Sanitary landfill site is a location designed for the final disposal of waste in an environmentally sound manner. The design includes controlling of leakage and gas, daily cover for the working surface of waste, runoff and run on diversions, which would result in decreasing the potential of surface and groundwater pollution. The Pilisaru project plans to establish a number of sanitary landfills in such a way that the LAs can make use of them to dispose residual wastes on a cluster system.

ix. Promoting home composting

Household composting usually involves relatively small volumes of organic materials generated from the kitchen and garden. Using a bin or pit helps to retain the heat and moisture that would be lost in a small, open pile. A container also has the advantage of being tidy, which is desirable in a residential area. Therefore, the Pilisaru project makes arrangements to promote the use of home composting by providing bins to LAs at a subsidized rate.

x. Monitoring and taking legal action for LAs continue to carry out improper SWM practices.

Pilisaru project, as its final action would resort to taking legal actions against LAs which do not carry out proper SWM practices. Regular evaluation and monitoring of SWM programmes being implemented by the LAs is carried out by a Monitoring and Evaluation Committee which consists of the environmental officers and the Pilisaru staff as the committee members.

2.8 Legislations Related to Plastics in Sri Lanka

There are six gazette papers published on September 01, 2017 based on the National Environmental Act, No. 47 of 1980, Order under Section 23 W, regarding some polythene related products and it is described below.

Gazette no. 2034/33 mentions that manufacture of polythene or any polythene product of 20 microns or below in thickness for in country use; or the sale, offer for sale, offer free of charge, exhibition or use of polythene or any polythene product which is 20 microns or below in thickness within the country are prohibited.

Anyhow, polythene or any polythene product of 20 microns or below in thickness may be permitted to be used with the prior written approval of the Authority for the purposes specified. According to the gazette, “polythene” means all forms of polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate or any other similar raw material and polyethylene terephthalate (PET) whether or not metalized or holographic PET film, polypropylene films whether or not metalized or pearlised, nylon, cast polypropylene or metalized cast polypropylene, polyvinyl chloride (PVC), polyethylene terephthalate glycol have been permitted to use for the purpose of laminating. Besides, polythene has been allowed to use for medical or pharmaceutical purposes in the absence of any other suitable alternative.

According to the gazette no. 2034/34, manufacture of food wrappers from polythene as a raw material for in country use and the sale, offer for sale, offer free of charge, exhibition or use of food wrappers manufactured from polythene as a raw material within the country are prohibited. Here, ‘‘food wrappers’’ means lunch sheets and ‘‘polythene” includes high density polyethylene, low density polyethylene and polypropylene.

Gazette no. 2034/35 expresses that manufacture of any bag of high density polyethylene as a raw material for in country use and sale, offer for sale, offer free of charge, exhibition or use of any bag manufactured from high density polyethylene as a raw material within the country are prohibited. However, garbage bag and textile bag have been allowed for in country use.

According to the gazette no. 2034/36, no person shall burn openly or cause to, allow or permit the open burning of refuse or other combustible matters inclusive of plastics and any person who fails to comply with the regulations above shall be liable to an offence and punishable under section 31 of the National Environmental Act, No. 47 of 1980. Here, section 31 mentions that every person who contravenes or fails to comply with any provision of this Act or of any regulation made there under shall be guilty of an offence and shall on conviction before a Magistrate be liable to imprisonment of either description for a term not exceeding two years or to a fine not exceeding one thousand five hundred rupees or to both such imprisonment and fine.

As well, the use of all forms of polyethylene, polypropylene, polyethylene products or polypropylene products as decoration in political, social, religious, national, cultural or any other event or occasion have been prohibited by the gazette no. 2034/37.

Gazette no. 2034/38 has banned the manufacture of food containers, plates, cups and spoons from expanded polystyrene for in country use and the sale, offer for sale, offer free of charge, exhibition or use of food containers, plates, cups and spoons manufactured from expanded polystyrene within the country.

In addition to aforementioned gazette statements there is another gazette published by Consumer Affairs Authority based on Act, No. 9 of 2003. It states that: “no trader shall at the time of selling of goods levy any charge directly or indirectly on consumers for any type of bags/wrappers issued to the consumers” (Sri Lanka. Consumer Affairs Authority Act 2003).

2.9 Future Trends of Plastic Recycling in Sri Lanka

Gunaratna (2012) has implemented a study to analyse the future trends of plastic waste in Sri Lanka. For this, wasted quantities of LDPE, HDPE, polypropylene, polystyrene, PET and polycarbonate have been employed from year 1995 to 2011. According to him, polythene would be the highest consumed plastic material where polystyrene would be the least consumed in year 2025. Further he has predicted that though polythene would be the highest consumed plastic material in year 2025 polypropylene would generate the highest waste quantity while polycarbonate generating the least. In addition, out of 310,000 tons of plastics consumed around 220,000 tons (70.99 percent) would be wasted in year 2025.

Moreover, he has examined ten randomly selected plastic waste collectors and recyclers registered with the Central Environmental Authority to analyse the future trends of plastic recycling in Sri Lanka from 2007 to 2011. According to the results revealed that, out of 170,000 tons of waste (77.27 percent of the wasted) around 50,000 tons (22.73 percent of the wasted) would still not be recycled in 2025. Simultaneously, it observed the issues related to recycling industry in Sri Lanka to acquire the theme of the green environment concept in year 2025 or before that. Additionally, it identified that the Government should support towards the National Post Consumer Plastic Waste Management Project (NPCPWMP) to introduce plastic recycling at Provincial Council level as short term recycling trends to achieve the theme of the green environment concept before 2025.

CHAPTER THREE

Research Methodology

3.1 Selection of Study Location

According to the secondary data sources in CEA and Japan International Cooperation Agency (JICA) in Sri Lanka, the highest rate of per capita consumption of conventional polythene is reported in the Western Province (around 12.52 kg). Besides polythene producers and vendors of the polythene shopping bags and lunch sheets are concentrated in the Western Province. That trend is more likely to spread to other parts of the country. Therefore, considering these, this study was conducted in every district in the Western Province, covering all the rural, semi-urban and urban areas.

3.2 Methods of Data Collection

Data was collected from government institutions, non-governmental organisations, material researchers, major foodstuff producers, polythene manufacturers, supermarket chains, grocery shops, food vendors, entrepreneurs, plastic collectors and recyclers as well as the general public. Key Informant Interviews, Focus Group Discussions and Questionnaire Surveys were used to obtain primary data and sources of CEA and the Department of Customs, details of research reports, journals and newspaper articles were employed as secondary data. A total of 1400 individuals had been interviewed in this study that largely focused on the Western Province, from March 2018 to February 2019.

Key Informants Interviews
Key informant interviews were conducted for 75 key persons (Annexure -2) including government institutions, non-governmental organisations, material researchers, polythene manufacturers, supermarket chains, major foodstuff producers and entrepreneurs in order to learn the situation following the polythene ban.

Focus Group Discussion
There was a main focus group discussion on May 30, 2018 with the participation of different parties (around 30 parties) including government institutions, non-governmental organisations, material researchers, major foodstuff producers, polythene manufacturers, supermarket chains, grocery shops, food vendors, entrepreneurs, plastic collectors and recyclers as well as the general public to gather the current situation on PBLS in Sri Lanka and evaluate the possible path forward.

Questionnaire Surveys
In this study, mixed reactions of both probability and non-probability sampling techniques were used for each questionnaire survey to attain the research objectives. Here, we

applied the cluster sampling techniques to select the respondents in each district. Here, gender base of the respondents was considered to obtain good results. Therefore, purposive sampling techniques were also applied with mixed reactions of both cluster sampling with two stages and purposive sampling techniques.

3.3 Sample Selection in Questionnaire Surveys

3.3.1 Proposed Sample Size and Obstacles Faced in Sample Selection

There are 40 divisional secretariats (DSs) in the Western Province (Colombo: 13, Gampaha: 13 and Kalutara: 14). Since the number of DSs are similar in each district, we had planned to interview 250 consumers, 64 households, 50 retailers/sellers, 50 food court owners/restaurateurs (bake houses, pastry shops, bread shops etc…), 25 supermarket owners/responsible persons and 25 alternative producers/entrepreneurs in each district. Altogether 1392 respondents including 750 consumers, 192 households, 150 retailers/sellers, 150 food court owners/restaurateurs (bake houses, pastry shops, bread shops etc…), 75 supermarket owners/responsible persons and 75 alternative producers/entrepreneurs were selected. For this, five DSs were selected from each district and aforementioned sampling techniques were applied to capture the above requirement. Moreover, 150 polythene collectors and recyclers registered with CEA were to be interviewed across the country. Then we planned to interview 1542 respondents in the study. Due to lack of support of some stakeholders and limited time, we were unable to cover the total sample size (1542) within the study period.

3.3.2 Selection of Sample and Size

Anyhow finally, 1325 persons were interviewed for the questionnaire survey (including representing consumers, households, retailers/sellers, food court owners/restaurateurs, supermarket owners, alternative producers/entrepreneurs, polythene collectors and recyclers) from the Western Province. According to Lackey and Wingate (1998), 10 percent of the final study size is commonly sufficient for pre-test study. Therefore, 133 sets of questionnaires were administered out for pre-test purpose in order to ensure the questionnaire quality and appropriateness.

3.3.3 Choice Experimental Techniques

Choice experimental techniques are widely used to value environmental resources. However, choice experiment techniques can be also used to derive value for other aspects as well. Various forms of non-market valuations related to wide sectors ranging from health, transport and infrastructure have been conducted using choice experimental techniques to estimate willingness to pay and accept of general public (Alpizar et al., 2001). Choice experiment techniques enable estimation not only of the value of the asset as a whole but also of the implicit values of its attribute (Hanley et al., 1998; Kuruppu et al., 2018). In this study since there are limited or no alternatives for polythene in the Sri

Lankan market, choice experimental technique was deployed to elicit willingness towards such alternatives.

3.4 Data Analysis

The main purpose of the data analysis strategies is to translate the meaning of raw data into meaningful information for interpretation (comparison, justification and exploration). Here, categorical data analysis (cross tabulation) was mainly employed to analyse the data with SPSS.

For achieving the factors affecting for the specific objectives mentioned in chapter one, main variables of consumers, households, retailers/sellers, food court owners/restaurateurs, supermarket owners, alternative producers/entrepreneurs and polythene collectors and recyclers were analysed and they consist of 35, 46, 32, 26, 29, 33 and 10 variables respectively.

Besides, CV method was used to estimate the willingness to pay (WTP) for an eco-friendly alternative by the households instead of polythene in Sri Lanka. For this, a theoretical consistency in line with the Lancaster's model of consumer choice was employed. According to Lancaster (1966), choice of consumer is derived not from the actual content of the system but from the characteristics or attributes of the elements within it. Simply, each and every part may contribute to derive the ultimate value of that system. Preference for the system is derived through its usability or utility. If a set of attribute bundle caters more utility consumer chooses that bundle.

However, if consumer is directed for a repeated choice then consumer chooses something else due to some random factors. Therefore, even consumer indirectly derives his preference from a set of attributes as a result of random factors repeated choices may vary. In this technique, a utility function (Uij) as derived from alternative is specified and behaviour is integrated into this function by Random Utility Approach, where utility of a choice is comprised of a deterministic component (V) and an error component (e), which is independent of the deterministic part and follows a predetermined distribution.

Thus, the utility can be specified as;

$$U_{ij} = V(Z_j, Si) + e(Z_j, Si)$$

For any given household *i*, a given level of utility will be associated with any alternative system *j*. Therefore, utility derived from any of the alternative depends on the attributes (Z) of the system and the social and economic characteristics (S) of households. This error component implies that the predictions cannot be made with certainty. Choices made between alternatives will be a function of the probability that the utility associated with a particular option (*j*) is higher than that the utility associated with other alternatives.

Finally, descriptive statistics of the data collection through the primary data sources (such as Key Informant Interviews, Focus Group Discussions and Observations) and secondary data sources (research reports, journals and newspaper articles) were used to justify the research objectives.

Choice Sets

Choice cards were prepared using the crucial attributes and the attribute levels. An example choice set is presented in Table 3.1. Orthogonalization procedure was used to recover only the main effects, consisting 32 alternative profiles and profiles were randomly blocked into eight different versions, each with four different alternatives for polythene products. After the questionnaire, households were presented with the choice card and each respondent was asked to select the best preferred alternative for polythene from the four alternatives.

Table 3.1: Sample Choice Set Used for the Study

Main Block 1				
Alternative Characteristics	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Material/s	Crop leaves & residue	Degradable plastics	Papers	Cloths
Frequency of usage	Only once	Multiple times	Multiple times	Only once
Degradable percentage	100%	100%	75%	75%
Availability	Any retail outlet	Any retail outlet	Any supermarket	Any supermarket
Unit Price	Rs. 6.00	Rs. 9.00	Rs. 3.50	Rs. 1.50

Source: Field Survey, 2018

Each choice card is consisted of four alternative choices and each alternative has five attributes and the sixth attribute was a proxy for blocking purposes. It is not feasible to select one alternative from a large number of alternatives; hence the main purpose of blocking was to reduce the number of alternatives for a respondent. From all five attributes two consisted of four levels and the rest of two levels. Attribute is a feature of the particular alternative and the level refers to possible stages of that attribute.

Besides, Conditional logit model was deployed in both scenarios for data analysis. In direct utility from each system takes the form as follows:

$$V_{ij} = \beta_1 In\,(Z_{\,1}) + \beta_2 In\,(Z_{\,2}) + \beta_3 In\,(Z_{\,3}) + \beta_4 In\,(Z_{\,4}) + \beta_5 In\,(Z_{\,5})$$

Whereβ refers to the coefficient, which is specified to account for the proportion of choice of participation in household level. The term β_{1-5} refers to the vector of coefficients associated with the vector of attributes describing system characteristics and the fifth represents the monetary attribute.

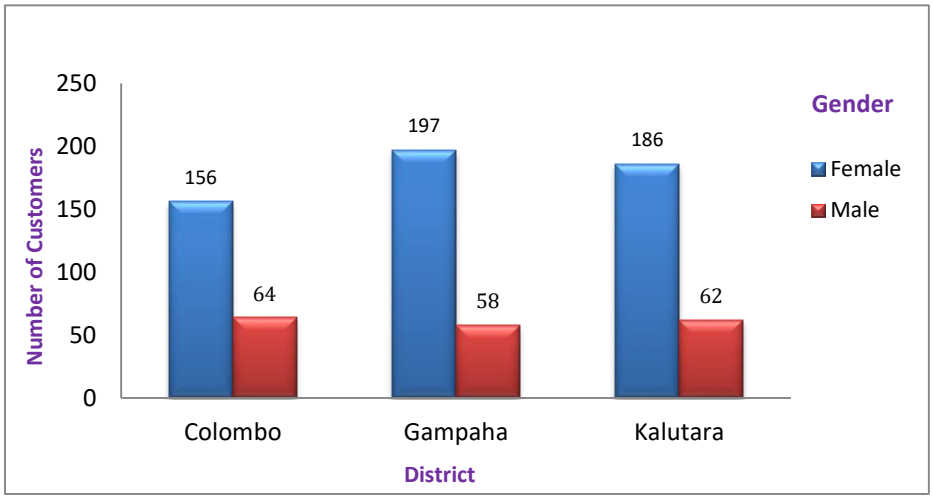
CHAPTER FOUR

Results and Discussion

4.1 Overview of the Stakeholders

4.1.1 Gender Distribution of the Customer Sample

Perception, difficulties faced and practices by various stakeholders on PBLS ban may vary based on the gender. Therefore, it is a vital component of the study. When considered the gender of the selected respondents, it could be observed that three fourth were female while the males were only one fourth. It is illustrated district wise in the graph given below.



Source: Field Survey, 2018

Figure 4.1: Customers in the Survey in each District

In another instance, respondents' perception and behaviour may differ according to the place of shopping. Therefore, respondents of 723 were interviewed in different places in each district from the Western Province and Table 4.1 shows it in a descriptive manner.

Table 4.1: Distribution of Customers/Consumers Participated in the Study

District	Sathosa	Keells Super	Cargills	Laugf Super	Arpico	Fair/ Central Market	Total
Colombo	51	24	27	21	21	76	**220**
Gampaha	45	30	-	14	66	100	**255**
Kalutara	150	-	-	-	-	98	**248**
	246	**54**	**27**	**35**	**87**	**274**	**723**

Source: Field Survey, 2018

4.1.2 Households Participated in the Survey

In this study 192 households in the Western Province, 64 in each district participated.

Table 4.2: Distribution of Households Participated in the Study

District	No.
Colombo	64
Gampaha	64
Kalutara	64
Total	**192**

Source: Field Survey, 2018

4.1.3 Retailers/Sellers Participated in the Survey

Here, 66 retailers/sellers were interviewed. The district wise breakdown is depicted below.

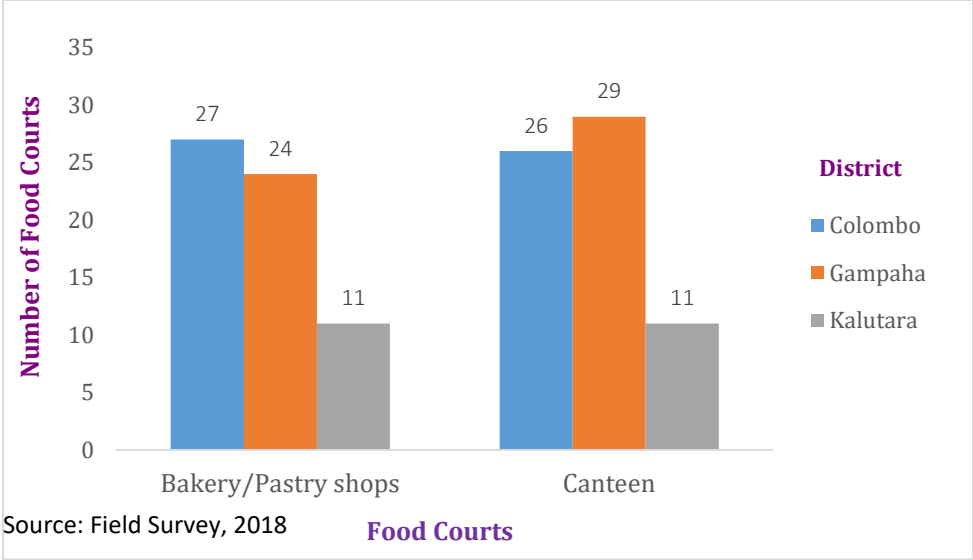
Table 4.3: Distribution of Retailers/Sellers Participated in the Study

District	No.
Colombo	26
Gampaha	29
Kalutara	11
Total	**66**

Source: Field Survey, 2018

4.1.4 Food Vendors/Restaurateurs Participated in the Survey

Here, of the total sample interviewed, 48 percent were pastry shops and 52 percent were canteen owners. Altogether 128 food vendors participated in the study. Figure 4.2 illustrates the distribution.

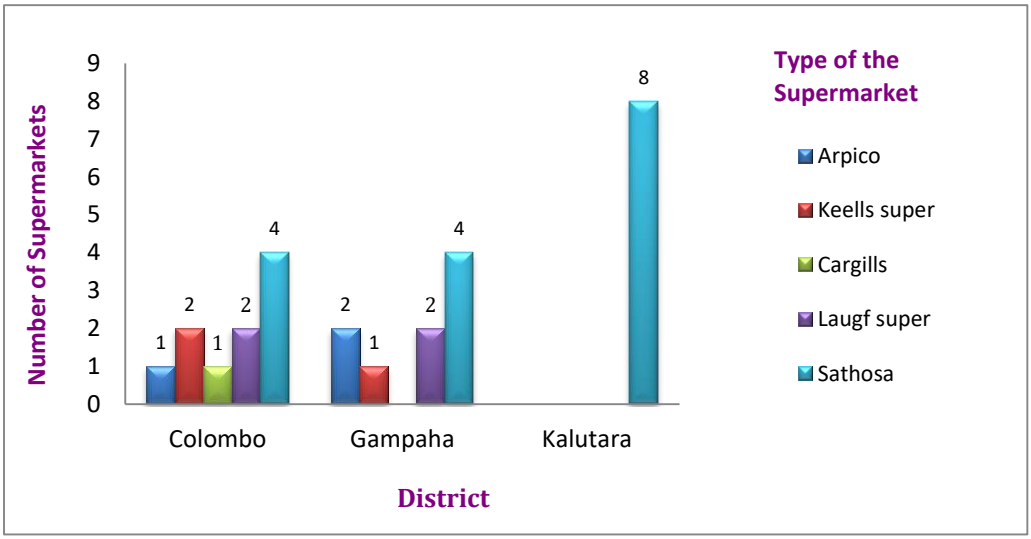


Source: Field Survey, 2018

Figure 4.2: Food Vendors Participated in the Survey in each District

4.1.5 Different Types of Supermarket Took Part in the Survey

There were 59 percent of Sathosa, 15 percent of Laugfs, 11 percent of Keells supermarkets, 11 percent of Arpico and four percent of Cargills in the study sample (Figure 4.3).

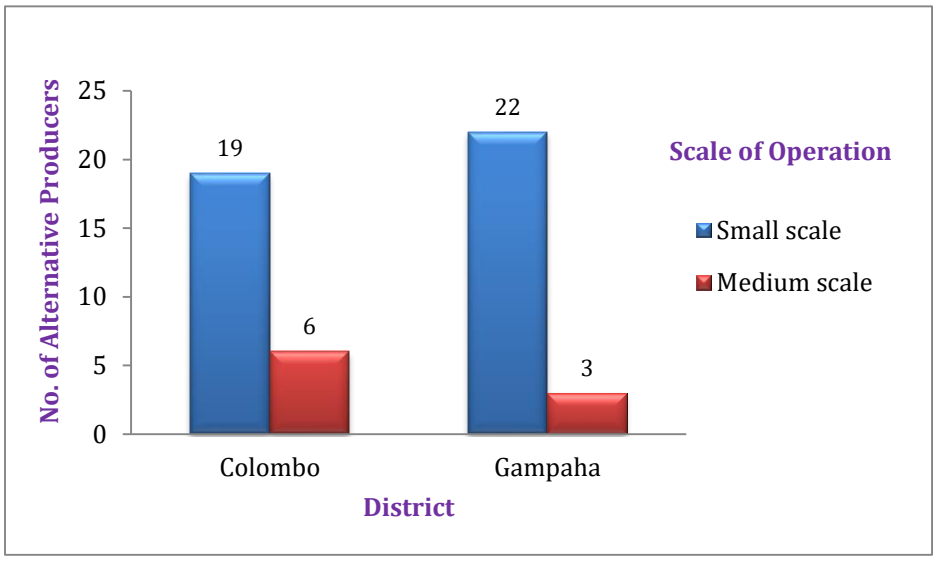


Source: Field Survey, 2018

Figure 4.3: Different Types of Supermarket Took Part in the Survey

4.1.6 Alternative Producers in the Survey

Based on the scale of operation of alternative producers in the study sample, policies can be made to uplift the producers of eco-friendly alternatives. The graph below shows the variation in the number of eco-friendly alternative producers in Gampaha and Colombo districts.



Source: Field Survey, 2018

Figure 4.4: Scale of Operation of Alternative Producers in each District

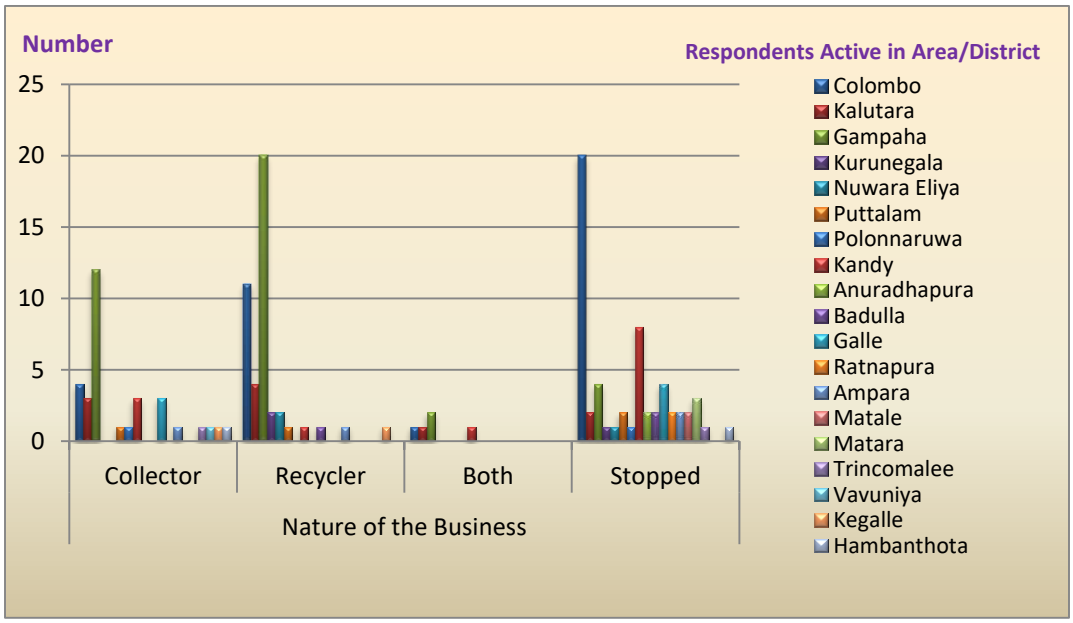
Majority (82 percent) are small scale producers in the sample. This is true to both the districts projected here. However, with entrepreneurs that have introduced and attempted to promote material and products as substitutes have expressed their disappointment with authorities who have done little in terms of providing support. This was clear with what was observed in the study, where very few alternative products were found to be available and in use. Of those that are being visibly utilised as alternatives for lunch sheets in the Western Province, the most prominent were banana leaves, areca nut leaves ("Kolapath") and lotus leaves used by food vendors. Yet, the study revealed that 97% of food vendors still relied on the use of lunch sheets (both biodegradable and not) in their business. The most common alternatives identified for polythene grocery bags at super markets and grocery stores were fabric bags, paper bags and bags made of starch based biodegradable plastics.

Another aspect uncovered in the study was the prevalence of "black market" polythene lunch sheets which sometimes pass off as biodegradable ones. This was a major concern raised by manufacturers of biodegradable lunch sheets, as they have to compete with lower priced fakes that undermine the environmental benefits of the imposed regulations. The presence of polythene lunch sheets in the market was further confirmed

by the finding that 25% of the food vendors were still using LDPE sheets in their shops and stalls when serving and wrapping food.

4.1.7 Plastic Collectors and Recyclers

When attempting to interview plastic collectors and recyclers registered at the Central Environmental Authority (139 persons), it was found that 42% of those contacted had given up the business. There are 32 collectors, 44 recyclers and five in to both activities. Of those who were still functioning 86% complained that there was minimal assistance or encouragement by the authorities for continuing and improving their industry. Unless there is economic viability and a sufficient amount of easily accessible material, the waste collection and recycling sector would gradually 'degrade' overtime. It would be in the best interest of the authorities (local and national) to promote and maintain this sector by formally incorporating it into the waste management process. Figure 4.2 illustrates the distribution of plastic collectors and recyclers.



Source: Field Survey, 2018

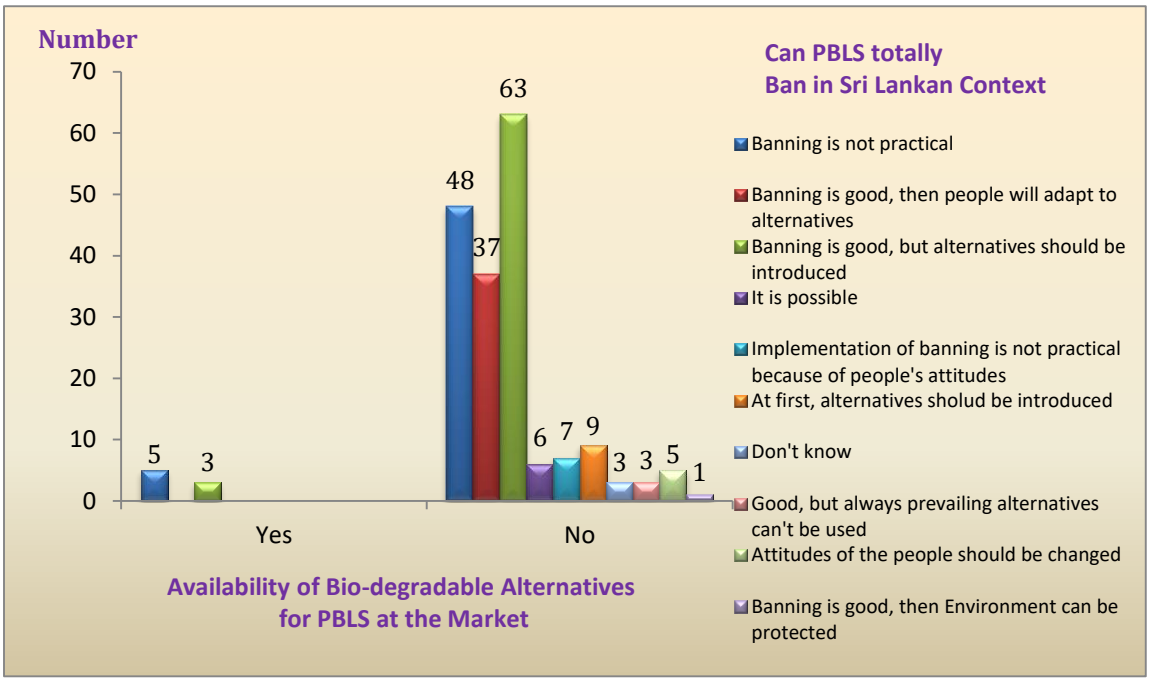
Figure 4.5: Plastic Collectors and Recyclers Active in Area

4.2 Perception and Experiences by Various Stakeholders on PBLS Ban

4.2.1 Households' Perception on PBLS Ban

Under this, households' perception on PBLS based on the availability of bio-degradable products has been taken into account. According to descriptive statistics, 96 percent of households said that bio-degradable products which can be used for polythene lunch sheets are not available at the market while only four percent of households replied in

the affirmative. Hence, 28 percent of the total households directly said that banning is not realistic while 20 percent of the total households responded in favour of the move and claimed people will look for alternatives. Moreover, 35 percent of total households while responding positively over the ban recommended the alternatives should also be introduced. Figure 4.6 shows the availability of bio-degradable alternatives for PBLS at the market.

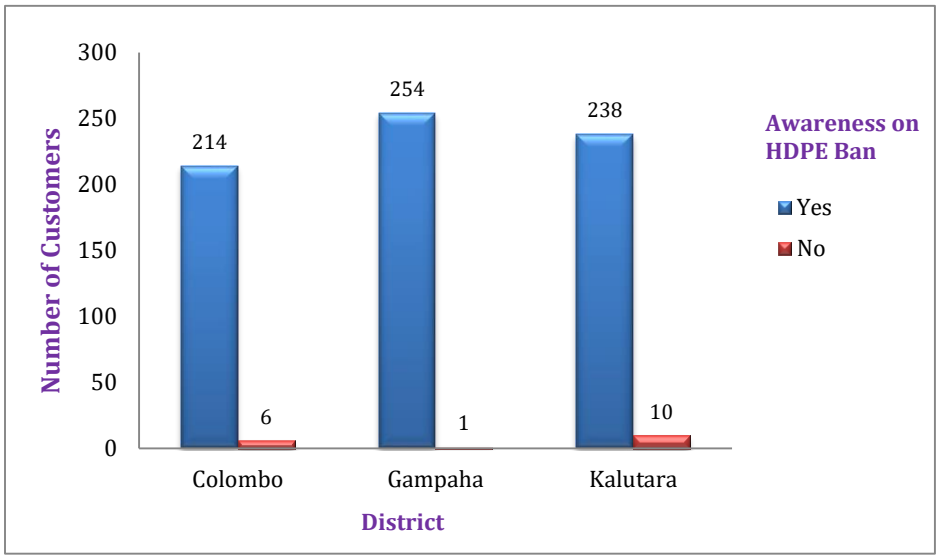


Source: Field Survey, 2018

Figure 4.6: Households' Perception on PBLS Ban based on Alternatives

4.2.2 Customer Awareness on PBLS Ban

According to descriptive statistics, 98 percent of customers had been educated on HDPE ban. Figure 4.7 illustrates this.

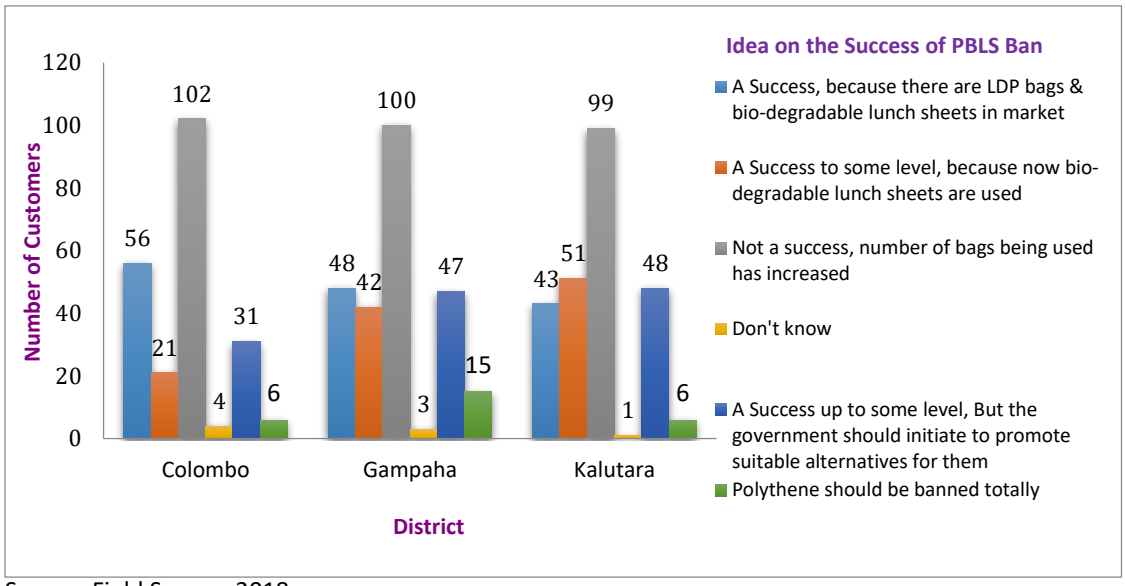


Source: Field Survey, 2018

Figure 4.7: Customer Awareness on PBLS Ban in each District

4.2.3 Customer Perception on the Success of PBLS Ban

Under this, customer perception on the success of PBLS ban has been considered based on the districts. According to descriptive statistics, 42 percent of customers said that PBLS ban is not a success, as the number of bags used has risen (after the ban). The inferior strength of the newer grocery bags had resulted in an apparent increase in polythene bag use and the higher price of alternative products for grocery bags and lunch sheets has made the shift to eco-friendlier options less attractive. As well, 18 percent of customers said the ban is not realistic due to unavailability of suitable alternatives. Altogether 60 percent of customers claimed that the PBLS ban is not a success. Only 20 percent of customers admitted that it is a success, as they start using LDPE bags and bio-degradable lunch sheets (Figure 4.8).

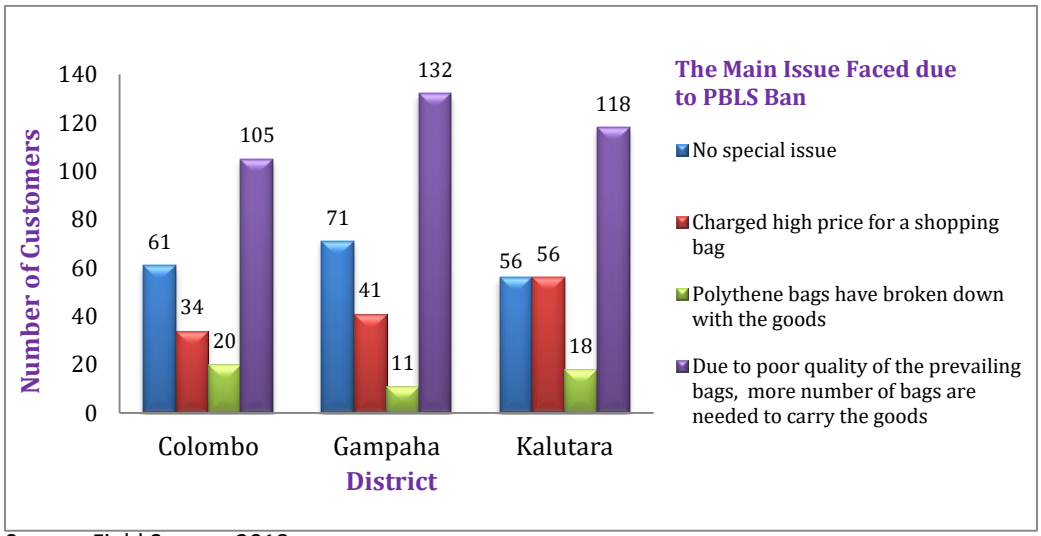


Source: Field Survey, 2018

Figure 4.8: Customer Perception on the Success of PBLS Ban Based on Districts

4.2.4 Main Difficulties Faced by Customers following PBLS Ban

Here, the main issue faced by each respondent following the PBLS ban in respective district was identified. Accordingly, half the respondents said that the use of bags has increased due to the poor strength of the bags. Around 18 percent of customers said they had to pay a high price for the prevailing bags while six percent claimed they were embarrassed sometimes as the polythene bags easily broke down with the goods. Anyhow, 26 percent of customers said they did not face any such issue. Figure 4.9 illustrates their responses.

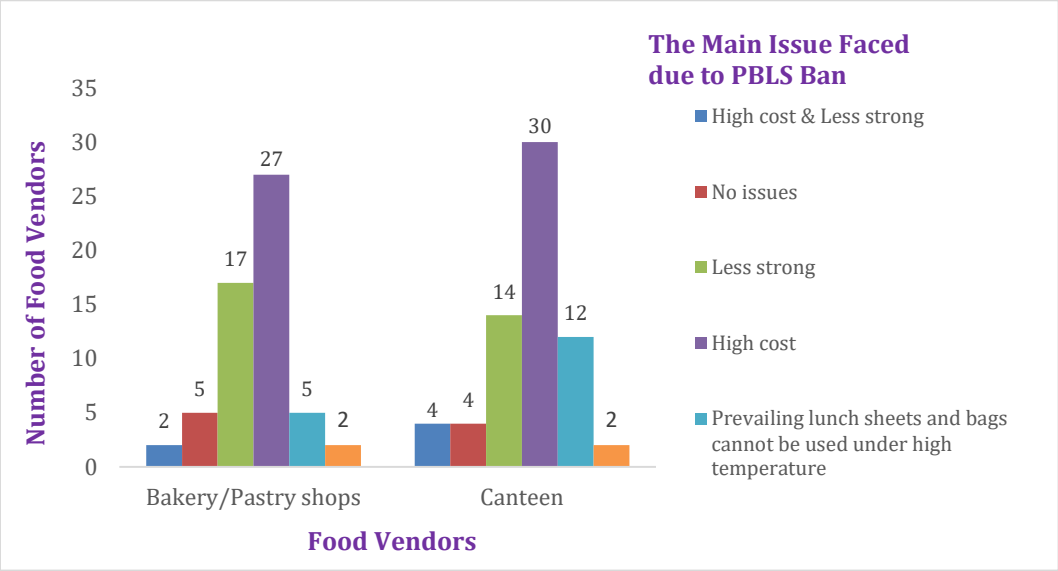


Source: Field Survey, 2018

Figure 4.9: Main Difficulties Faced by Customers following PBLS Ban

4.2.5 Main Difficulties Faced by Food Vendors following PBLS Ban

Under this, the main issue faced by food vendors following PBLS ban has been considered. Accordingly, 46 percent of food vendors claim that the prevailing PBLS are expensive. Besides, one fourth of the food vendors state that the quality of the prevailing alternatives is poor. At the same time 14 percent vendors complain that the heat resistant quality of the prevailing PBLS is poor (Figure 4.10).



Source: Field Survey, 2018

Figure 4.10: Difficulties Faced by Food Vendors following PBLS Ban

According to the literature and the polythene manufacturers, HDPE bags' strength and recyclability rate is higher than the LDPE. Also, its production cost is low. When the study was conducted, the reason for replacing HDPE by LDPE was inquired from few government officials. According to them, the main objective of this was distancing the consumers from using polythene owing to the poor quality of the LDPE bag. On the contrary the study reveals that stakeholders' demand has not changed much.

4.2.6 Main Difficulties Faced by Lanka Sathosa due to PBLS Ban

A Senior Trade and Marketing Manager of Lanka Sathosa stated that more expenses are incurred now than before the ban to buy LDPE shopping bags. Hence, he mentioned that due to the inferior quality of LDPE shopping bags the customers ask for more bags now as the bags cannot hold much weight and tends to tear off easily.

4.2.7 Polythene Manufacturers' Perception on PBLS Ban

According to the polythene manufacturers, although large-scale factories comply with the polythene law, it is difficult to control the production of unregistered domestic industrialists. In addition, lunch sheets, produced by LDPE polythene released to the market in the name 'biodegradable' tag is another problem that is yet to address. On the other hand, bio-degradable additives are costly. Therefore, producers tend to use less amount of additives, which would lead to less effectiveness of degradable material. Besides, when interviewed the polythene manufactures they held that the government should have discussed the matter (ban) with them before enforcing.

Further, according to former Chairperson, Anura Wijethunga of All Ceylon Polythene Manufacturers and Recyclers Association, shopping bags and lunch sheets have become an essential commodity in today's busy life. Therefore, with the laws imposed on polythene shopping bags and lunch sheets, customers as well as the polythene manufacturers are in an embarrassing situation. However, abiding by the law they have now converted the machinery in their factories to make LDPE. However, according to him unlicensed HDPE polythene products are rampant in the market a reason that hinders consumers from buying LDPE at a higher cost.

Due to the government banned polythene bags and lunch sheets and promoted biodegradable methods, a cess tax of 15 percent was charged from plastic importers for the plastic raw materials to discourage polythene importation. Therefore, members of the All Ceylon Polythene Manufacturers and Recyclers Association have imported 600 tons of biodegradable polythene raw material in to the country by the end of May 2018 minimizing importation of polythene. Here, they have paid Rs. 700,000.00 per a ton. Nevertheless, according to him, demand for biodegradable polythene products is minimum as the market is flooded with bogus HDPE. Also, the scent of these biodegradable lunch sheets stocks have attracted mice, cockroaches and animals. Moreover, he stressed the need for a proper waste management system for polythene in Sri Lanka in place of polythene ban.

4.2.8 All Ceylon Canteen Owners' Perception on PBLS Ban

Mr. Asela Sampath, President of the Sri Lanka Canteen Owners Association charged that following the ban a bio-degradable lunch sheet was introduced but with poor discrimination. Consequently, most traders were tempted to sell LDPE lunch sheets in the guise of biodegradable lunch sheets at a high price in the market. So he stressed the need for a mechanism to identify the genuine biodegradable lunch sheets.

4.2.9 Industrial Development Authority's Perception on PBLS Ban

Mr. B.K. Tharanga of the Industrial Development Authority said that polythene shopping bags and lunch sheets had been promoted as a small-scale industry by their institution.

Hence, industrialists were facilitated to obtain bank loan facilities to uplift their industries. However, owing to the ban, the small industrialists had been severely inconvenienced with the case of HDPE polythene shopping bags and lunch sheets. Since the Authority encouraged the small-scale industries to promote polythene related products by no means they can help the law enforcing authorities to nab the culprits who violate the ban. However, the bank has stopped issuing loans to discourage the small-scale polythene manufacturers to support the law. He also said they direct them to take up alternative livelihoods as much as possible.

4.3 Prevailing and Potential Alternatives for PBLS

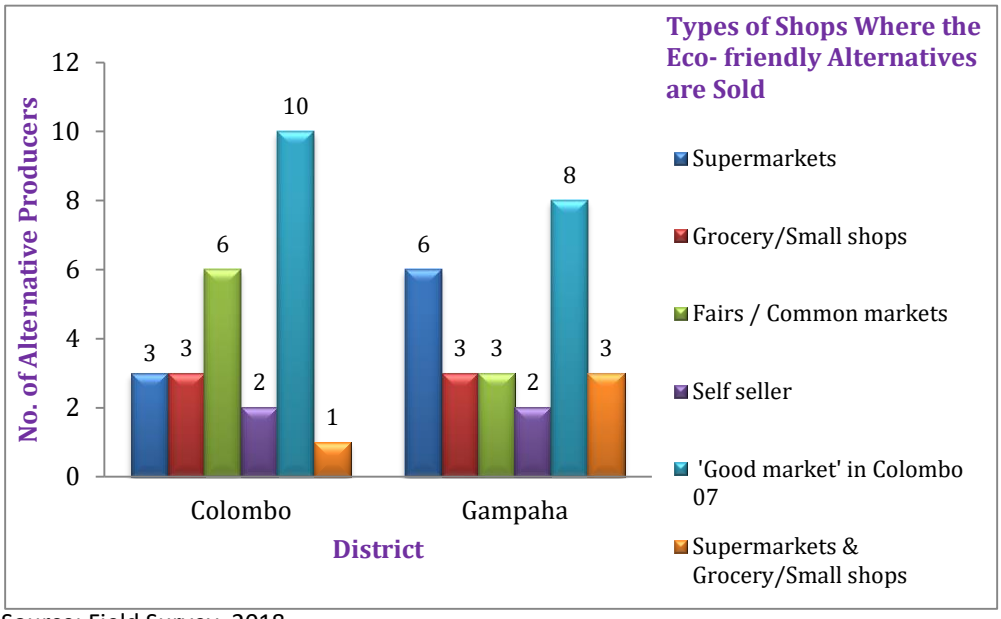
This study found the prevailing and possible alternatives for polythene products in Sri Lanka and weaknesses in identification of alternatives. Although consumers use banana leaves, lotus leaves and other types of leaves instead of lunch sheets, there is no sufficient supply for the current demand. In the meanwhile, Dr. Sujatha Weerasinghe a lecturer of the University of Colombo conducted study applying bio technology to produce banana leaves in a large area to wrap food while gaining a bumper harvest (Source: HARTI Survey data of this Study, 2018). Therefore, amenable officers should promote such programmes. Moreover, the research team visited National Craft Council, Pelawatta twice at the initial stage of the study (May 2018) as well as at the latter stage of the study (January, 2019) to observe that a few projects producing eco-friendly alternatives for polythene products were a foot in the latter visit.

Kolapath Plates/Plates Made of Arecanut Leaves and Lunch Boxes

Mr. Ananda of the National Craft Council revealed, there are kolapath plates and lunch box suppliers registered with the National Craft Council. Besides, they have ability to supply these products in mass quantity and kolapath plate price is starting from Rs. 10.00. At that time, they have been put in supermarkets for trial. According to him the products can be reused for a month.

Places to Purchase Eco-friendly Alternatives

According to eco-friendly alternative producers, if consumers want to buy the products, with the help of supermarkets, grocery/small shops, fairs /common markets, producers' own place they can fulfill their requirement. That means producers have chosen those channels to sell their productions and Figure 4.11 below shows the scale of the products in different markets.



Source: Field Survey, 2018

Figure 4.11: Eco-friendly Alternative Shops

4.4 Stakeholders' Perception on Alternatives

4.4.1 Households' Perception on Alternatives

Based on the key informant interviews and discussion conducted with the experts in the field, five important attributes related to alternatives for polythene products were derived. Key attributes are: basic material used to produce the product, usability of the product, relative recyclability of the product, availability of the product and price of the product. Accordingly, four basic materials were also identified as material derived through plant and biomass, recyclable plastics, paper base and cloth base. Usability was defined as frequency of using the product: one-time usage and several times usage. For recyclability again two levels: 75 percent recyclability and 100 percent recyclability was derived. Availability of the product was defined as relative accessibility to the product at two levels: only from retail shops and only from supermarkets was derived.

Table 4.4: Conditional Logit Estimates for Alternatives

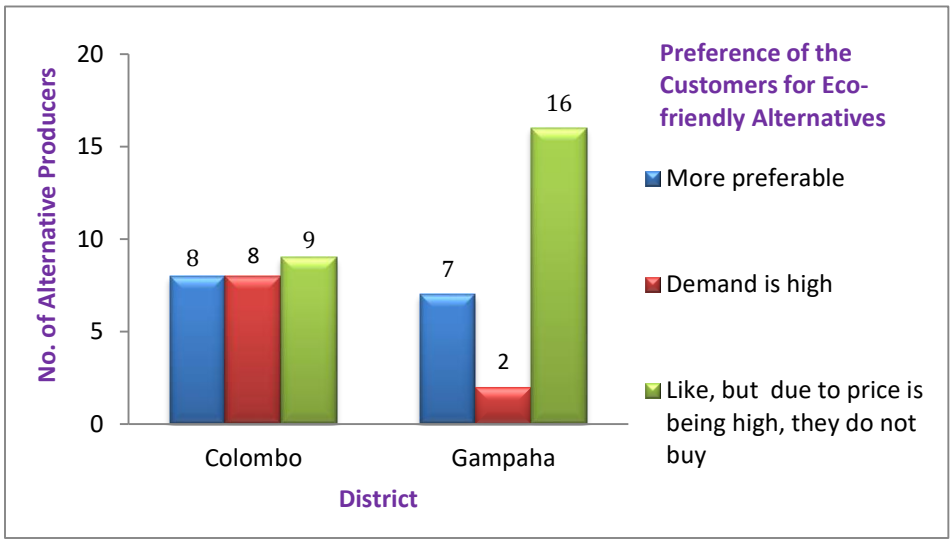
Variables	Coefficient	P-Value
Use of recyclable plastic	-0.177	0.568
Paper base	0.081	0.797
Cloth base	0.740**	0.023
Usability	-0.061	0.568
Recyclability	-0.029	0.929
Availability	-0.229	0.483
Price of the product	1.06e-12***	0.010

***Significant at 1% level, **Significant at 5% level, *Significant at 10% level
Source: Field Survey, 2018

According to the conditional logit estimates, respondents' willingness was placed only for the material which the alternative was made and the price is at 95 percent confidence level. All other attributes: usability, recyclability and availability was not significant at 95 percent confidence level. Interestingly, respondents are willing to use an alternative product made of fabric. Also, respondents have placed relatively a low price for the alternative. Hence, it is envisaged that, new alternative products should be manufactured using cloths and when pricing, it is suitable to place relatively low or penetration price for that alternative product. Penetration pricing is a pricing strategy where the price of a product is initially set low to rapidly reach a wide fraction of the market and initiate word of mouth. Through penetration price more customers may switch to that product promptly. This would be the best strategy to promote as well as attract households to use these types of products.

4.4.2 Alternative Producers View on Customers' Purchasing Behaviour on Alternatives

Various responses received when asked about the buying behaviour of the customers of eco-friendly alternatives by producers. According to the producers, every person wishes to use alternatives. But, half of the producers stated although customers wish to buy the alternatives, the high price, stay them away from buying. It is illustrated in Figure 4.12.

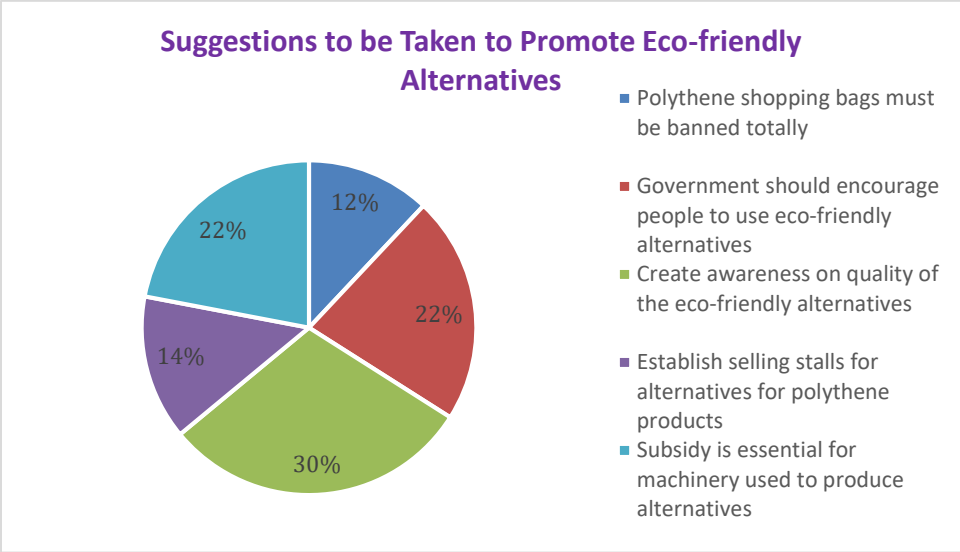


Source: Field Survey, 2018

Figure 4.12: Alternative Producers' View on Customers' Purchasing Behaviour towards Alternatives

4.4.3 Alternative Producers' View on Promotion of Eco-friendly Alternatives

Producers' view on promotion the eco-friendly alternatives were questioned. Then, 12 percent stated that polythene shopping bags must be banned totally while another 22 percent held the view that government should encourage people to use eco-friendly alternatives. As well, 30 percent expressed that people should be educated on the quality of the eco-friendly alternatives while 14 percent stated stalls for selling alternatives for polythene products should be established. Moreover, the rest 22 percent said a subsidiary is essential for machinery used to produce alternatives.



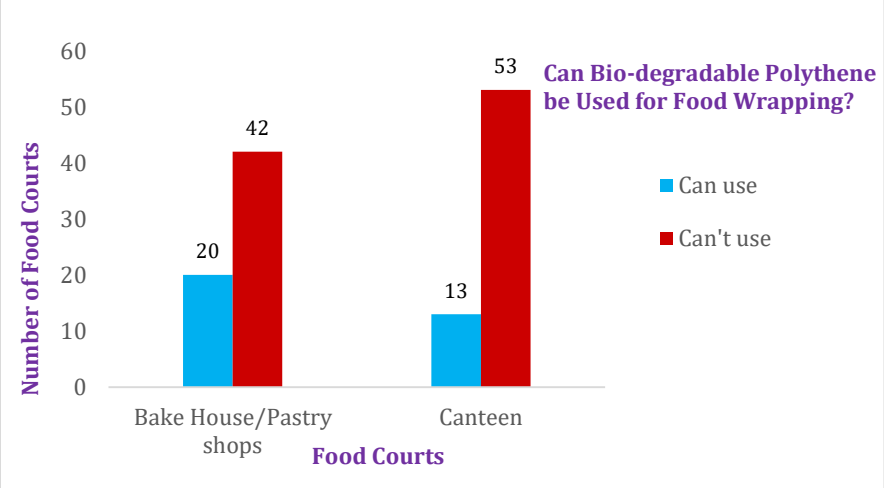
Source: Field Survey, 2018

Figure 4.13: Suggestions to Promote Eco-friendly Alternatives

An official in CEA informed that the government has taken steps to promote production of lunch sheets, which are biodegradable as alternatives to the banned polythene. According to him, the Central Environmental Authority has requested the government to grant tax concessions to import raw materials to produce biodegradable polythene shopping bags and lunch sheets. Further, he mentioned that if traditional polythene manufacturing factories are converted to ones that make biodegradable polythene, they are to be provided 50 percent concession for machinery repairs. Accordingly, polythene manufacturers should be paid for the machines they possessed. According to the manufacturers, cost per machine is around Rs. 400,000.00. However, when inquired about on the situation about the concession from polythene manufacturers by February 2019, they informed they were paid only Rs. 200,000.00 (Irrespective of the number of machines) instead of the above concession for repairs. Therefore, they were disappointed over the relevant government officials especially in the CEA. In addition, he informed that the government is planning to impose more taxes on imported raw materials for polythene production.

Similarly, according to a senior officer in the Sri Lanka Standards Institution, standards have been outlined to produce biodegradable and composting polythene by now. Therefore, the Institution provides the CEA with an opportunity to check the quality of imported raw materials and the quality of production. However, according to him, although the government is offering such relief the industrialists are not interested in producing biodegradable polythene. The Institute had granted approval to 16 individuals to import biodegradable polythene materials by end of May 2018. In addition, only six to seven industrialists have handed over applications to obtain the standards of biodegradable polythene manufacturing.

4.4.4 Food Vendors' Perception on Alternatives



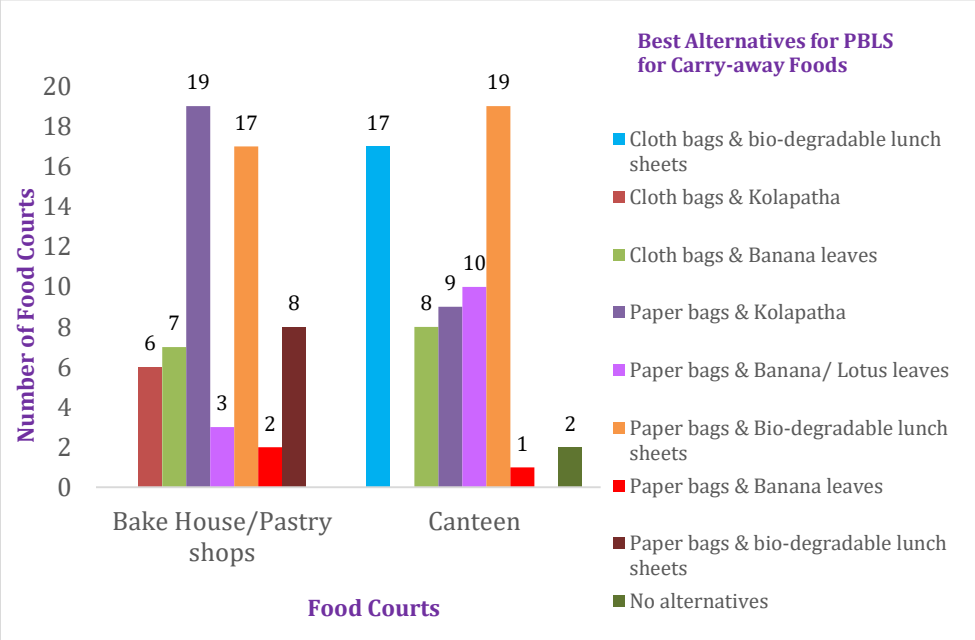
Source: Field Survey, 2018

Figure 4.14: Food Vendors' Perception on Alternatives

Here, suitability of bio-degradable polythene for food wrapping in food courts has been questioned. Accordingly, around 74 percent of food vendors (canteen owners and bakery owners) said it is difficult to use bio-degradable polythene in food wrapping.

4.4.5 Food Vendors' Perception on the Best Alternatives for PBLS

Here, best eco-friendly alternatives for PBLS have been identified. Food vendors' perception on them have been noted down and Figure 4.15 in detail.

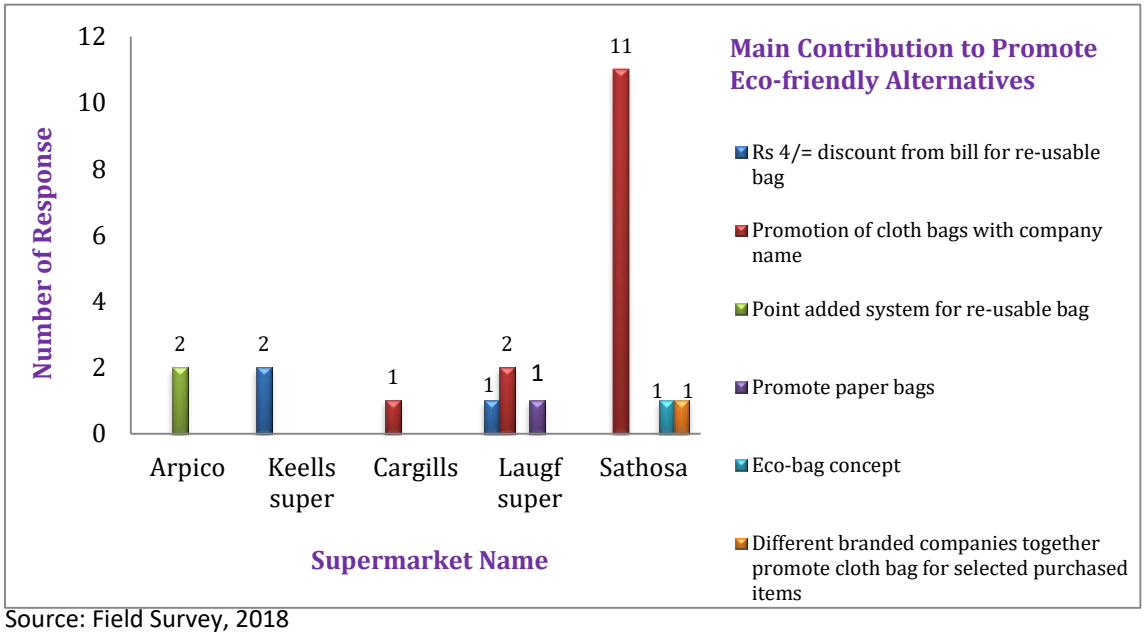


Source: Field Survey, 2018

Figure 4.15: Food Vendors' Perception on the Best Alternatives for PBLS

4.4.6 Main Contribution of Supermarket Chains to Promote Eco-friendly Alternatives

Under this, supermarket chains' main contribution to promote eco-friendly alternatives was investigated. Accordingly, 64 percent of supermarkets have promoted the cloth bags with its name printed on it while 14 percent of supermarkets award four-rupee discount from the total bill for a reusable bag. Figure 4.16 shows the responses.

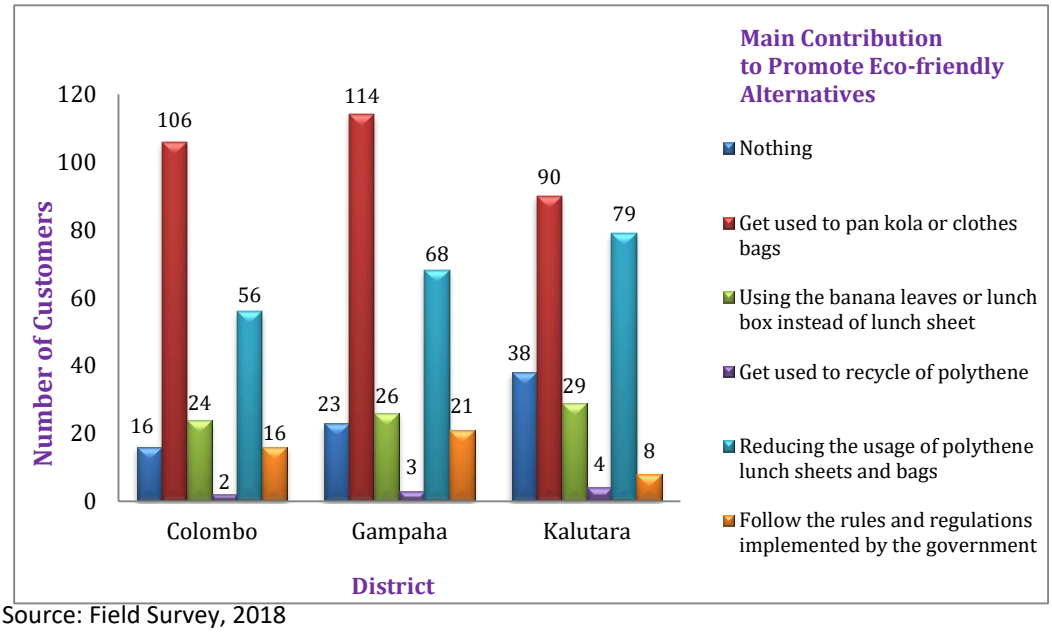


Source: Field Survey, 2018

Figure 4.16: Main Contribution of Supermarket Chains to Promote Eco-friendly Alternatives

4.4.7 Main Contribution of Customers to Promote Eco-friendly Alternatives

Here, customers' main contribution to promote eco-friendly alternatives in each district has been noted. Accordingly, 11 percent of customers were not following any practices to promote eco-friendly alternatives. Figure 4.17 shows the responses in detail.

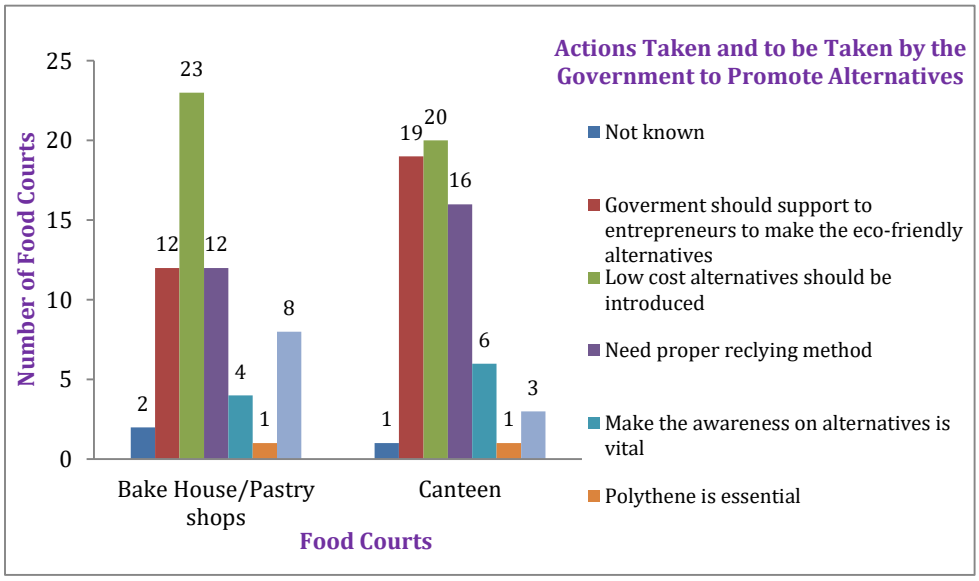


Source: Field Survey, 2018

Figure 4.17: Main Contribution of Customers to Promote Eco-friendly Alternatives

4.4.8 Views of Food Vendors on Promoting Eco-friendly Alternatives

Here, food court owners have expressed their views on promotion of eco-friendly alternatives (Figure 4.18). Accordingly, 34 percent of food court owners called for low cost alternatives while 24 percent of food court owners from total expressed that the government should support entrepreneurs to make eco-friendly alternatives.

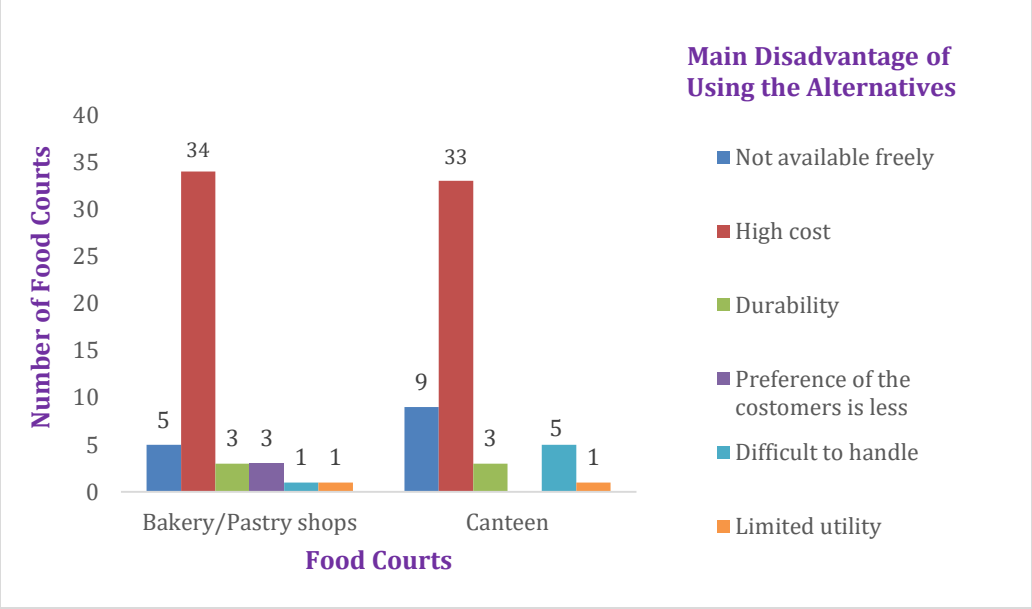


Source: Field Survey, 2018

Figure 4.18: Views of Food Vendors on Promoting Eco-friendly Alternatives

4.4.9 Main Obstacles Faced by Food Vendors when Using Alternatives

There are few eco-friendly alternatives in our country, but due to various issues stakeholders refrain from using them. The main constraint in using the alternatives as per the food court owners was the high cost (68 percent). Thirteen percent of food court owners pointed out the free availability as an issue. Figure 4.19 illustrates the constraints in using eco-friendly alternatives.

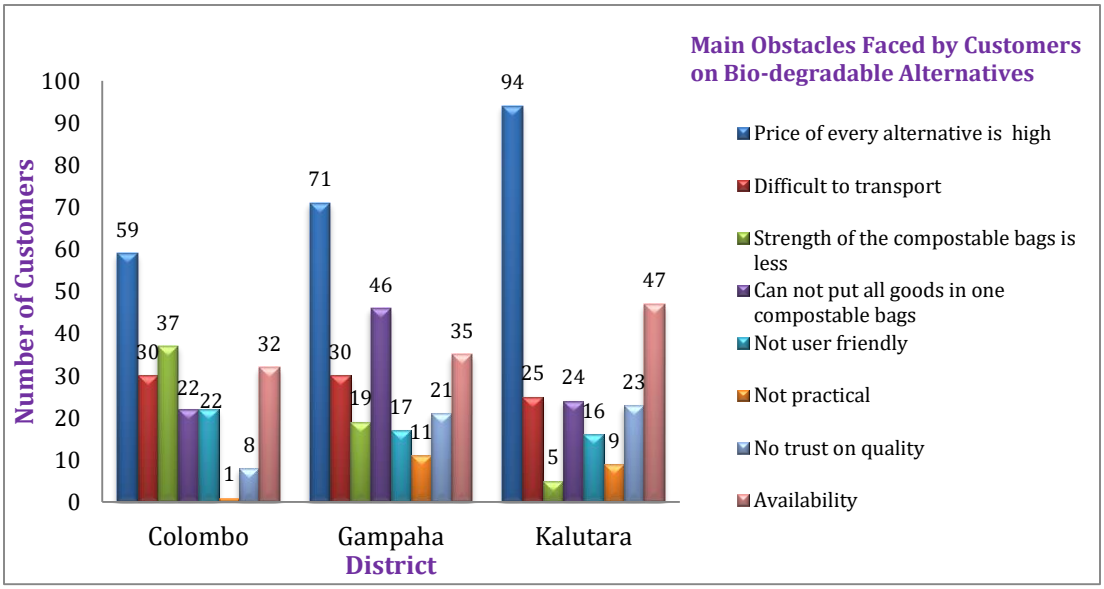


Source: Field Survey, 2018

Figure 4.19: Main Obstacles Faced by Food Vendors when Using Alternatives

4.4.10 Main Obstacles Faced by Customers when Using Alternatives

Here, the main obstacle faced by customers when biodegradable alternatives are used in each district was in focus. Accordingly, majority of customers (32 percent) said that the price of every alternative is high. Figure 4.20 shows the responses.

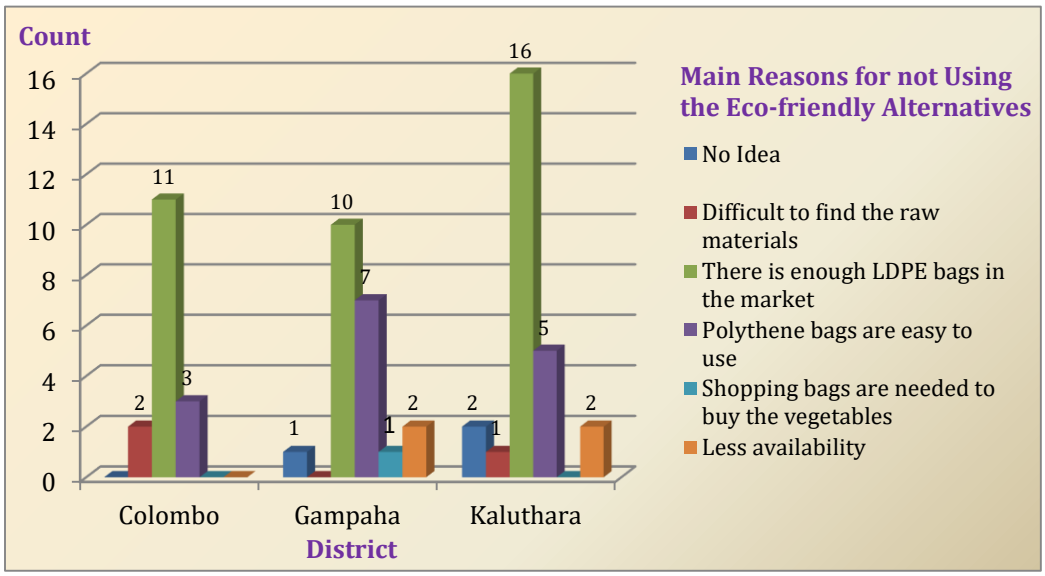


Source: Field Survey, 2018

Figure 4.20: Main Obstacles Faced by Customers when Using Alternatives

4.4.11 Main Reason for not Using the Eco-friendly Alternatives by Households

The main reason for not using the eco-friendly alternatives in each district has been identified. Accordingly, majority of households (59 percent) said the free availability of LDPE bags in the market discouraged them to switch to alternatives. Besides, 24 percent expressed that 'polythene bags are easy to use'. Five percent of households claimed the less availability of alternatives as reason not to use the alternatives. See Figure 4.21.



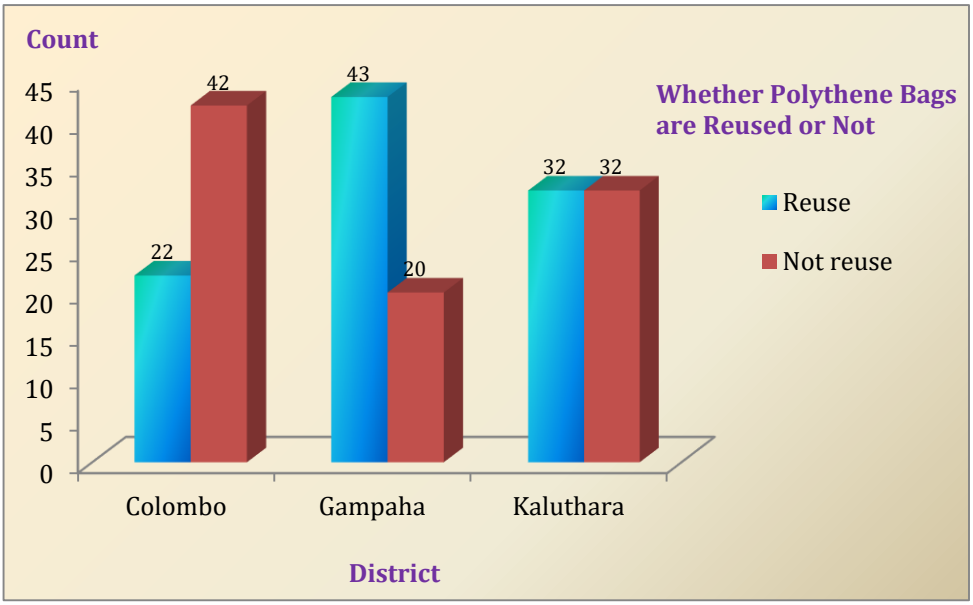
Source: Field Survey, 2018

Figure 4.21: Main Reasons for not Using Eco-friendly Alternatives by Households

4.5 PBLS-Current Availability in the Market

4.5.1 Households' Behaviour on Polythene Bag Usage

Under this, households' behaviour on polythene bag usage in each district has been considered. According to descriptive statistics, 51 percent of households have got used to reuse the plastic bags while 49 percent have not.

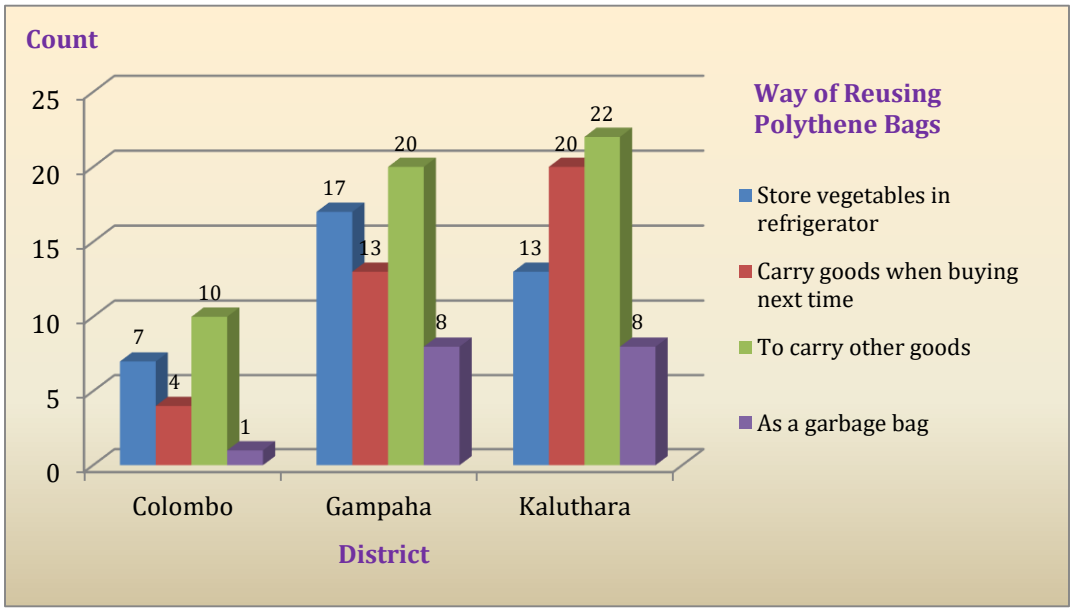


Source: Field Survey, 2018

Figure 4.22: Households' Behaviour on Polythene Bag Usage

4.5.2 Households' Behaviour on Reusing Polythene Bags

Households' behaviour on reusing the polythene shopping bags in each district has been shown. According to descriptive statistics, 36 percent of households have got used to reuse the plastic bags to carry other goods while 26 percent of households have got used to store vegetables in the refrigerator. Moreover, another 26 percent of households use them to carry goods when buy things the next time while 12 percent of households use them as a garbage bag. See Figure 4.23.

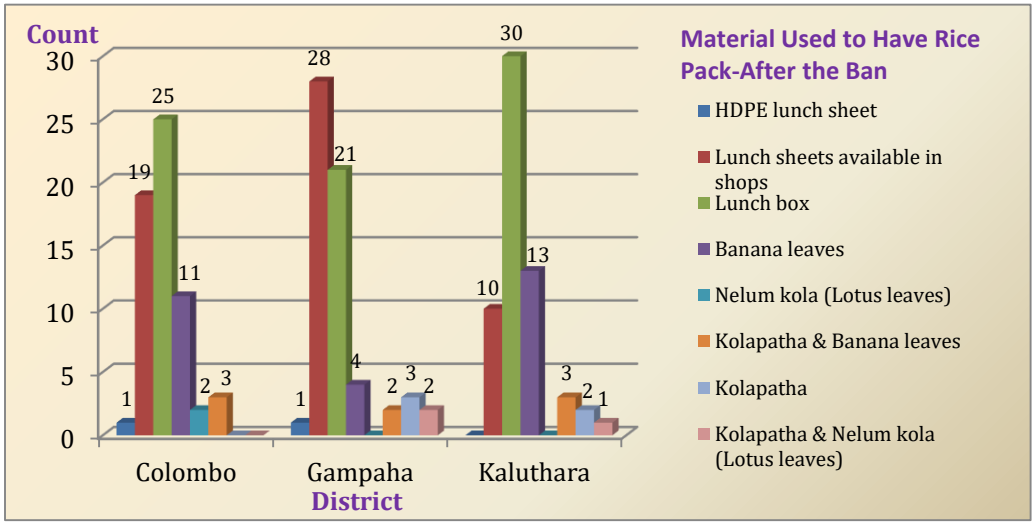


Source: Field Survey, 2018

Figure 4.23: Households' Behaviour on Reusing Polythene Bags

4.5.3 Main Material Used by Households to Wrap Meals

Under this, main material used by households to wrap meals has been identified. According to descriptive statistics, after the ban, 42 percent of total households said they use lunch boxes while 32 percent of total households said they use lunch sheets available in the market. Moreover, 15 percent of the total households have opted for banana leaves. Only one percent said they use lunch sheets made from HDPE. Despite their claim, it is hard to distinguish the HDPE lunch sheet from that is made off bio-degradable material. See Figure 4.24 for further details.

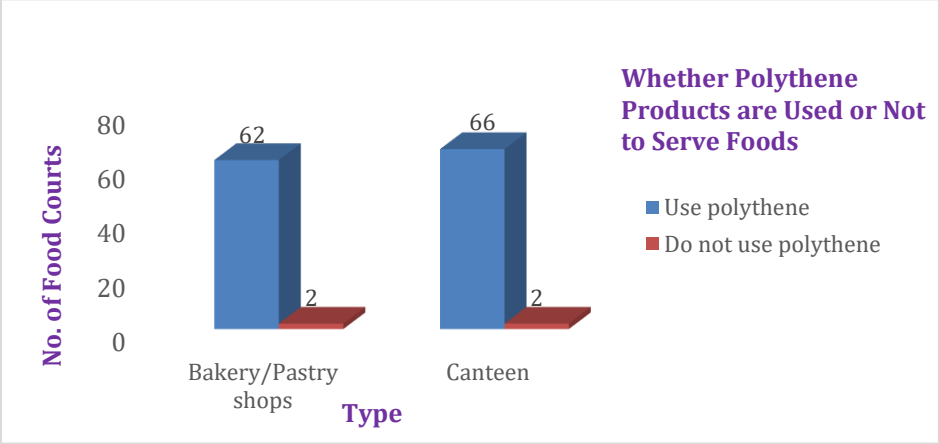


Source: Field Survey, 2018

Figure 4.24: Main Material Used by Households to Wrap Meals

4.5.4 Food Vendors' Behaviour towards Polythene Usage

Here, 97 percent of both bake houses/pastry shops and canteens use polythene to serve foods. The usage of polythene by food vendors is given in Figure 4.25.

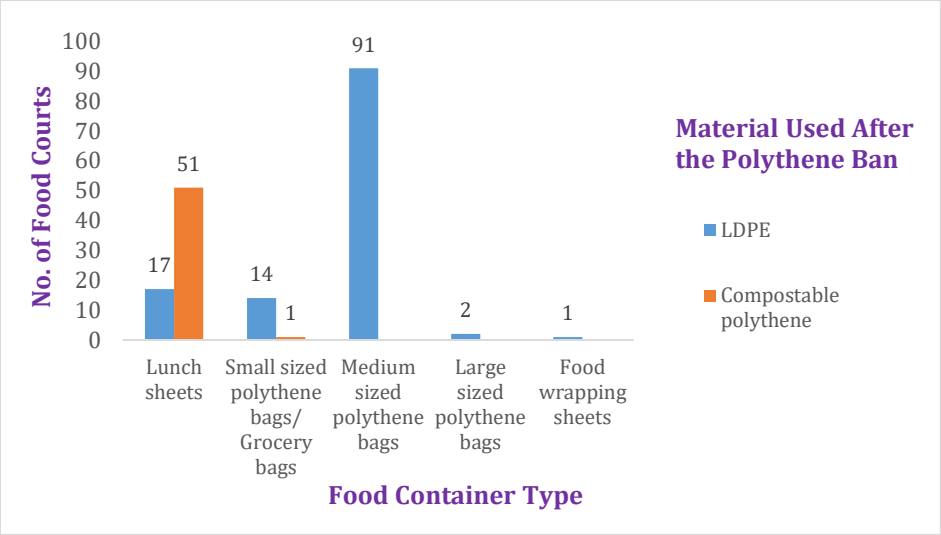


Source: Field Survey, 2018

Figure 4.25: Food Vendors' Behaviour towards Polythene Usage

4.5.5 Material of Each Food Container Used by Food Vendors

According to descriptive statistics, a quarter of food vendors still use the LDPE lunch sheets to wrap the foods. It was confirmed by checking the number of lunch sheet that were in store at that moment. Figure 4.26 illustrates the situation.

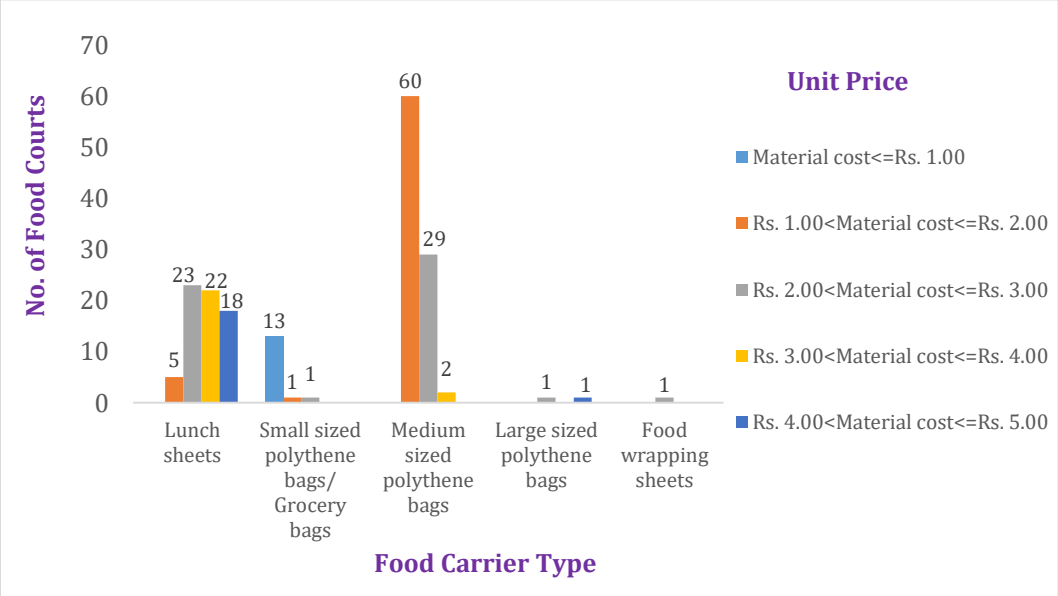


Source: Field Survey, 2018

Figure 4.26: Material of Food Wrapper/Bag Used by Food Vendors

4.5.6 Material Cost of Food Carriers (After the Ban) as per Food Vendors

The material cost of food carrier after the polythene ban and the number of places where those products are sold has been noted down in Figure 4.27.

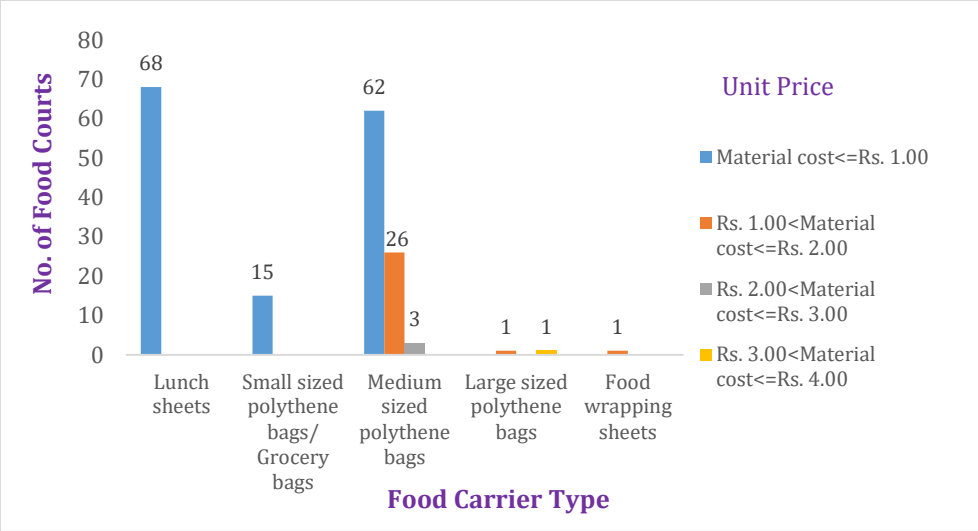


Source: Field Survey, 2018

Figure 4.27: Material Cost of Each Food Carriers (After the Ban) as per Food Vendors

4.5.7 Material Cost of Food Carriers (Before the Ban) as per Food Vendors

The material cost of food carrier before the polythene ban and the number of food courts where those products are sold has been illustrated in Figure 4.28.



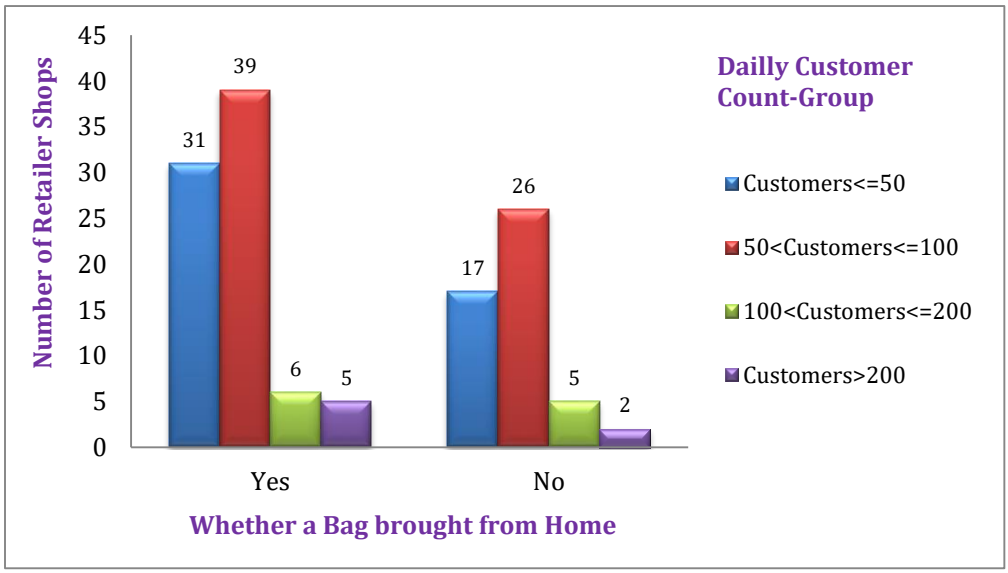
Source: Field Survey, 2018

Figure 4.28: Material Cost of Food Carriers (Before the Ban) as per Food Vendors

When considering the material cost per unit item of different food carriers before and after the ban, we can clearly identify that the price has increased in every category. For an example, earlier the price of a lunch sheet was less than a rupee whereas presently it has increased to five rupees.

4.5.8 Retailers' View on Customers

Daily customer count and whether the majority bring their own bag to carry the goods from the store has been identified. Accordingly, 62 percent of customers practise it while 38 percent do not. Moreover, among the retailer shops that practise is not observed, 52 percent of shops the daily customer count varies from 50 to 100 and 34 percent of shops the count is equal or less than 50. Figure 4.29 illustrates this situation.

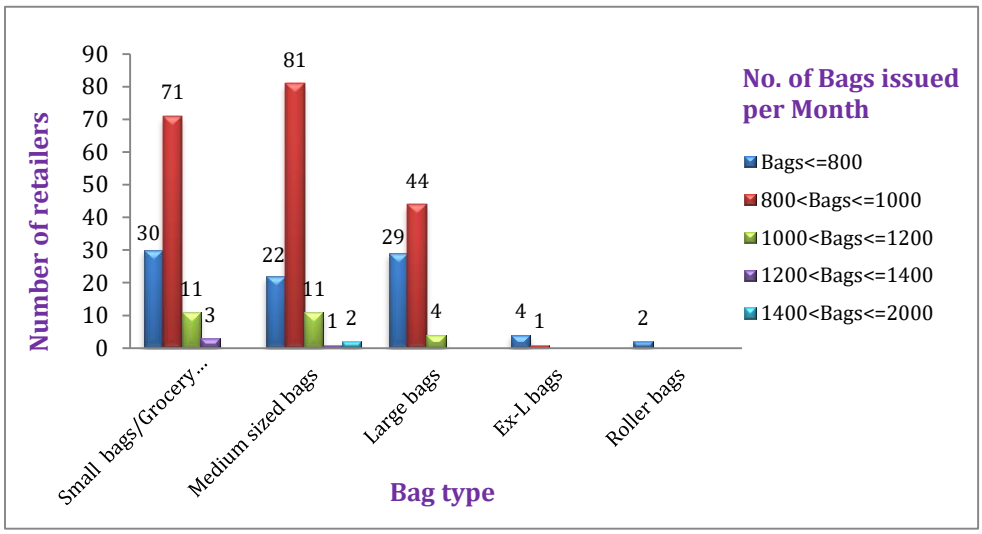


Source: Field Survey, 2018

Figure 4.29: Retailers' View on Customers

4.5.9 Types of Polythene Bags Used by Each Retailer Shops

Different types of polythene bags used by retailer shops per month have been recorded. According to descriptive statistics, 62 percent of retailers use 800 to 1,000 bags per month while 28 percent use similar number or less than 800 bags per month. This is shown in Figure 4.30.

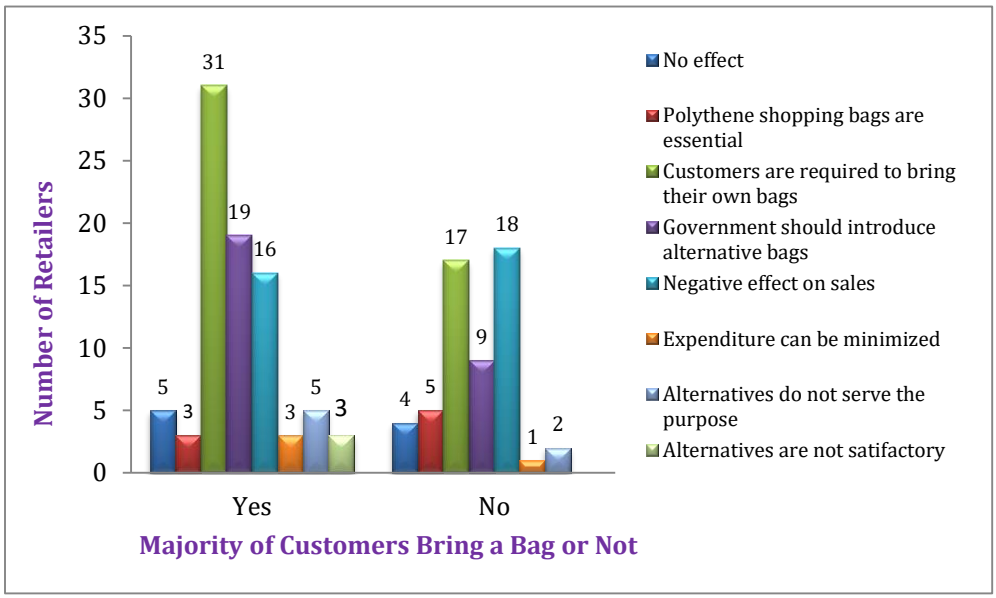


Source: Field Survey, 2018

Figure 4.30: Types of Polythene Bags Used by Retailer Shops per Month

4.5.10 Retailers' Perception on a Total Ban of Polythene Bags

According to descriptive statistics, 37 percent of retailers said that in the case of such a ban customers are required to bring their own bags. Another 21 percent of retailers held that the government should introduce alternative bags. Figure 4.31 demonstrates the different views.

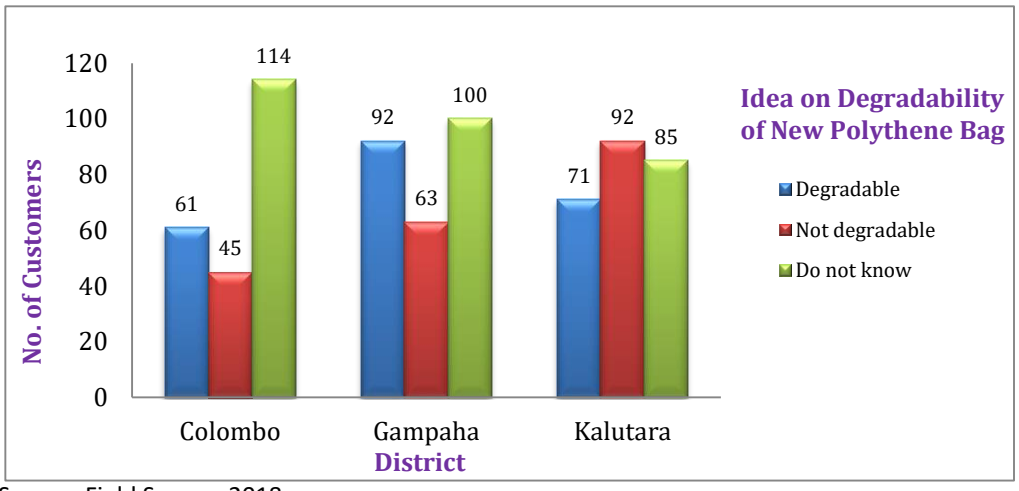


Source: Field Survey, 2018

Figure 4.31: Retailers' Perception on If a Full Ban of Polythene Bags is Enforced

4.5.11 Customer Perception on Degradability of New Polythene Bags

Under this topic, customers' perception on degradability of new polythene shopping bags in each district has been scrutinized. Accordingly, 31 percent of customers stated that new plastic bags are decomposable while 41 percent expressed doubt about their degradability. Altogether 72 percent do not have adequate knowledge on the degradability of new bags. This may give rise to the polythene bag usage of the customers (Figure 4.32).



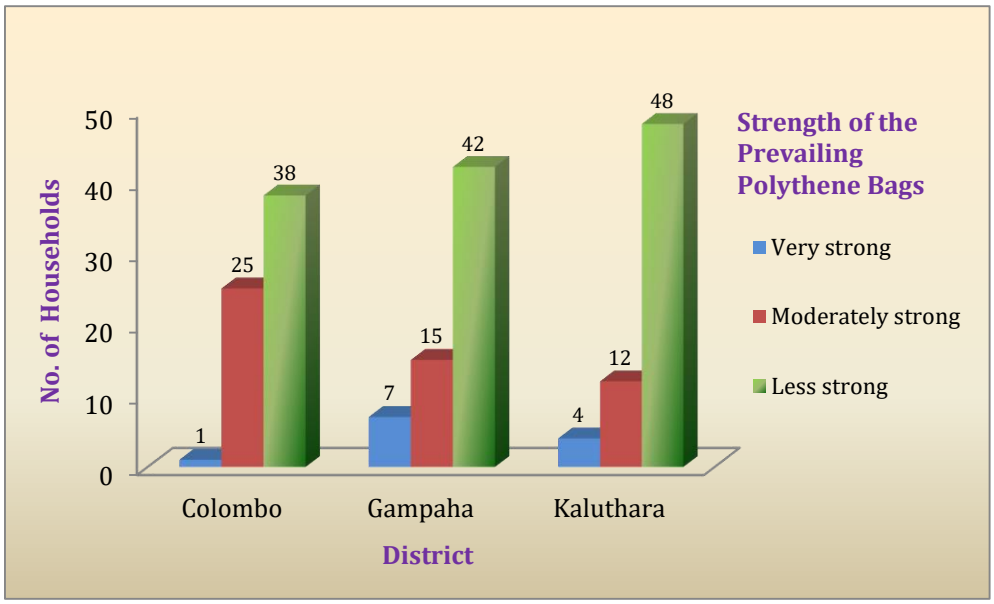
Source: Field Survey, 2018

Figure 4.32: Customer Perception on Degradability of New Polythene Bags

4.6 Positive and Negative Qualities of PBLS according to Relevant Stakeholders

4.6.1 Perception of Households on Strength of the Prevailing Bags

Households have expressed their perception on the strength of the prevailing bags in each district. Accordingly, 67 percent of households' perception on the new bag is its strength is poor and 27 percent claim that the strength is moderate. See Figure 4.33 for a detailed picture.

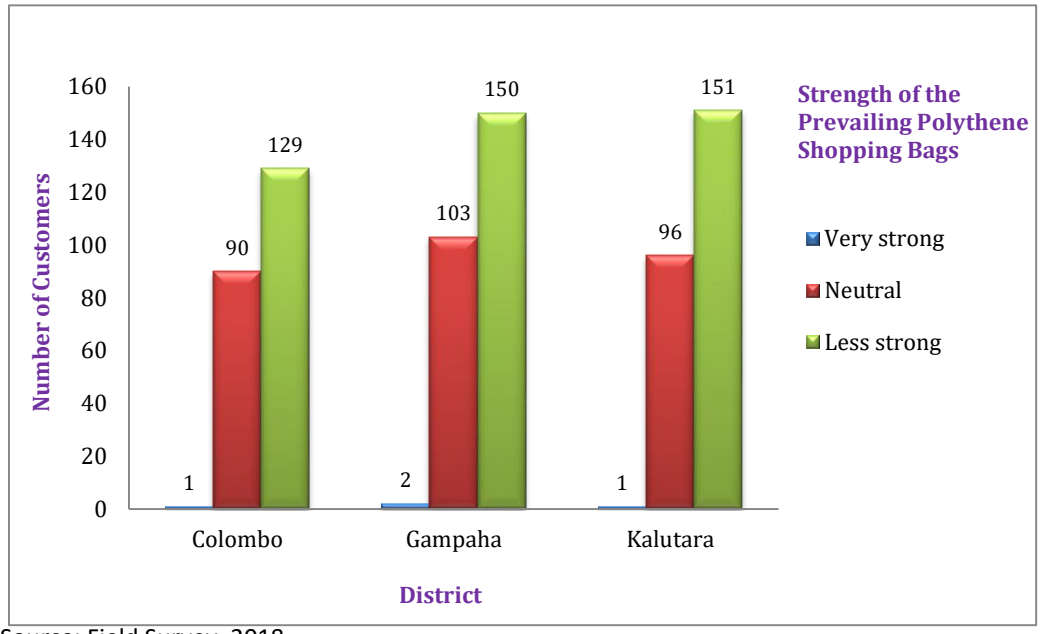


Source: Field Survey, 2018

Figure 4.33: Perception of Households on Strength of the Prevailing Bags

4.6.2 Perception of Customers on Strength of the Prevailing Bags

Customers' perceptions on the strength of the bags in each district have been noted. Accordingly, 60 percent of customers said the new bag's strength is poor. See Figure 4.34 for a detailed illustration.

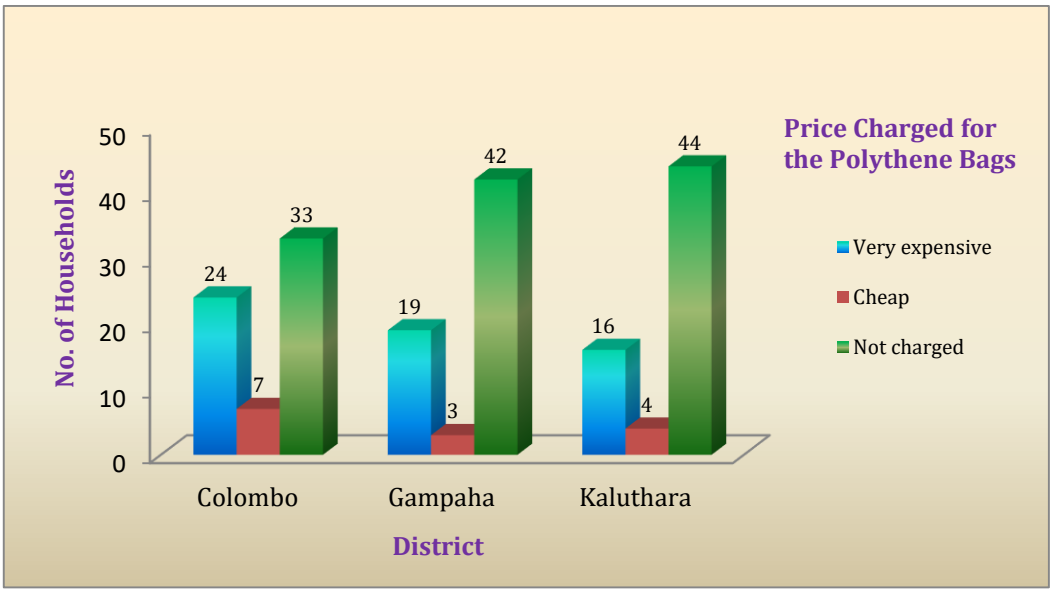


Source: Field Survey, 2018

Figure 4.34: Perception of Customers on Strength of the Prevailing Bags

4.6.3 Price Charged for the Bags

Whether households are charged for polythene bags when buying goods was considered. Accordingly, 62 percent of households responded in the negative.

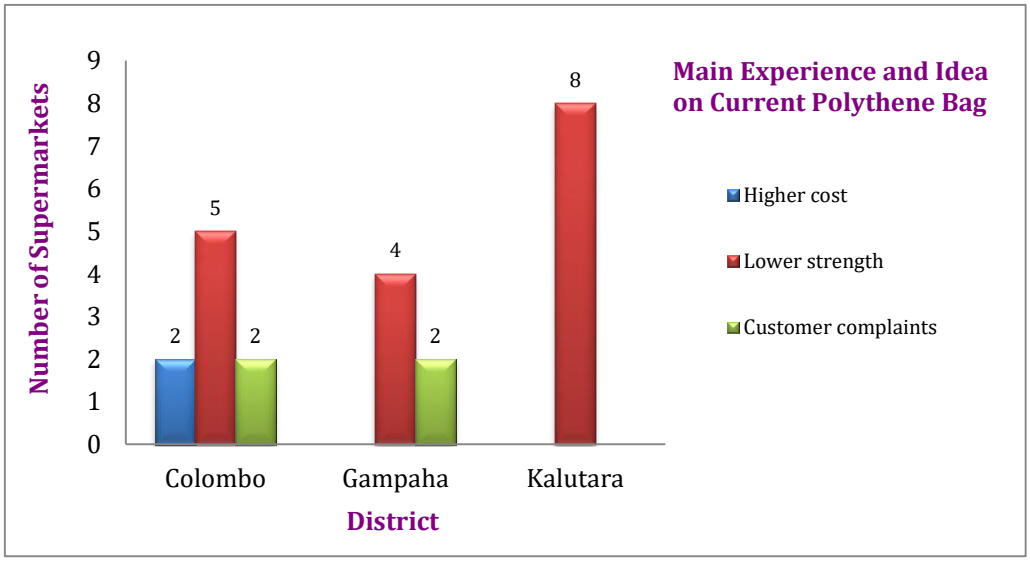


Source: Field Survey, 2018

Figure 4.35: Price Charged for the Bags from Households

4.6.4 Supermarket Chains' Main Experience and Idea on Current Polythene Bag

Supermarkets' experience and idea on current polythene bag was investigated. Accordingly, 74 percent of supermarket authorized persons said strength of the polythene bag which came after the ban is low. Similarly, 17 percent said that they received complaints from their customers on the bags. The remaining Nine percent said the cost of the current bag is high.



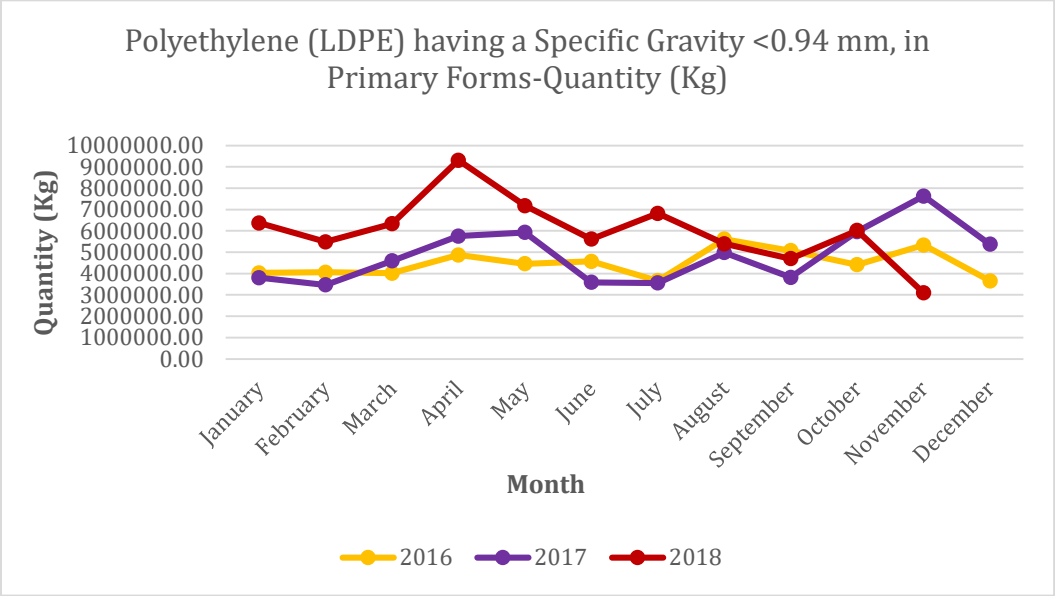
Source: Field Survey, 2018

Figure 4.36: Supermarket Chains' Main Experience and Idea on Current Polythene Bag

4.7 Details on Polythene Imported to Sri Lanka

The global production of plastic is currently estimated to be around 300 million tons per year, while plastic pollution in the marine environment alone is estimated to be around 9.5 million tons, with a staggering 1.5 million tons ending up in the ocean annually (The International Union for Conservation of Nature, 2018).

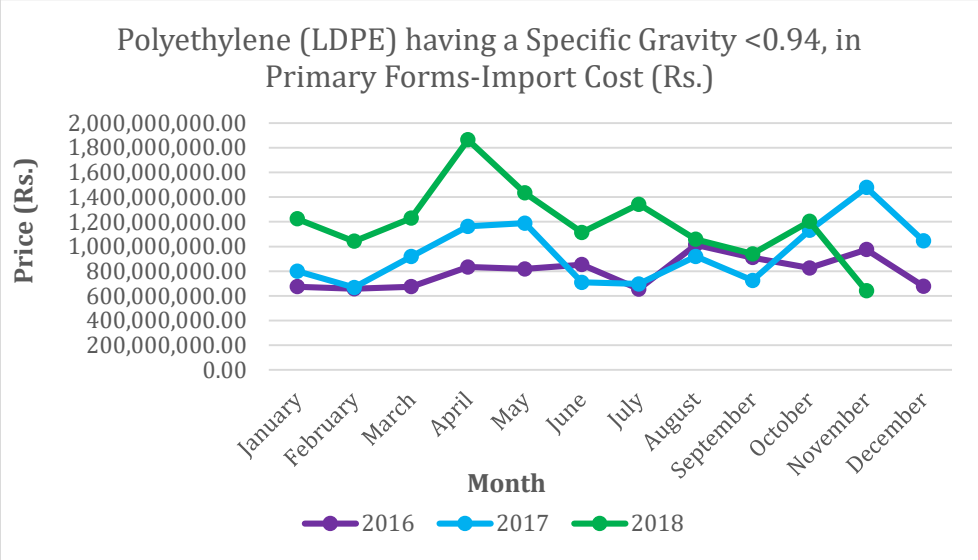
In this study, the quantity and the price of polythene (low density polythene and high density polythene) imported to Sri Lanka in the past three years was obtained from the Department of Customs and shown below. Specific gravity <0.94 mm denotes low density polythene while >=0.94 mm denotes high density polythene.



Source: Field Survey, 2018

Figure 4.37: Total Quantity of LDPE Imported to Sri Lanka in the Past Three Years

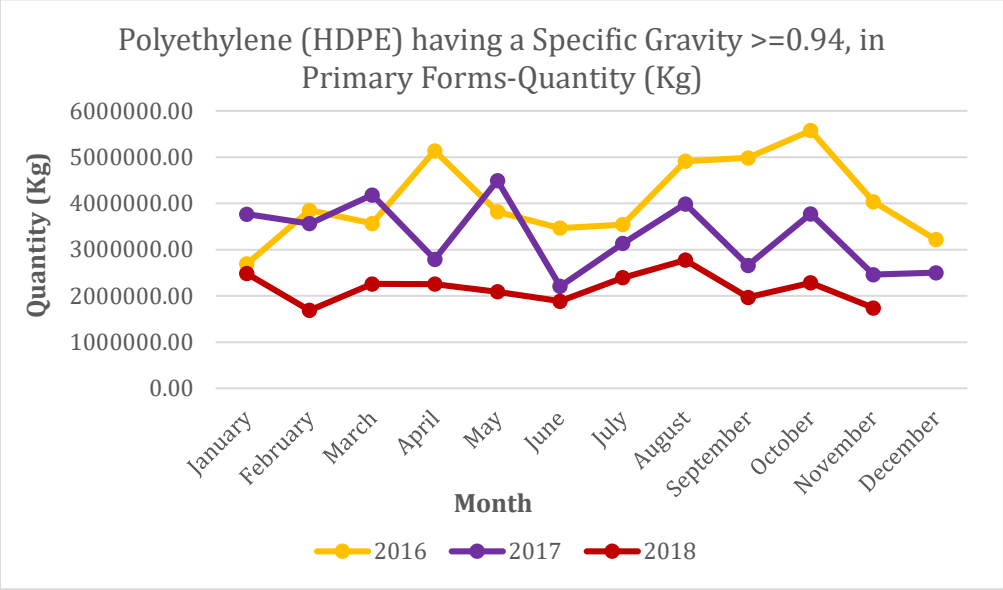
From the beginning of the November 2017 to end of the October 2018, Sri Lanka has imported around 76,500 Mt of LDPE. Besides, it is clear in that quantity of the LDPE every month has significantly increased in 2018 in comparison to previous years.



Source: Field Survey, 2018

Figure 4.38: Total Expenditure of LDPE Imported to Sri Lanka in the Past Three Years

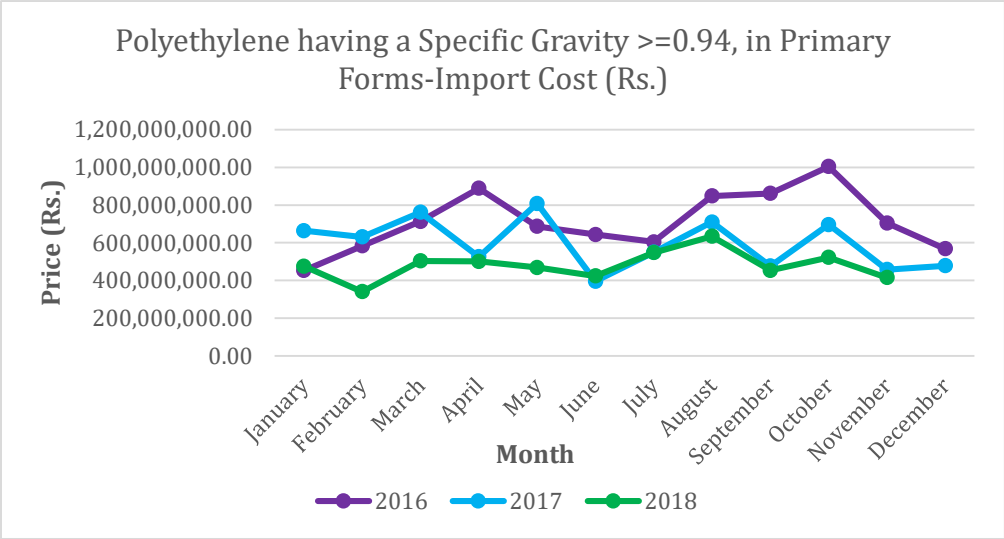
From November 2017 to end of October 2018, Sri Lanka has paid Rs. 15 billion on LDPE. Hence, it is clearly visible that the expenditure on LDPE every month has significantly increased in 2018 in comparison to previous years.



Source: Field Survey, 2018

Figure 4.39: Total Quantity of HDPE Imported to Sri Lanka in Past Three Years

From November 2017 to end of October 2018, Sri Lanka has imported around 27,500 Mt of HDPE and the quantity has significantly decreased in 2018 in comparison to previous years.



Source: Field Survey, 2018

Figure 4.40: Total Expenditure on HDPE Imported to Sri Lanka in Past Three Years

From November 2017 to end of October 2018, Sri Lanka has paid around Rs. 6 billion on HDPE. Thus, it is clear that the expenditure on buying HDPE every month has significantly decreased in 2018 in comparison to previous years.

It is clear that variation of the imported quantity of polythene and expenditures for them in many months has enhanced. In addition, average quantity and expenditure of the 14 plastic items (Acrylonitrile-butadiene-styrene (abs) copolymers- in primary forms, Ethylene-vinyl acetate copolymers- in primary forms, Expansible polystyrene-in primary forms, Other polymers, Other polymers of ethylene-in primary forms-nes, Other polymers of propylene or other olefins-in primary forms-nes, Polyethylene having a specific gravity <0.94-in primary forms, Polyethylene having a specific gravity >=0.94- in primary forms, Polyisobutylene-in primary forms, Polypropylene- in primary forms, Polystyrene (excl. expansible) - in primary forms, Propylene copolymers- in primary forms, Styrene-acrylonitrile (san) copolymers-in primary forms, Water based homopolymers and copolymers) imported to Sri Lanka in the past three years were quantified. Accordingly, Sri Lanka has imported around 184,000 Mt of plastic last year expending Rs. 38 billion. A Cess tax of 15 percent on the import of plastic raw materials and goods has been imposed by the Sri Lankan government to mitigate this situation.

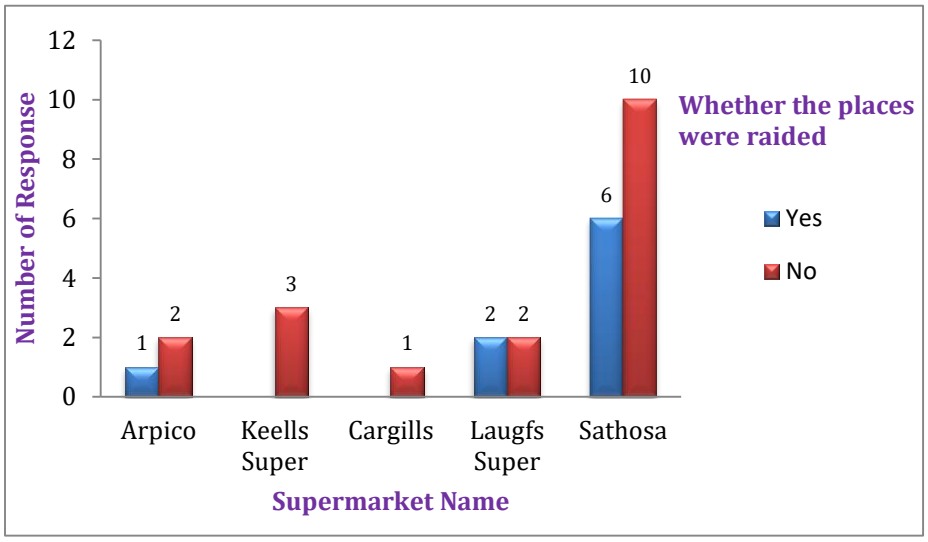
4.8 Sustainable Remedies on Plastic Waste Management in Sri Lanka

During the study, Professor Jagath Premachandra, the University of Moratuwa was interviewed on the ban on polythene. Then he has commented and the most important point in his comment was considering the 3R concept in garbage management. In addition, he further noted that the total ban on polythene is a very difficult process. On January 1, 2018, only four types of products under polythene were banned. It is essential that polythene users must be encouraged towards rescue of polythene. Recycling should be done as much as possible after use. Then, gradually, usage of polythene will decrease.

According to him, agricultural waste and waste products in the garment industry can be used for producing alternative bags. In addition, traditional ingredients such as cans and straws can be used for producing the alternatives. The University of Moratuwa is conducting a research to produce alternative bags with agricultural waste and waste products in the garment industry. There are several issues with regard to the production of biodegradable polythene. The process is heavily time consuming. Another issue in Sri Lanka is the absence of technical facilities to test the time taken by biodegradable polythene complete degradation and decompose into carbon dioxide, water and humus. In addition, it is possible to make lunch sheets by using the polylactic acid is imported for producing bio-degradable lunch sheets, mixed with starch (sugarcane, corn, rice) instead of HDPE and lunch sheets. These products are already being manufactured in countries such as India and England. Even it is possible to use Oxo biodegradable; it must be mixed with heavy metals to direct decompose in the first stage. In this process, after it decomposes up to 90 percent, the remaining 10 percent is decomposed by soil microbes. In certain countries, this method is banned, but is a common practice in Saudi Arabia. According to the Premachandra, Sri Lanka can produce polythene by using Oxo biodegradable as a raw material, if approved by the Sri Lanka Standards Institution. Nevertheless, it was not environmental friendly and he pointed out those heavy metals added at the initial stage of the process may be added to the environment.

4.8.1 Raids by CEA Officials on Supermarket Chains for Polythene Investigation

Raiding helps trace illegal polythene products and it is vital to discourage the producers and sellers involved in these activities. Accordingly, the questionnaire survey conducted up to end of August 2018 revealed that 67 percent of supermarkets were investigated by the CEA officials. Around 63 percent of supermarkets out of the total supermarkets raided were checked only one time. Punitive measures were taken against offenders last year for violating polythene laws. Those first time offenders were fined Rs. 10,000.00 while it was five times for repeating the offence. According to the key person interviews, observations and focus group discussions, CEA is in good stead in terms of the polythene raiding compared to year of 2018. The fine should be revised for raiding to be more effective. Consequently, CEA has to increase the frequency of raiding to limit the illegal producers, sellers and etc. For this, more staff is needed, which is a constraint. Figure 4.41 below shows the frequencies.



Source: Field Survey, 2018

Figure 4.41: Raids of CEA Officials on Polythene

4.8.2 Polythene Waste Incineration Process in Matale Pradeshiya Sabha

In the study, whether the government sector is following the incineration process to dispose the plastic waste in Sri Lanka was found. Accordingly, Matale Pradeshiya Sabha is the only government institution where an incineration process is observed. At present, Matale Pradeshiya Sabha is collecting around a ton of waste within the Matale region per week and nearly 40 percent of that is incinerated.

The Industrial Development Board, District Engineering Office and National Engineering Research & Development Centre (NERDC) have extended the technical support to establish this incineration unit and the Central Environmental Authority has funded the project. For this, polythene waste collected in the Matale Municipal Council area is being used. Before incineration, they should be cleaned to free from food contamination at a huge cost. Technical Officer of the Incineration Unit in Matale Pradeshiya Sabha outlined the establishment cost, technology and environmental requirements.

Establishment cost:

Construction cost Rs. 4,000,000.00 – Granted by CEA
Other cost (For office premises and other facilities) Rs. 1,000,000.00 – Revealed by Matale Pradeshiya Sabha

Technology:
Pyrolysis and gasification process
Pyrolysis- Convert plastic into liquid fuel – This output of fuel burnt again

Gasification – Convert plastic into gas – This output of gas burnt again and therefore no harmful air emission

Capacity – 2 $m^{3,}$ Diesel Furner, Three chambers –

1. Load polythene waste into first chamber
2. 2^{nd} and 3^{rd} chambers- burners

Inside temperature: 1100 centigrade
To maintain heat; Digital display is in the insulation unit
Functioning of insulation unit: Once a week at present
Load 200 kg of polythene waste at once.
Labour requirement: At least 2 heads

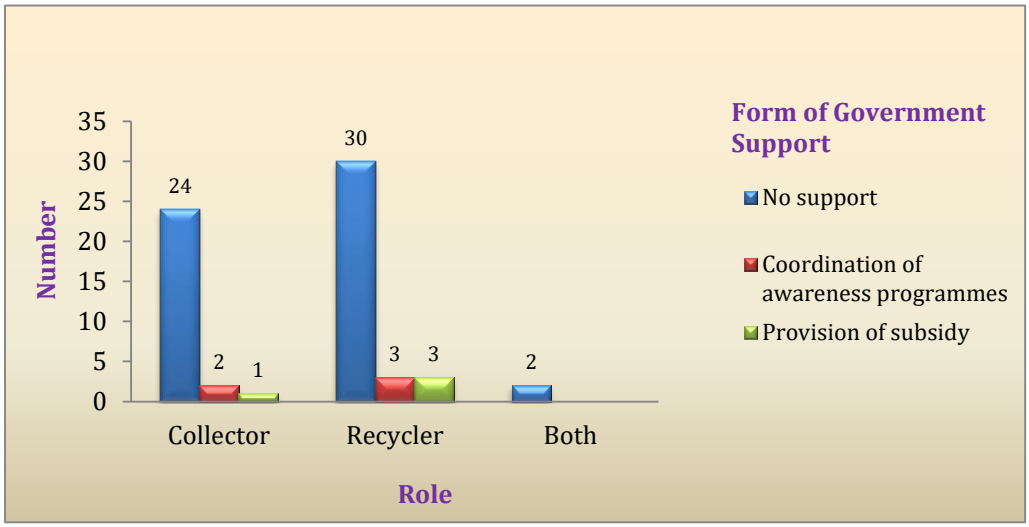
Environmental requirements:
Need ½ acre of buffer zone.
ITI revealed that there is no harmful emission from this process

Source: HARTI Survey Data of this Study, 2018

4.8.3 Plastic Waste Collection

4.8.3.1 Government Support for Plastic Collectors and Recyclers

Government support for the plastic collectors and recyclers to manage the plastic waste was found. Figure 4.42 shows the government support for each respondent. According to descriptive statistics, 86 percent of plastic collectors and recyclers have not received any support (awareness or incentives) by the government. There are 43 percent of collectors, 54 percent of recyclers and three percent both collectors and recyclers who did not receive any government support. Hence, only 14 percent of plastic collectors and recyclers claimed they received support (knowledge or incentives) by the government. Of them, six percent of respondents have received subsidy while eight percent attended programmes for capacity building.



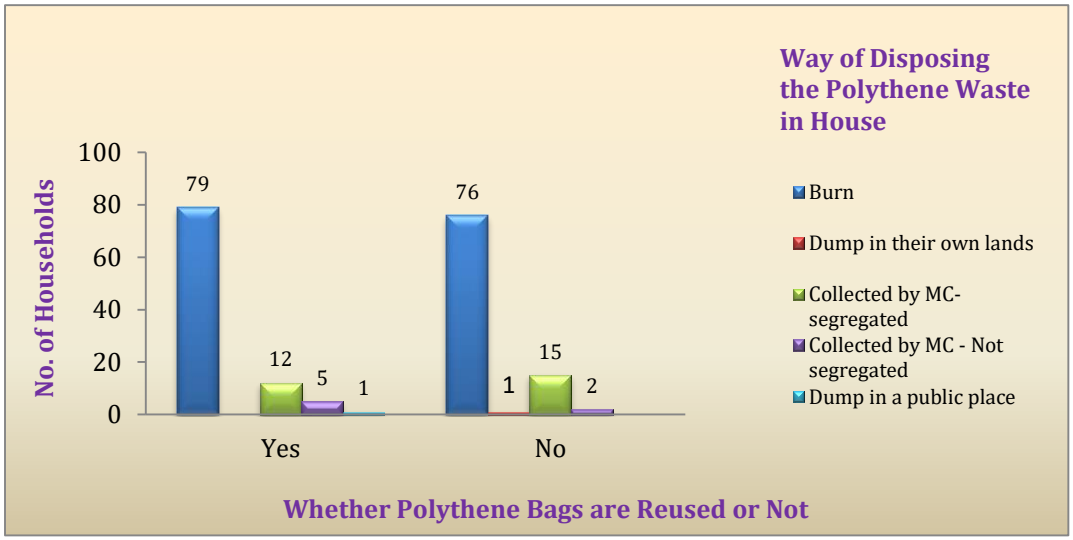
Source: Field Survey, 2018

Figure 4.42: Government Contribution for the Plastic Collectors and Recyclers

4.8.4 Plastic Waste Disposal Methods

4.8.4.1 Household Behaviour with regard to Plastic Waste Disposal

Plastic waste disposal methods of households, whether polythene bags are reused or not were taken into consideration. Accordingly, 81 percent of households in the study sample burn their plastic waste while 18 percent of them handover them to the Municipal Council. The remaining one percent dump it in an open area. Moreover, 51 percent of households disposing by burning reuse the bags prior to disposing those while 49 percent do not do so. Figure 4.43 shows the trend.

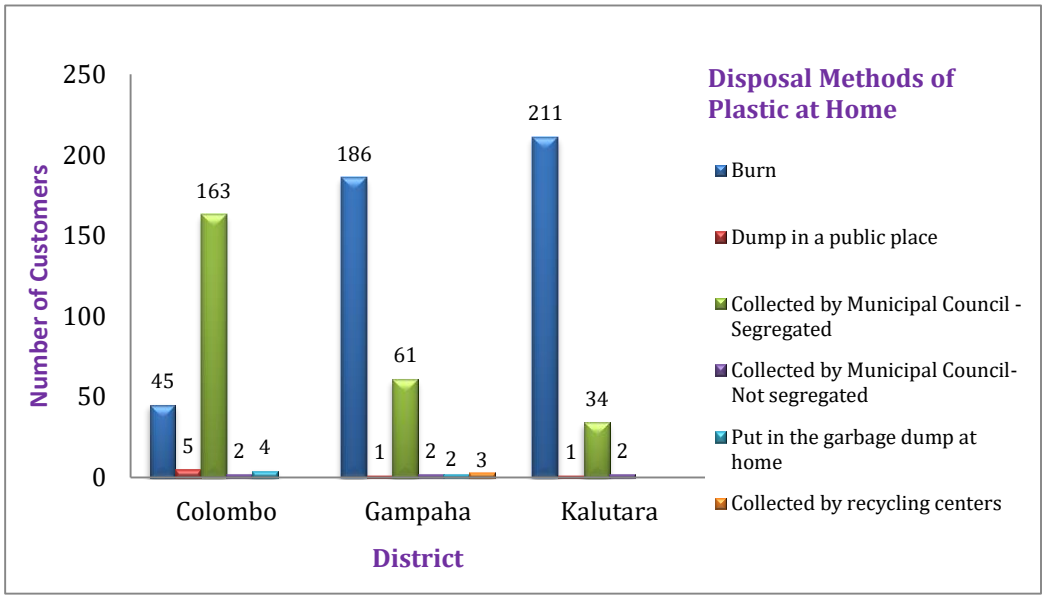


Source: Field Survey, 2018

Figure 4.43: Plastic Waste Disposal Methods of Households

4.8.4.2 Plastic Waste Disposal Methods of Customers (Domestic Level)

Under this, plastic waste disposal methods of customers in each district were outlined. Different methods were practiced to dispose the plastic waste and 61 percent of customers were burning while 37 percent hand over it to the Municipal Council. Figure 4.44 shows it in detail.

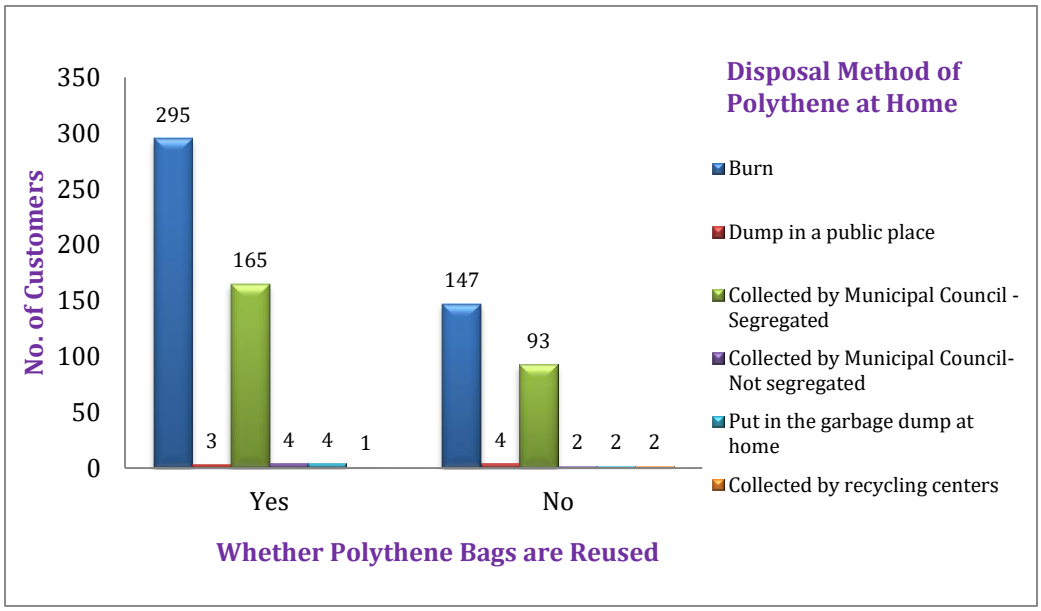


Source: Field Survey, 2018

Figure 4.44: Plastic Waste Disposal Methods of Customers (Domestic Level)

4.8.4.3 Customer Behaviour regarding Plastic Waste Disposal based on the Practice

Plastic waste disposal methods of customers/consumers based on whether polythene shopping bags are reused before disposing have been discussed. According to descriptive statistics, 67 percent of customers who burn, reuse the polythene bags before disposing while 33 percent of customers do not.

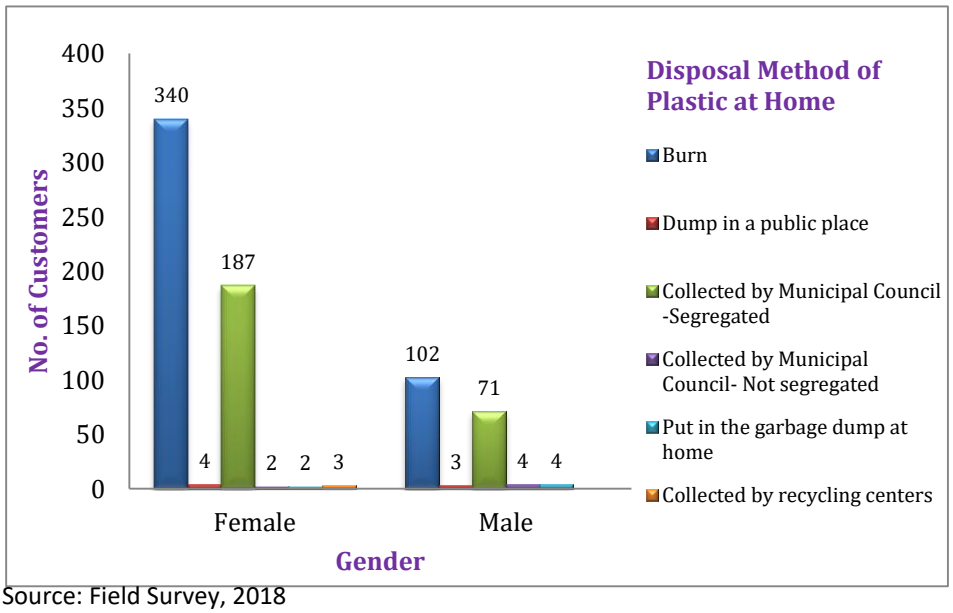


Source: Field Survey, 2018

Figure 4.45: Customer Behaviour with regard to Plastic Waste Disposal based on Practices

4.8.4.4 Customer Behaviour with regard to Plastic Waste Disposal based on Gender

Plastic waste disposal methods of customers based on gender have been discussed. According to descriptive statistics, 63 percent of females practiced burning as the waste disposal method while it is around 55 percent for males.

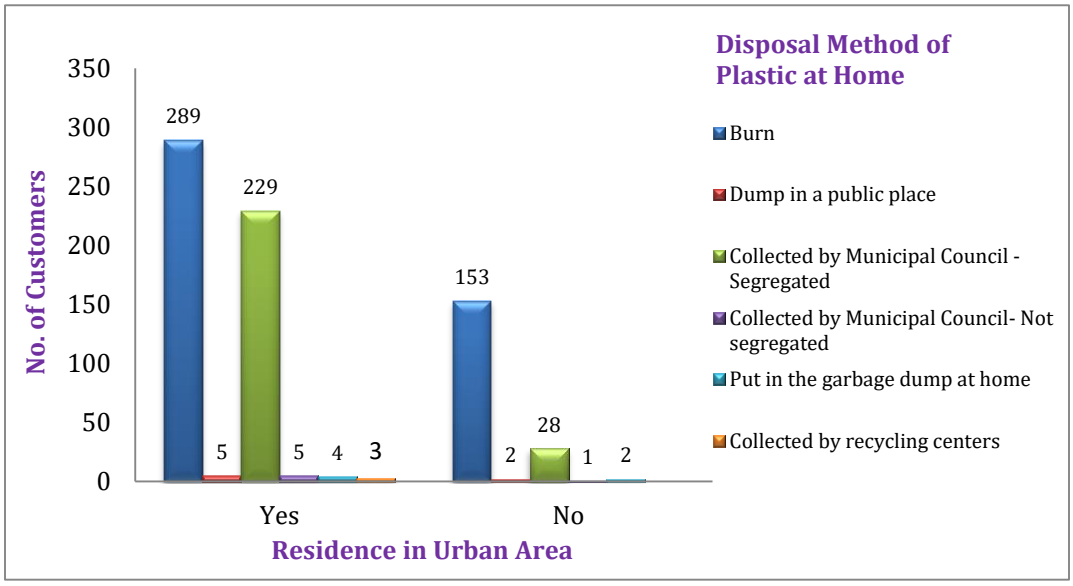


Source: Field Survey, 2018

Figure 4.46: Customer Behaviour with regard to Plastic Waste Disposal based on Gender

4.8.4.5 Customer Behaviour with regard to Plastic Waste Disposal based on Residential Area

Plastic waste disposal methods of customers based on the area living in have been considered. According to descriptive statistics, 82 percent of customers living away from town/village practice burning as the waste disposal method while it is around 54 percent for those living in urban area. Figure 4.47 illustrates this.

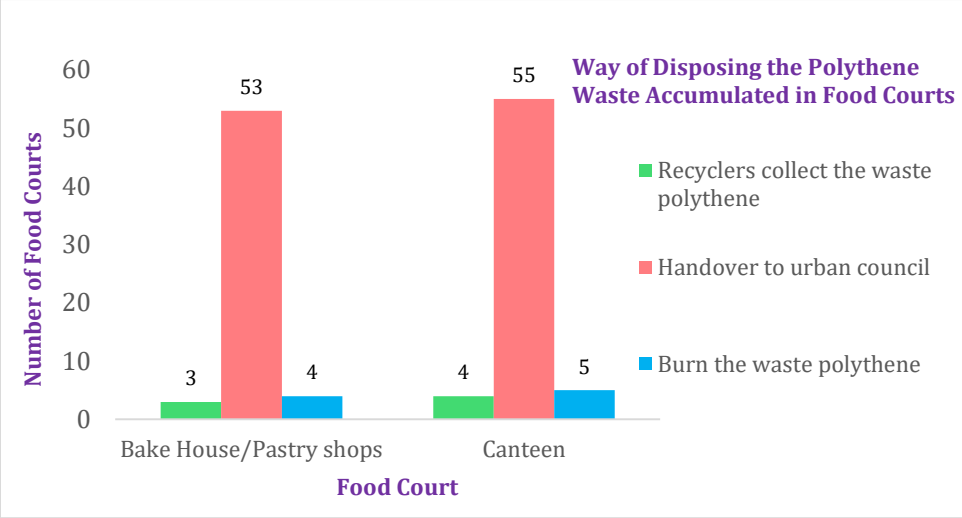


Source: Field Survey, 2018

Figure 4.47: Customer Behaviour with regard to Plastic Waste Disposal based on Residential Area

4.8.4.6 Way of Disposing the Polythene Waste Accumulated in Food Courts

The ways of disposing the polythene waste accumulated in food courts are discussed here. Accordingly, 87 percent of food court owners' handover their plastic waste to the Urban Council while seven percent of food court owners burn the waste polythene. Hence, the remaining six percent of food court owners have directed the plastic waste to recycling centres. Figure 4.48 presents this data.

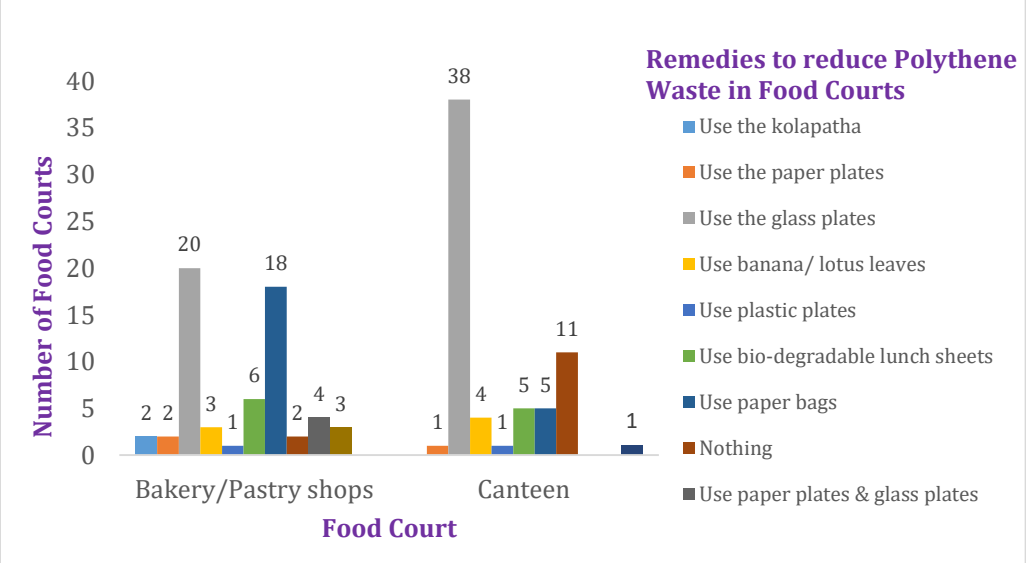


Source: Field Survey, 2018

Figure 4.48: Way of Disposing Polythene Waste Accumulated in Food Courts

4.8.4.7 Remedies to Reduce the Polythene Waste in Food Courts

Eco-friendly alternatives to polythene are sought to reduce the plastic and polythene usage. Accordingly, 45 percent of food courts out of the food courts in the study serve food in glass plates in place of lunch sheets. As well, nine percent of food courts use the bio-degradable lunch sheets. With regard to banana leaves, six percent of food courts out of the total use them. Besides, there are kolapath plates (areca nut leave plates), paper plates, lotus leaves used in food courts. However, the percentages are negligible. Figure 4.49 below shows a detailed picture.



Source: Field Survey, 2018

Figure 4.49: Remedies to Reduce Polythene Waste in Food Courts

CHAPTER FIVE

Conclusion and Recommendations

5.1 Conclusion

1. An interesting finding outlined in this research was the presence of an act that would have been a major contributor to the excessive use of polythene grocery bags and lunch sheets over the years. Consumer Affairs Authority Act, No. 9 states that: "*no trader shall at the time of selling of goods levy any charge directly or indirectly on consumers for any type of bags/wrappers issued to the consumers*".

2. The public had been largely misinformed regarding the PBLS ban, as the study found 31 percent of the surveyed public assuming the newer grocery bags to be biodegradable, while 41 percent being uncertain about its make.

3. Sixty-seven percent of the consumers and 74 percent of the supermarkets interviewed in the research had pointed that their bag usage is higher than prior to the ban due to inferior quality of the current one.

4. According to manufacturers of grocery bags, compared to the previously used HDPE, LDPE based bags used at present were not only of poor strength, but also incurred a higher production cost while being more difficult to recycle after use. A similar issue was raised with regard to the new lunch sheets by 74 percent of the food vendors surveyed, that these lunch sheets were easily damaged, leading to leaking of wrapped food while making the wrapping process more difficult compared to the polythene sheets used before.

5. Another aspect revealed in the study was the prevalence of "black market" polythene lunch sheets which sometimes were passed off as biodegradable. This was a major concern raised by manufacturers of biodegradable lunch sheets, as they have to compete with lower priced fake products that undermine the environmental benefits of the imposed regulations.

6. Enforcement of the law by the government would play a major role in making the "polythene ban" effective. According to the Central Environmental Authority, an increasing number of inspections and raids had been carried out at retail shops, supermarkets and manufacturing facilities to detect illegal polythene products. Yet, the researchers found quite a few limitations in the processes used in the detection of illegal products. The government has to rely on the importation certificates confirming legitimacy of the raw materials used in the manufacturing process, while having only limited resources and methods to check for banned substances in the finished products. It was also identified that the government

sector, at present, has no laboratory facilities to test degradability of material, so as to confirm whether the required standards are met by the manufacturer.

7. The study was able to find that the amount of plastic waste generated per year by an individual on average is around 11 kilograms. Not only does this highlight the gravity of the environmental hazard, but also of its potential to become an abundant raw material source for the recycling industry. When interviewed plastic collectors and recyclers registered at the Central Environmental Authority, it was found that 42 percent of those contacted had quit the trade. Of those still operating 86 percent lamented on the minimal assistance or encouragement by the authorities for continuing their industry.

8. With entrepreneurs that have introduced and attempted to promote material and products as substitutes have expressed their disappointment with authorities for their meagre commitment in providing support. As a result, very few alternative products were found to be available. Of those alternatives for lunch sheets in the Western Province, the most common were banana leaves, Areca-nut leaves ("Kolapath") and Lotus leaves used by food vendors. Yet, the researchers found that 97 percent of food vendors still relied on lunch sheets despite the ban. The most common alternatives identified for polythene grocery bags at supermarkets and grocery stores were fabric bags, paper bags and bags made of starch based biodegradable plastics. These alternatives for lunch sheets and polythene bags had failed to become popular for the disadvantages they have in terms of price, availability and convenience.

9. The most preferred alternative for polythene shopping bags was cloth bags due to its physical attributes while the high price was a main limitation for it to become popular.

10. Another aspect of plastic waste management is enforcement of laws regulating manufacture, use and disposal of polythene and plastics. Even if there are laws strict enforcement and regular monitoring is needed to achieve the expected outcome. Our study found many concealed as well as blatant violations of environmental laws related to plastics, committed due to lack of awareness or disregarding it.

5.2 Recommendations

1. Amendment or abolition of Consumer Affairs Authority Act, No. 9 of 2003 could pave the way for retailers and food vendors to introduce a system of charging the customer for any bags or wrappers they request, while competitively promoting the use of biodegradable alternatives and even the reuse of polythene bags. Even though certain supermarkets in Sri Lanka have already introduced commendable steps such as providing loyalty card points and discounts for bringing own reusable bag, it is suggested taking it a step further to bring in a points system for reusing used plastic bags as well. If the government could intervene and negotiate the use of such incentive programmes across all supermarket chains in Sri Lanka, it could be a positive step towards limiting the usage of plastic bags in the country.

2. A slogan hailed by other countries is 'polluter pays, by way of extended producer responsibility'. In this approach, producers are held responsible for the plastics and packaging they manufacture or use within the entire life cycle of the product. The producers themselves would have to take steps to establish a system that recovers and manages the waste generated form their product.

3. Along with this, we stress the importance of establishing a proper packaging policy for industries in the country. This would standardise the methods and material used in packaging, so that their recovery and recyclability would improve, in addition to other aspects, such as hygiene (Annexure - 4).

4. Sri Lanka has a long way to go before polythene waste management, let alone overall waste management, reaches a satisfactorily sustainable state. It is hoped that authorities would implement future steps in this regard in a more rational manner; with prior consulting with experts, while taking into consideration opinions of relevant stakeholders and openly communicating the approach and its basis to the public, so as to avoid the shortcomings of the "polythene ban" of 2017 (Annexure - 3).

5. If the consumers of Sri Lanka are to move away from polythene related products, those that introduce and manufacture eco-friendly alternatives should be encouraged. Therefore, attention and support should be provided to entrepreneurs and producers of eco-friendly alternatives for plastics and polythene by the state and a systematic campaign should be implemented to promote their use among the general public.

6. Establishment of a systematic approach in monitoring of violations with increased allocation of officers to the environmental units of police stations is needed. The task of these police officers should include raising awareness of the public as well as conducting inspections and raids to unmark the offenders. It was also apparent that the existing fines to punish the offenders fall for short of any effect.

Therefore, it is recommended to increase the fines to create more impact in the society.

7. Lack of funds is a major drawback in systematic waste management. Therefore, adequate funds for local bodies/local authorities are needed to streamline and regularize the collection process (Annexure - 5).

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Annexure 1

Bio-plastics from Waste Newspapers

I. Preparation of Raw Material

The raw material used here is newspaper, which is the most common and easily available household asset. Loads of newspapers are dumped into oceans for disposal which come from 500,000 trees which are cut every week for their production and 88% of that is never recycled. These newspapers can be put to utilization in preparation of bioplastic as raw materials, after undergoing through some simple processing.

Waste newspapers are converted to pulp which can be done using pulp mills. Pulp can be manufactured by mechanical, semi chemical or fully chemical methods. This treatment can also be done using water which gets rejected in other processes (like household rejected water) to minimize water consumption and wastage. The waste newspapers are now segmented into small pieces in the mill and water is added to them to obtain a lingo Cellulosic fibrous pulpy material which is then grinded to finally obtain what is known as paper sludge. The process removes lignin from paper and leaves cellulose fibers intact which facilitates in the process of extraction of cellulose.

II. Preparation of Bio-Plastic

1. Extraction of cellulose from pulp:

Cellulose is extracted from paper sludge after treating it with 1-butyl-3-methylimidazolium chloride which is a good solvent of cellulose. This co solvent addition is kept at appropriate stirring conditions (600C). This allows the fractionation of a paper-grade Kraft pulp into separated cellulose and a regenerated hemicellulose fraction. Both of these exhibited high levels of purity, without any yield losses or de polymerization. Thus, this process represents an ecologically and economically efficient alternative in producing dissolving pulp of highest purity.

2. Conversion of cellulose into dextrose:

The process of breaking down of cellulose is called Cellulolysis.
Cellulolysis is the process of breaking down cellulose into smaller polysaccharides called cellodextrins or completely into glucose units; this is a hydrolysis reaction. Because cellulose molecules bind strongly to each other, cellulolysis is relatively difficult compared to the breakdown of other polysaccharides. However, this process can be significantly intensified in a proper solvent, e.g. in an ionic liquid.

The enzymes utilized to cleave the glycosidic linkage in cellulose are glycoside hydrolases including endo-acting cellulases and exo-acting glucosidases. Such enzymes are usually secreted as part of multi enzyme complexes that may include dockerins and carbohydrate-binding modules.

Cellulose is converted to glucose in a two stage process in which cellobiase is produced from a cellulosic feedstock under the influence of Trichodermareesei in a first stage and cellobiase from the first stage is converted to glucose in a second stage by the action of purified cellobiase derived from Aspergillus terreus. Cellobiase from A. terreus is purified by contacting a crude aqueous extract of the cellobiase with an ion exchange resin and an anion exchange resin. The purified cellobiase may be immobilized on a suitable substrate.

The present invention relates to a process for the production of glucose from cellulose. In one of its more specific aspects, this invention relates to a process for the conversion of cellulose to glucose wherein cellulose is converted to cellobiase under the influence of Trichodermareesei and cellobiase is converted to glucose by a purified cellobiase derived from Aspergillus terreus. In another of its more specific aspects, this invention relates to a process for the production of a purified enzyme having a very high activity for the production of glucose from cellobiase.

There is presently tremendous scientific and commercial activity in the quest for economic means to convert cellulose (abundant in the form of wood, waste paper, and agricultural products, e.g. bagasse) to glucose and thence to ethanol and other chemicals. Cellulose may be converted to glucose by the action of various enzymes derived from moulds.

It is known from the prior art that Trichodermareesei is a fungus that has the ability to degrade cellulose very rapidly. Currently Trichodermareesei is the preferred organism for studies in the hydrolysis of cellulose to glucose for industrial purposes. The conversion of cellulose to glucose is not yet economically feasible, due partially to the fact that the cellobiase produced by Trichodermareesei has a low specific activity. Additionally, glucose, which is the final product of reaction, further inhibits the activity of the Trichodermareesei enzymes.

We have discovered an efficient method for the conversion of cellulose to glucose in a two stage process. In the first stage, cellulose is converted to cellobiase by the action of a cellulase produced by Trichodermareesei, and in the second stage, cellobiase is converted to glucose by the action of a purified cellobiase produced by Aspergillus terreus. This is a distinct departure from the prior art processes in which Trichodermareesei enzymes perform both functions at efficiencies and conversion rates considerably less than those obtained in our process.

3. Preparation of PLA bio-plastic:

To produce PLA, starch is extruded from waste newspaper, which results in a simple starch called dextrose. Dextrose is a type of glucose, which is a simple sugar that plants produce during photosynthesis. Now dextrose is put through a fermentation process similar to the one used to make beer. Instead of alcohol, however, the dextrose is converted into lactic acid - the same stuff that makes your muscles cramp when you exercise without proper hydration. Heat is applied to the lactic acid polymers, causing them to link together and form a long chain that ultimately becomes the material used to make many bio-plastic products.

Annexure 2

Name List of Key Person Interviews

	Name	Designation	Institute
1	Mrs. Sarojinie Jayasekara	Director	Solid Waste Management, Central Environmental Authority
2	Mr. Palitha Gamage		Solid Waste Management, Central Environmental Authority
3	Mrs. M.R.N. Siriwardena	Additional Director	Investigation, Central Environmental Authority
4	Mr. N.S. Gamage	Director	Central Environmental Authority
5	Ms. Sewwandi Abeygunawardena	Environment Officer	Central Environmental Authority
6	Ms. P. Hiruni		Central Environmental Authority
7	Ms. M.L. Ranawaka		Central Environmental Authority
8	Prof. Jagath Premachandra	Professor	University of Moratuwa
9	Mr. Vinoy Jayashantha	Senior Manager Quality Assurance & Research& Development	Maliban Biscuit (Pvt) Ltd.
10	Mr. Dishantha Rajakaruna	Senior Engineer	Engineering Department, CBL
11	Mr. Duminda Gamage		Nestle Lanka (Pvt) Ltd.
12	Dr. Anush Amarasinghe	Managing Director/ CEO	BPPL Holdings PLC
13	Mr. D.M.S. Priyankara		Eco Spindles (Pvt) Ltd.
14	M.M. Jagath	Recycler, (Al coated)	MMJ Service
15	Mr. Jayantha Kumarasiri	Polythene Up-cycling	
16	Ms. Menu Kotagama	Alternative Producer	
17	Dr. Samantha Karunarathna		Consumer Affairs Authority
18	Mr. Hemantha Vithanage	Executive Director	Centre for Environment Justice
19	Mr. Ranjan Karunanayaka		Centre for Environment Justice
20	Mr. Nandana Edirisinghe	Research Fellow	NERD
21	Mr. J.K.A.R. Perera	Polythene Recycler	Berng Lanka Services
22	Mr. S.P.C. De Silva	Polythene Recycler	
23	Mr. E.A. Sunil Edirisinghe	Polythene Recycler	Edirisinghe Polythene Recycling
24	Mr. Thissa Gamage	Assistant Director	Solid Waste Management, Central Environmental Authority
25	Mr. Ajith Weerasundara	Former Director	Solid Waste Management, Central Environmental Authority
26	Mr. A.P. Kandage		Sri Lanka Standard Institute
27	Dr. Iresha Kottegoda		ITI, Ministry of Science, Technology & Research

28	Mr. L.D.C. Nayanajith		ITI, Ministry of Science, Technology & Research
29	Ms. Yoga Malani		ITI, Ministry of Science, Technology & Research
30	Mr. Nimal De Silva		Waste Management Authority, Western Province
31	Dr. (Mrs.) S.H.P. Gunawardena	Head, Chemical & Process Engineering	University of Moratuwa
32	Prof. P.G. Rathnasiri	Professor, Chemical & Process Engineering	University of Moratuwa
33	Dr. U.P.K. Epa		University of Kelaniya
34	Mr. Ranjith Rajapaksha	Assistant Director	Ministry of Environment
35	Dr. Sujatha Weerasinghe		University of Colombo
36	Mr. Anura Wijethunga	Former President	Polythene Manufacturers & Recyclers Association of Sri Lanka
37	Mr. Shamin Perera		Polythene Manufacturers & Recyclers Association of Sri Lanka
38	Mr. Asela Sampath	National Organizer	All Ceylon Canteen Owners Association
39	Mr. Ranjith Vithanage	Chairman	National Movements for Consumer Rights Protection
40	Mr. Amil Priyanthage	Civil Engineer	Green Eco Science & Technologies
41	Mr. Nalin Dolawatta	Director	Sri Lanka Inventors Commission (SLIC)
42	Mr. Mervyn Dias Mrs. Mayuri Dias		Plastic Packaging (PVT) Ltd
43	Ms. B.A. Malani Amarasena	Alternative Producer Clothes Bags	
44	Ms. P.P. Nalani	Alternative Producer Clothes Bags	
45	Ms. Sanjeewani Valmilla	Alternative Producer Clothes Bags	
46	Ms. Ayomi Vidanagamage	Alternative Producer Clothes Bags	
47	Ms. Gangani Kolambage	Alternative Producer Clothes Bags	
48	Ms. R.B. Ashanjali Manel	Alternative Producer Clothes Bags	
49	Mr. M.M. Edirisooriya	Bags, Shoes Producer	
50	Mr. Vasantha Anuruddha		National Science Foundation
51	Mr. Ayoma Priyadarshana		National Science Foundation

52	Ms. Dilushi Munasinghe		National Science Foundation
53	Mr. Malith		Viridis (Pvt) Ltd
54	Mr. Asanda Perera	Business Development Coordinator	Viridis (Pvt) Ltd
55	Mr. B.K. Tharanga	Project Officer	
56	Mr. Roshan S. Hassen	DGM- Operations	Lanka Sathosa Ltd.
57	Mr. Yasantha Palliyaguruge	Deputy Manager	Perera and Sons (Pvt) Ltd.
58	Mr. Janaka Malinda	Senior Manager	Arpico
59	Mr. Sachith Wijesekara	Executive	John Keells
60	Mr. Janitha Pallegedara	Head/ HR	Fab Foods (Pvt) Ltd.
61	Mr. Chandima Dasun Jayathilaka		Fab Foods (Pvt) Ltd.
62	Mrs. R.P. Deepika	Alternative Producer	
63	Mrs. Priyani Rathnaweera	Alternative Producer	
64	Mrs. Padma Vallawagedara	Alternative Producer	
65	Ms. Upekshi		Green Choice Lanka Organization
66	Ms. Devaki Gomas	Alternative Producer	
67	Mr. Namal	Alternative Producer	
68	Mr. V. Mayantha	Polythene Collector	
69	Mr. Ishara Gammanpila		Maliban Biscuit (Pvt) Ltd.
70	Mr. Chandima Herath		Maliban Biscuit (Pvt) Ltd.
71	Mr. W.I.C. Senaka		Sri Lanka Inventors Commission
72	Ms. D.C. Basnayaka		Sri Lanka Inventors Commission
73	Mr. Ananda Jayasinghe		National Craft Council
74	Mr. Jayantha	Technical Assistant	Matale Pradeshiya Sabhawa

Annexure 3

Integrated Environment Bodies

The Government should mediate to establish Integrated Environment Bodies (IEB) from Village level to National level with the participation of relevant stakeholders {government officers who should be amenable, some consumers, some households, some retailers/sellers, some food court owners/restaurateurs representing All Ceylon Canteen Owner's Association, some supermarket owners under the various categories, some eco-friendly alternative producers/entrepreneurs, some polythene collectors and recyclers representing collection and recycling companies, plastic and polythene producers representing All Ceylon Polythene Manufactures and Recyclers Association, police environment protection units and etc.} to manage the waste including plastic in sustainable manner. Then only, we can find a sustainable solution to the waste. Here, everyone can share their experiences and obstacles with each other and find the solutions easily. With the support of CEA and other amenable officials Local Authorities should mediate to make a platform to the IEB. Besides, a win-win system should be formed in order to get benefits to all the stakeholders. Consequently, waste including plastic will not be a waste furthermore and it will become a resource.

Annexure 4

A Proper Packaging Policy

There should be a proper packaging policy for industries in Sri Lanka, and it should consist of the following:

a) Avoidance of packaging material that may negatively impact quality, health, safety and environment during the whole life cycle of the product, including disposal.

b) Truncating packaging requirement and waste by design and material choice throughout the whole packaging system (primary, secondary and tertiary) and product life cycle (production, distribution, consumption and disposal).

c) Furtherance of concentrated products and compact packaging which accords to efficiencies in transport and distribution, thus reducing costs.

d) Commendation the use of packaging components which are recoverable or recyclable where economically available, legally permissible and technically feasible.

e) A framework should be established that makes consumer goods manufacturers and marketing companies to take greater responsibility in the management of waste generated from their products. Here, if some company distributes items that would lead to generation of plastic waste through their consumers, the company itself would be required to setup a system to collect and recycle or dispose of those plastic products linked to their products. This should be especially relevant with regard to waste such as biscuit wrappings and Tetra packs that require specific recycling infrastructure. It would be possible for these companies to work with the above mentioned IEB, when collecting waste related to their products. As an example, if the company could establish a system of payment (buy back) for the biscuit wrappings and Tetra packs, then consumers could be persuading to hand them over to relevant places while being able to generate some income. Those places of collection can be established at LA level at places such as supermarket premises.

Annexure 5

Local Bodies/Local Authorities to Waste Management

If authorized persons can employ a separate tractor for collection of the organic garbage and another tractor for other waste, then people will get used to sort out the waste. It can be done by allocation of the same tractor for different days to collect different garbage or different tractors in same day to collect the garbage from households. Afterwards, compost can be prepared by organic waste and others can be sold via the IEB. Those data should be recorded by each IEB in village level to National level. Therefore, LA's should be supplied enough funds for the process. For this, a cess tax of 15 percent charged from plastic importers for the plastic raw materials can be employed to mitigate this situation. Furthermore, there should be few good recycling plants with incinerators. If there is some non-recyclable waste which isn't used by anyone, it can be incinerated as the final option to dispose of the remaining waste.