APPLICABILITY OF CARBON PRICING INSTRUMENTS TO REDUCE ENERGY BASED CARBON EMISSIONS OF APPAREL SECTOR IN SRI LANKA

Thesis submitted in partial fulfilment of the requirements for the degree Master of Science by Research

T.L.W. Karunaratne

(178094R)

Degree of Master of Science by Research

Department of Building Economics

University of Moratuwa

Sri Lanka

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ABSTRACT

Global warming and subsequent climate change have been identified as critical global issues which need urgent and close attention. Nevertheless, addressing this has become a problem due to the direct relationship between development and greenhouse gas (GHG) emissions. However, with the introduction of Paris agreement, countries are trying to reduce GHG emission by using various emission reduction policy instruments. Price based emission reduction instruments are deemed to be effective in achieving emission reductions, as they induce emission reductions through price signals, and also generate revenues which can later be used. Carbon tax systems and emission trading schemes are identified as the most popular pricing instruments. However, implementation of carbon pricing instruments in not that common seen. Hence, this research focuses on identifying the applicability of carbon pricing instruments to reduce GHG emissions in apparel sector, which is also a highly energy intensive sector in Sri Lanka. Data collection was done through semi-structured interviews and questionnaires. Data collected through questionnaire survey was analysed using Fuzzy Extended Analytic Hierarchy Process (FEAHP), while data collected through interviews were analysed through content analysis. A preliminary survey was done to validate literature findings, which was used in the questionnaire. Questionnaire survey was conducted to evaluate the response of apparel firms to carbon pricing instruments. When evaluating the response of firms, the importance given by firms to decision alternatives was analysed using FEAHP. Accordingly, investing in new technologies was found as the most important decision alternative for apparel firms with an importance weight of 0.24, while shifting cost to customers was found as the decision alternative with lowest importance with a weight of 0.17. From the expert interviews, it was found that the carbon pricing revenue should be used to programmes which targets emission reductions. Further, the expert interviews revealed that there could be barriers at organization level, sector level and national level when implementing a carbon pricing instrument. Hence, it was found that the necessary steps should be taken at all those three levels to overcome the barriers and implement a lasting carbon pricing instrument which is capable of achieving emission reductions.

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ABBREVIATIONS

AHP- Analytic Hierarchy Process

CEA- Central Environment Authority

CEB- Ceylon Electricity Board

CEYPETCO- Ceylon Petroleum Corporation

CFC- Chlorofluorocarbon

CSR- Corporate Social Responsibility

ETS- Emission Trading Scheme

FCM- Fuzzy Comparison Matrix

FEAHP- Fuzzy Extended Analytical Hierarchy Process

GHG- Greenhouse gas

HFC- Hydrofluorocarbon

NCPC- National Cleaner Production Center

NDC- Nationally Determined Contributions

PFCs- Perfluorocarbons

SAC- Sustainable Apparel Coalition

SEA- Sustainable Energy Authority

UNFCCC- United Nations Framework Convention on Climate Change

CHAPTER 1

1.0 INTRODUCTION

1.1 Background

Excessive emission of greenhouse gases (GHGs) has become one of the most impactful environmental issues that the world is facing currently (Sisco, Bosett, & Weber, 2017). These GHG emissions are identified to be a direct cause of the climate change and global warming (Lin & Li, 2011). International Panel on Climate Change (IPCC, 2012) defines GHG as any gas that absorbs infrared radiation, which traps the heat in the atmosphere. According to IPCC (2015), greenhouse effect is the phenomenon where GHGs trap the heat radiation within the surface troposphere. This is the principal reason for increased temperature on earth, which leads to climate change. United Nations Framework Convention on Climate Change (UNFCCC, 2009) has identified six GHGs as carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6). Of the six GHGs, the most prominent GHG emitted by human activities is carbon dioxide (CO_2), which accounts for around 82% of all GHGs emitted, followed by around 9% of methane (CH_4), around 6% of nitrous oxide (N_2O) and about 3% of fluorinated gases (Fegases) such as HFCs, PFCs and sulfur hexafluoride (SF_6) [Environmental Protection Agency (EPA), 2015]. The reason for this high proportion of CO_2 emission is the rigid link between fossil fuel burning and CO_2 emissions, as CO_2 emissions are an inevitable consequence of fossil fuel combustion (Quadrelli & Peterson, 2007).

After the industrial revolution in 18^{th} century, the quantity of carbon emissions increased significantly. Hence, to regulate this, the responsibility of the damages caused by firms to the environment were passed on to the firms by using environmental economics principles. This was simply a method of internalizing the damages caused by the firms to society by way of pollution to air, soil and water (McGuire & Lynch, 2017). Consequently, countries reached agreements over individual and collective commitments to reduce harmful emissions. The first such instance was Montreal Protocol in 1987, which was to deal with substances that

depleted the Ozone Layer (Molina et al., 2009). Nevertheless, this agreement exerted control over Chlorofluorocarbon (CFCs) and HCFCs which are also GHGs with global warming potentials (Hu et al., 2017). However, the initiation of UNFCCC ensured subsequent international commitments which were directly focused on GHG emissions (Schipper, 2006).

The UNFCCC first introduced Kyoto Protocol in 1997, which enforced emission reduction targets on 37 developed countries including the European Union (Annex 1 countries of Kyoto Protocol) for a period of four years from 2008 – 2012 (United Nations, 1998). Kyoto Protocol does not impose emission reduction targets on developing countries (Babiker, Reilly, & Jacoby, 2000). However, the success of Kyoto Protocol is widely questioned, as the Kyoto protocol has failed to reduce emissions or emissions growth by noticeable levels (Prins & Rayner, 2007; Rossen, 2015; Savaresi, 2016). Therefore, a second commitment period was started with amendments to the initial protocol. This is known as the Doha Amendment to the Kyoto Protocol, which was effective from 2013 – 2020 (Dogan & Seker, 2016). Nevertheless, the Doha amendment was also not successful as several countries which were under the initial protocol opted out in the second commitment period (McCrary, 2017). The major drawbacks of Kyoto protocol were highlighted as its different treatments to developed and developing countries and its top down nature which lays down emission reduction targets to developed countries (Goldemberg & Guardabassi, 2015). With the aim of overcoming the above issues, the Paris Agreement was drafted in 2015 to come into effect from 2020 onwards (Savaresi, 2016). Unlike Kyoto Protocol, the Paris Agreement is applicable to both developed and developing countries, and it does not enforce targets (McCrary, 2017). Instead, the Paris Agreement encourages the countries to focus on intended Nationally Determined Contributions (NDCs) which should be realistic and achievable (Hulme, 2016).

Advent of the Paris Agreement has alarmed both developed and developing countries to look for methods of achieving domestic emission reduction targets or NDCs. However, many countries have adopted various emission reduction policy instruments for many years without much success. In the earlier stages, direct

command and control instruments such as emission cap and energy efficiency mandates were given more emphasis (Parry & Williams, 1999). However, with the below par results, the attention expanded to incentive-based approaches which impose a price on carbon emissions (Goulder & Parry, 2008). According to Cong and Lo (2017), during the past ten years, countries have inclined more towards price-based climate policy instruments. For instance, carbon tax system and emission trading scheme (ETS) are considered as the two most common carbon pricing instruments (Goulder & Parry, 2008). Carbon pricing instruments focus on internalizing external environmental costs into the production cost (Lin & Li 2011). According to Andrew and Kaidonis (2011), this additional environmental cost is expected to induce behavioural changes in firms to minimize carbon emissions. However, it is essential to ensure that the behavioural change of firms would result in emission reductions (Neuhoff, 2010). The reason for this is that the response of every firm, governed by the carbon pricing instrument would not be the same. Some firms may respond by passing the additional cost to another party, while some may take efforts to reduce their emission quantities to reduce the carbon price they have to pay. Hence, the success of a carbon pricing instrument in achieving emission reductions would greatly be influenced by the way the firms respond to it.

Carbon tax is a consumption tax which is based on the usage of carbon-based fuels (Lin & Li 2011). Even though the primary objective of both carbon tax and ETS is to inflict a price on carbon emissions, they are two distinct policy instruments. In a carbon tax system, the price is known, as the tax rate is fixed, while the total emission quantity is not known as the carbon tax system does not impose a limit for emissions (Sumner, Bird, & Dobos, 2011). On the other hand, in an ETS, the emission quantity is known, as the cap is fixed at the beginning while the price is varied depending on the market behavior (Elkins & Baker, 2001). Firms which are unable to function within the allowed carbon cap, need to purchase carbon permits matching their level of emissions to avoid penalties (Tang, Wu, Yu, & Bao, 2015). Conversely, the authors explain that the firms which operate within or below the allowed limit can either save the permits for future requirements or sell them to other firms which need the permits.

It is understood that the carbon pricing instruments induce behavioural changes in firms through price signals to reduce emissions (Andrew & Kaidonis, 2011). In addition to that, carbon pricing instruments raise revenue of government, which can be directed towards activities targeted at reducing emissions (Sumner et al., 2011). However, there is a strict difference in the way that the two systems generate revenues. Revenue generation of a carbon tax system is continuous as it accumulates revenue as long as the tax is imposed, while ETS will only collect revenue at the initial allocation phase, that too only if the allowances are auctioned (Wittneben, 2009). There are various options when considering the revenue utilization of carbon pricing instruments. The more suited approach would be to fund carbon mitigation programmes like energy efficient technological innovations or reforestation (Gerlagh & Lise, 2005). On the other hand, some countries feed the earnings of the carbon pricing instruments directly into the government budgets (Liu & Lu, 2015). However, this is not identified as an effective approach, because when the tax revenue is absorbed into the government budget, utilization of the funds to carbon mitigation programmes is uncertain (Baranzini & Carattini, 2016).

According to Muthukumarana, Karunathilake, Punchihewa, Manthilake, and Hewage (2018), industrial sector contributes to significant energy use throughout the world. More specifically, Conca (2015) has revealed that apparel industry is responsible for 10% of the world's carbon emissions, making it the second highest industrial polluter after the oil industry. Sri Lankan manufacturing industry is highly energy intensive with apparel sector accounting for major portion of energy consumption due to its massive growth. Apparel manufacturing industry is the largest export industry in Sri Lanka with a contribution of 52% to the total industrial product exports (Sri Lanka Export Development Board, 2018). Furthermore, the expansion of the apparel sector is proven by the number of factories around the country which stands at 270 as at year 2014 (Gunathilaka & Gunewardena, 2014). Due to the high energy intensity and GHG emissions of the apparel sector, it is identified as an industry with massive emission reduction potentials.

1.2 Problem statement

As explained in the background section, the increased emission of GHGs has become a critical concern as it causes global warming which leads to climate change. The impacts of climate change are becoming more evident and frequent. With the NDCs in relation to the Paris agreement, both developed and developing countries are looking for policy instruments which aim at reducing carbon emissions. Sri Lanka, a developing country, ratified the Paris Agreement in 2016 in the anticipation of minimizing emissions while facilitating the development objectives of the country. Under the NDCs of Sri Lanka, five main sectors; energy (electricity generation), transport, industry, forests and waste have been identified for mitigation of GHG emissions (Ministry of Mahaweli Development and Environment, 2016). In the above NDCs report, it is explained that Sri Lanka is aiming to achieve 10% total emission reductions in transport, industry, forests and waste sectors compared to business as usual scenario.

A carbon pricing instrument involves many design considerations such as which sectors to govern, how to impose a price and how to ensure that emission reduction goals are achieved. Moreover, the response of the firms also needs to be studied as it defines the success of the carbon pricing instrument in achieving emission reductions. Nordhaus (2002) has highlighted the importance of monitoring the response of firms while Bumpus (2014) has conducted a qualitative study to determine the response of firms in relation to British Columbia's carbon tax. Furthermore, Okereke and Russel (2010) have revealed that the corporate responses widely vary in different regional carbon pricing instruments. Hence, it is essential to specifically identify how the apparel firms of Sri Lanka would respond to a carbon pricing instrument.

According to Wang, Hubacek, Feng, Wei, and Liang (2016), both ex-post evaluations in the implemented countries and ex-ante simulations provide evidences for effectiveness of carbon pricing instruments in achieving emission reductions. Despite the scientific evidence of the effectiveness of carbon pricing instruments, implementation of a carbon pricing instrument for any industrial sector in a South Asian country is yet to be seen (World Bank, 2017). Siriwardena, Wijayatunga,

Fernando, Shrestha, and Attalage, (2007) have studied the economic impacts of a carbon tax instrument on power generation sector in Sri Lanka. However, a study focusing on the applicability of carbon pricing instruments in apparel sector is not available.

Even though there is a carbon tax system for emissions by vehicles in Sri Lanka, it is not well designed, as it is just based on how old a vehicle is (Claessen, 2019). Further, there is massive opposition to this carbon tax from the public. Hence there is a requirement to study the potential of using a carbon pricing instrument to reduce carbon emissions in a developing country like Sri Lanka, while giving more emphasise on high energy intensive sector like apparel sector.

1.3 Aim

To examine the potential of using carbon pricing instruments to reduce carbon emissions of the apparel sector in Sri Lanka.

1.4 Objectives

In order to achieve the aim of the study, several objectives were set.

1. To review,
    I. decision alternatives available for firms in response to carbon pricing instruments and
    II. revenue utilization options in a carbon pricing instrument
2. To evaluate the level of importance of decision alternatives for apparel firms in Sri Lanka when responding to carbon pricing instruments
3. To determine the suitable revenue utilization options to incorporate with a carbon pricing instrument in Sri Lanka
4. To assess the barriers in implementing carbon pricing instruments in Sri Lanka and strategies that can be used to overcome those barriers

1.5 Methodology

Initially a comprehensive literature review was carried out to identify the key principles of environmental economics and available price-based emission reduction

policy instruments. Further, the available decision alternatives for firms in response to price-based emission reduction policy instruments were also reviewed through a literature review. In order to validate the literature findings, a preliminary survey was conducted with three experts who are experienced in the field of sustainability in apparel sector. Further, the decision criteria considered by apparel firms when determining decision alternatives in response to carbon pricing instruments were also established through the preliminary survey. Subsequently, a questionnaire survey was conducted to evaluate the importance of each decision alternative for apparel firms when responding to carbon pricing instruments. For this, ten key apparel firms in Sri Lanka as identified by the "Sri Lanka Export Development Board" were selected as the sample. Fuzzy Extended Analytical Hierarchy Process (FEAHP) was employed to identify the most preferable decision of the firms. Moreover, to determine the suitable revenue utilisation options, and to assess the barriers in implementing carbon pricing instruments and the strategies to overcome the barriers in Sri Lanka, expert interviews were conducted. For this, five experts who have worked in different branches of environment sustainability in apparel sector and are thorough with the carbon pricing policy instruments were consulted.

1.6 Scope and limitations

The scope of this study is narrowed only to export-oriented apparel firms in Sri Lanka. Because export-oriented apparel firms represent a major proportion of the sectors' carbon emissions due to the higher number of factories. Further, the profit margins of export-oriented firms are considered to be high, and hence are expected to be able to cope with a carbon pricing instrument.

1.7 Chapter breakdown

Figure 1 indicates the breakdown chapters and how the objectives are achieved in different chapters of the study.

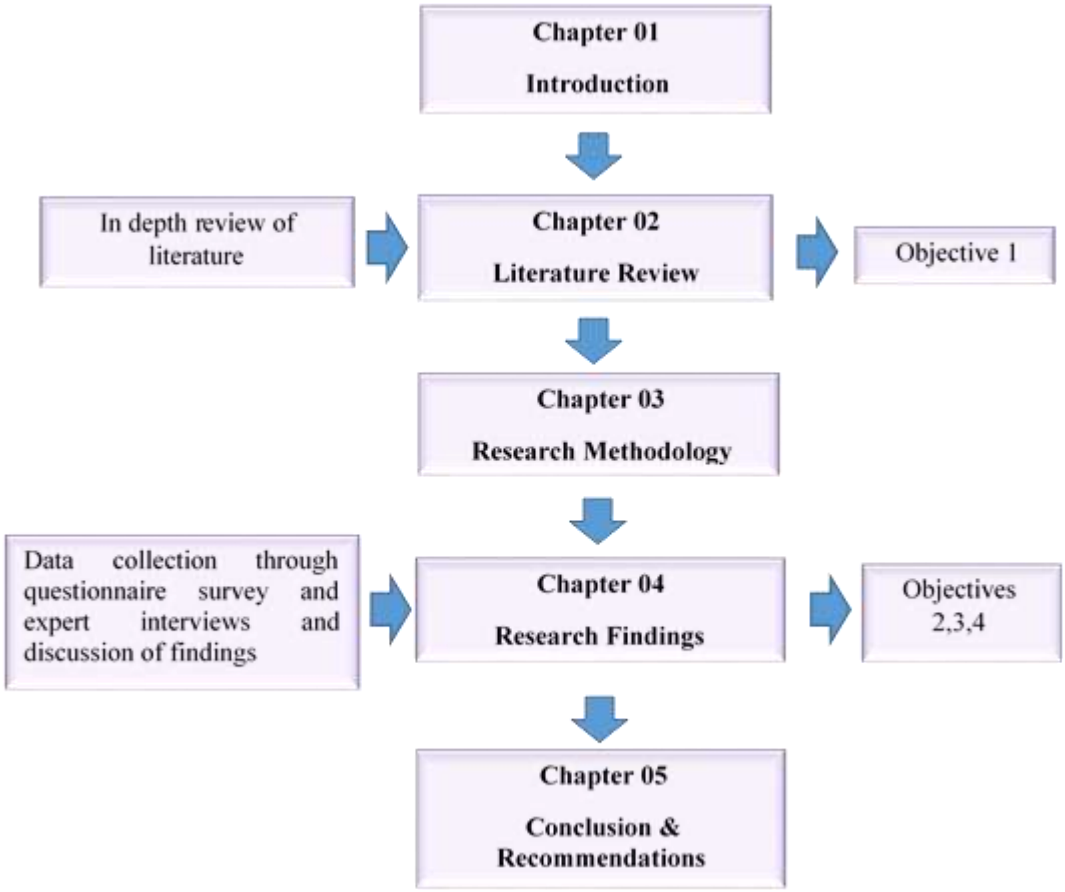


Figure 1: Chapter breakdown

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter reviews and discusses the existing literature on how the environment and the economy is connected. It explains the key economic principles that govern the impacts of economic activities on the environment. Therefore, it is believed that the countries should control the economic activities to minimize negative impacts on the environment. In this regard, this chapter explains the international agreements between countries to control global warming and resulting climate change. Further, it describes how the responsibility of emission reduction falls on different countries, the policy options available to minimize emissions and how the firms will respond if such a policy is implemented.

2.2 Key principles of environmental economics

Industrial revolution which started in 18^{th} century is considered as the point in the history at which the global anthropogenic carbon emissions accelerated. Gabel and Mansfield (2008) describe industrial revolution as a time of transition in which the industrial processes started to depend on machines operated by external energy sources rather than human or animal power. Moreover, according to McLamb (2010), biomass which was the primary energy source up to 18^{th} century, changed to fossil fuels after the industrial revolution. Subsequently, authors highlight that since the start of the industrial revolution in 18^{th} century, the global average CO_2 emissions have increased from 280 ppm to 381 ppm in 20^{th} Century.

At the beginning of the industrial revolution most of the costs of pollution were imposed on the community as the firms were permitted to externalize environmental pollution of air, soil and water (McGuire & Lynch, 2017). The adverse impacts of environmental pollution such as health complications and natural disasters were borne by the society. However, there was a need to make sure that uncompensated social costs of firms were internalised into plans and budgets of firms (Soderholm & Sundqvist, 2003). Hence, over the time the responsibility of environmental pollution

by firms was transferred back to firms through various pollution control regulations which demanded the firms to minimise the environmental damage caused by the production process, by either cleaning up the environment or installing pollution control devices (Andrew & Kaidonis, 2011). These regulations exist to fulfill the need to gain control over the environmental damage caused by human activities (McGuire & Lynch, 2017). In countries where pollution control regulations are imposed, legal or regulatory terms are laid down on power companies, industry and households with potential financial penalties for non- compliance (Oikonomou & Jepma, 2007).

On the other hand, Callan and Thomas (2003) have argued that market decision making has a direct link to environmental damage and resource depletion. Because, according to the authors, it is the market that decides the demand and supply of goods and the required level of cost efficiency for firms to be competitive. Firms adjust the production processes according to market behavior and that adapted production process and choices made during that process dictates the level of environmental damage caused by a particular firm (Soytas, Sari, & Ewing, 2007). Therefore, the concepts of environmental economics came up in 1960s, to understand the nexus between economic activities and environment, for clear decision making of firms and governing bodies (Sandmo, 2015). However, there will be some level of trade-off, as having completely pure water or clean air, while continuing to grow economically is impossible (Hák, Janousková, & Moldan, 2016).

Environment is defined as a commodity which is used and exploited as an input for economic growth (Callan and Thomas, 2003). However, Wiesmeth (2012) emphasizes that, unlike ordinary commodities, the condition of the environment influences the short and long-term prosperity of human beings all around the globe. Therefore, the integration of the environment into the economic system has been long identified as an essential criterion for sustainable growth (Grossman & Krueger, 1995).

2.2.1 The circular flow model in economics

The role and the position of environment in the economic system can be explained through the economic theory-the circular flow model (Callan & Thomas, 2003). The standard circular flow model is depicted in Figure 2.

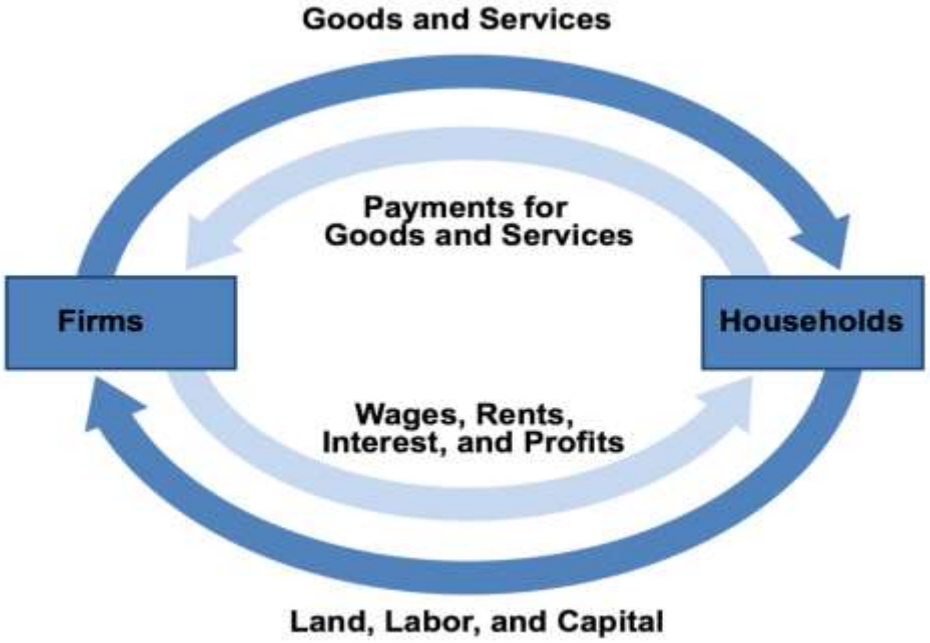


Figure 2: Standard circular flow model

Source: Harris & Roach (2017)

The standard circular flow model shows how the firms and households interact in the economy (Daly, 1985). According to author, it depicts that households supply factors of production i.e. land, labour and capital, which are used by the firms to produce goods and services. In return to the supply of factors of production to firms, households receive benefits in the forms of rents, wages, interests or profits (Harris & Roach, 2017). Similarly, firms receive payments, in return to selling goods and services (Patterson, 1998). However, in this model, natural resources such as fossil fuels, forests, fisheries, minerals and so on fall under land (Harris & Roach, 2017). The other two factors of production, labour and capital regenerate through the above circular process; however, there is no reference to environment from where the land and other resources come from (Stead & Stead, 2014). Authors highlight that, the

process of regeneration for natural resources is not indicated. On the other hand, a reference to the wastes generated in the production process is also lacking in the standard circular model (Day & Hall, 2016).

However, according to Folloni and Zelinski (2016), the global perception on the availability and durability of natural resources has changed, which is demonstrated by the introduction of legal and economic instruments to environmental management and then introducing it into the circular flow of economy in the form of externalities.

Figure 3 illustrates an extended circular flow model, which addresses the shortcomings in relation to environmental resources in the standard circular flow model.

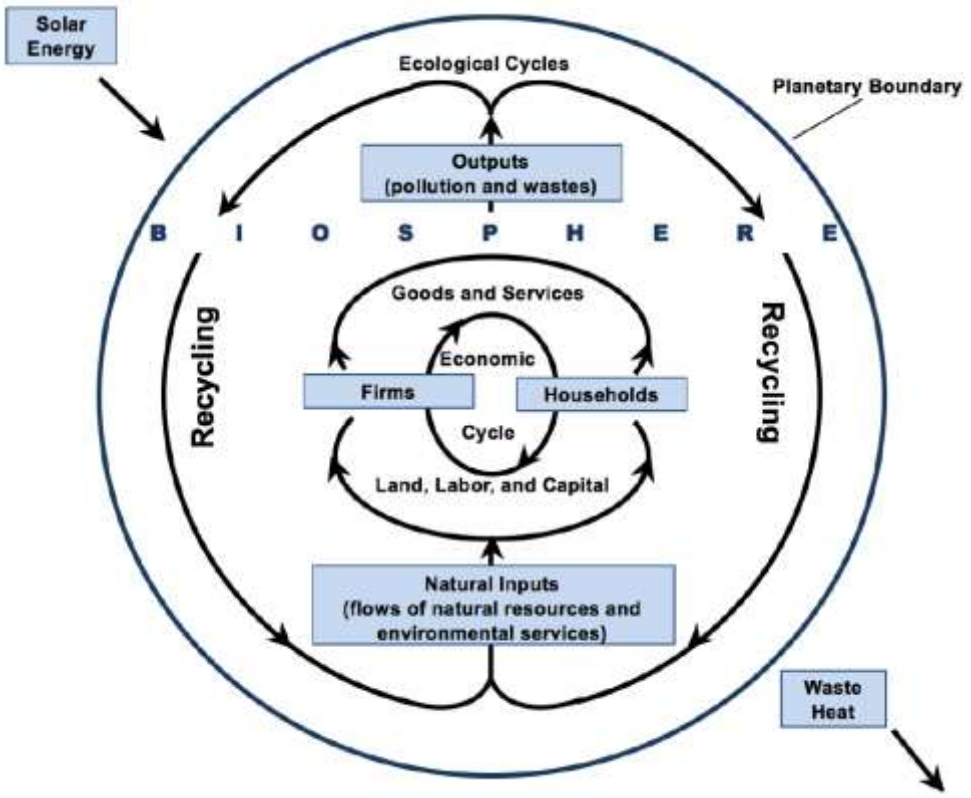


Figure 3: Extended circular flow model

Source: Harris & Roach (2017)

In this extended flow model, the essential inputs of solar energy and natural resources are recognized. This indicates that the human well-being is dependent on these resources and thus there should be alternative indicators to measure human well-being in place of standard economic metrics such as gross domestic product (GDP). Similarly, the waste pollution and waste in the production process are also recognized (Harris & Roach, 2017). Both these aspects suggest that the economic system is constrained by the availability of natural resources and the ability of the environment to absorb and digest pollution. Moreover, in a similar model, Stead and Stead (2014) have indicated that, in the broader flow, there is only one net input as solar energy and one net output as waste heat. Hence, it is imperative to factor environmental factors into the economic decision making.

2.2.2 The Pigouvian principle

Another basic tenet in environmental economics is the "Pigouvian" principle which suggests that pollution should be priced at marginal external cost (Goulder & Parry, 2008). The Pigouvian principle can be adopted in the form of a socio-environmental tax which internalize environmental costs (Falloni & Zelinski, 2016). According to Ikeme (2003), the main idea of Pigouvian" principle is also derived from the principle of compensatory justice where an obligation inflicted to compensate for the damage caused to the environment. Moreover, Steininger, Lininger, Meyer, Muñoz, and Schinko (2015) state that, there are three main relevant principles of compensatory justice as,

- Polluter Pays Principle (PPP)- attributes the compensation responsibility to the emitter
- Beneficiary Pays Principle (BPP)- attributes the compensation responsibility to the beneficiary of emissions
- Community Pays Principle (CPP)- attributes the compensation responsibility to members of a community

Internalization of environmental costs would also have an impact on the free flow and the growth of firms. Nevertheless, it is also important to understand that the growth could well be affected by damages to the environment in the absence of

pollution control mechanisms (Stern, 2006). According to Folloni and Zelinski (2016), climate change which is primarily caused by GHG emissions, has profound implications on prosperity and human development. Ultimately, environmental economics can be narrowed down as the use of economic policy instruments with two purposes: the generation of resources to pay for public services of an environmental nature and guiding the behavior of firms towards environmental preservation (Stern, 2006).

With the identification of the importance of preserving nature in the development process, the countries have entered into global level agreements to ensure the protection of environment while achieving the optimum level of economic growth.

2.3 International agreements on global warming

There have been numerous international agreements over various global issues throughout the history. Similarly, the countries have reached collective agreements concerning the issues of environmental pollution. The first such instance was Montreal Protocol in 1987, which was to deal with substances that depleted the Ozone Layer (Velders, Andersen, Daniel, Fahey, & McFarland, 2007). This agreement exerted control over CFCs and HCFCs which are also GHGs with global warming potentials (Hu et al., 2017). However, international agreements directly focusing on climate change were empowered, only after the establishment of UNFCCC, which was adopted at the Rio Summit in 1992 with the aim of stabilising GHG concentrations in the atmosphere (Banan & Maleki, 2013). The focus in these agreements was to limit the global emissions within the assimilative capacity of the environment to avoid harmful natural consequences (Hák et al., 2016). Because it was identified that eliminating harmful emissions completely is not practical with the prevailing development goals and limiting emissions to a level which the environment could safely negate is adequate. The first agreement under UNFCCC was the Kyoto protocol (1997) followed by the Doha amendment to Kyoto protocol in 2012 (UNFCCC, 2018a). The latest agreement under UNFCCC is the Paris agreement which was adopted in 2015 (UNFCCC, 2018b). Those agreements are explained below.

2.3.1 The Kyoto protocol (1997)

Kyoto Protocol contains legally binding emissions targets for 37 countries (including the European Union), also known as Annex I countries to reduce their collective GHG emissions by 5.2% (compared to 1990 level) at the end of the first commitment period (2008- 2012) (United Nations, 1998). The Kyoto Protocol has introduced three flexible mechanisms for developed countries to implement their emission reduction targets: Clean Development Mechanism (CDM), Joint Implementation (JI), and Emission Trading (ET) (Villoria-Sáez, Tam, Merino, Arrebola, & Wang, 2016). The three mechanisms are proposed in order to achieve the quantitative emission reduction targets where CDM and JI are based on projects and ET is based on emission quotas. (Zhang, 2016).

However, there are major criticisms over the success of Kyoto Protocol. According to Prins and Rayner (2007), despite massive economic cost and political capital invested in Kyoto Protocol, it has failed to create a noticeable impact on global carbon emissions. More specifically, Rossen (2015) has revealed that the Kyoto Protocol has failed to produce noticeable reductions in emissions or reductions in expected emission growth. On the other hand, the Kyoto Protocol bind only the developed countries to cut down their GHG emissions, based on the notion that the emissions of developed countries are significantly high compared to that of developing countries. However, according to Grossman and Krueger (1995), it is a misconception to believe that the environmental quality deteriorates with the economic growth. Moreover, the authors explain that, economic growth brings environment deterioration in the initial phase, but it is followed by a phase of improvement subsequently. Hence the strict difference in the way the Kyoto Protocol treats the developed and the developing nations in terms of emission reduction targets is perceived as inequitable (Babiker et al., 2000). On the other hand, Kyoto protocol is top down in nature, as it lays down emission reduction targets for the countries who have signed it (Prins & Rainer, 2007).

2.3.2 Doha amendment (2012)

Doha amendment to the Kyoto Protocol was agreed on the 8th Conference of the Parties in Doha in 2012 (UNFCCC, 2018a). It established a second commitment period from 2013 to 2020 (Dovie & Lwasa, 2017). The influence of the second commitment period was limited to 14% of global emissions because only 27 countries from European Union and Australia have commitments while the Russia, Canada, Japan and New Zealand, who previously signed the Kyoto Protocol have opted out (McCrary, 2017). However, countries without commitments under the Kyoto Protocol have made voluntary pledges for climate action up to 2020 (Erbach, 2015).

2.3.3 The Paris agreement (2015)

The Paris Agreement aims to reinforce the global response to the issue of climate change by maintaining the global temperature rise of this century well below two degrees Celsius above pre-industrial levels and to follow the prospects of limiting it even to a temperature rise of 1.5 degrees Celsius (UNFCCC, 2018b). It deals with GHG emissions mitigation from year 2020 and beyond, where the effective period for the second commitment period of Kyoto protocol ends (Savaresi, 2016). The Paris Agreement requires all parties to estimate their own emission reduction targets through NDCs and to achieve these targets while exerting maximum efforts in the years ahead (McCrary, 2017). The continuous efforts of the parties to achieve NDCs are monitored via regular reports prepared by the parties as part of the agreement (Hood & Soo, 2017).

With the introduction of NDCs system in the Paris Agreement, the parties under UNFCCC are asked to commit voluntarily to their own emission reduction targets (McCrary, 2017). This was aimed at mitigating the differentiation that was created in the Kyoto Protocol between developed and developing nations. Therefore, it is clear that the approach adopted in Paris Agreement is more bottom-up in nature which required the parties to decide on their own emission reduction targets as opposed to the Kyoto Protocol which was top-down in nature with imposed emission reduction targets on the parties (Pan, Elzen, Hohne, Teng, & Wang, 2017).

The current UN emission allocation system uses a production-based principle which attributes GHG emissions to the country in which emissions physically occur during production (Steininger et al., 2015). However, according to Liang, Qu, Zhu, Guan, and Xu (2016), the production-based allocation method neglects indirect GHG emissions embodied in the supply chain, which encourage carbon leakage. Carbon leakage happens when firms offshore production activities to avoid limitations of emission quotas in mother country. Therefore, there are three other emission accounting principles as extraction-based principle, income-based principle and consumption-based principle (Steininger et al., 2015). In extraction-based principle emissions are allocated based on where the fossil fuels are extracted. In consumption-based principle, emissions are allocated according to the place of final consumption (Davis & Caldeira, 2010). On the other hand, in income-based principle, emissions are attributed to specific agents along the supply chain based on the income levels earned (Liang et al., 2016).

2.4 Emission reduction policy instruments

After the 21st conference of Parties under UNFCCC was held in Paris where the Paris Agreement was negotiated, the countries were expected to develop and introduce policies to achieve pledged emission reduction targets (Baranzini et al., 2017). For many years, numerous policy instruments have been implemented by various countries with the aim of reducing GHG emissions. These include both direct command-and-control instruments which are regulatory instruments and incentive-based instruments (Goulder & Parry, 2008). Command and control instruments include policies such as emission cap per unit of output, performance standards and mandates, licenses and bans (Dinica, 2009; Parry & Williams, 1999). On the other hand, Goulder and Parry (2008) indicated that incentive-based instruments include environmental taxes, ETS and subsidies for pollution abatement.

Moreover, Sorrell and Sijm (2003) have classified emission reduction policy instruments as price-based instruments and non-price-based instruments. Further, according to Andrew and Kaidonis (2011), there are three main policy instruments available to governments for imposing a price on greenhouse emissions as ETS,

carbon tax or an emissions fee and regulations on emissions to push polluting firms to reduce their emissions.

As the impacts of climate change and global warming emerge more evidently, the number of policy instruments also grows rapidly with the potential for interaction between these instruments (Sorrell & Sijm, 2003). Moreover, according to the authors, the scope of these policy instruments is not confined as they also interact with policies in a wide range of areas such as energy, environment, transport, trade, fiscal, technology, agricultural, and social policy.

The implementation of policy instruments would result in economic costs to government. Therefore, it is imperative to understand the nature of the costs and to select the appropriate policy instrument with the minimum economic cost to enhance the potential of a lasting policy instrument (Parry & Williams, 1999). However, the selected policy instrument should have the capacity to achieve emission reductions through a wide range of aspects including changes in behavior which condemn energy wastages and change in consumption pattern which encourages consumer to buy cleaner products over dirty products and innovations of energy efficient and low carbon technologies (Baranzini et al., 2017).

According to Cong and Lo (2017), during the past ten years, the world has witnessed a shift in climate policy preference from non-price based command and control instruments to price-based market instruments. Liu, Tan, Yu, and Qi (2016) have highlighted the reason for this shift from command and control instruments as high cost, referring to China's increased recent focus on market-based instruments such as ETS. Moreover, Baranzini et al. (2017) argue that the popularity of carbon pricing instruments has grown due to their ability to meet ambitious emission reduction targets. According to the authors, low emission reduction levels and high cost of abatement activities are more likely with non-price-based policy options which can also jeopardize potential future emission reduction targets. On the other hand, price-based instruments provide the incentive for the firms to innovate and achieve emission reductions above a stipulated standard (Lo & Francesch-Huidobro, 2017). Moreover, Parry (2003) has a similar perception about the other non-price-based

instruments, explaining that they are inefficient, as the emission reduction targets are achieved at the expense of a massive economic cost compared to price-based instruments like emissions taxes and emissions trading schemes. Carbon pricing works on the energy sources in proportion to carbon content of the energy source as the emissions are proportional to the carbon content (Baranzini et al., 2017).

Andrew and Kaidonis (2011), highlighted that, when the firms receive a price signal, they will change accordingly by changing from carbon fuels to renewable green energy sources. According to the authors, this behavioural change is a key outcome of carbon pricing. Moreover, many governments have accepted carbon pricing as a method to insert a market-based cost component into the relative cost of energy sources based on their carbon emission levels (Jenkins, 2014). Baranzini et al. (2017) and Hong, Chu, Zhang, and Yu (2017) have suggested that carbon tax and emissions trading system as the two main instruments of setting up a carbon price. Moreover, according to Parry and Williams (1999), the economists and carbon policy developers have identified carbon taxing and ETS to be more effective over other emission reduction policy instruments.

In a carbon tax system, the price of emissions is known as the tax rate is set at the initial step, while the total emission quantity after the tax system takes effect is not known (Goulder & Parry, 2008). Authors highlight that, the change of behavior of different firms in response to the imposed tax is uncertain. On the other hand, in an ETS, the total emission quantity is known as the carbon cap is decided at the outset, but the price of emissions is not known as the price is depend on the market behavior (Rezaee, Dehghanian, Fahimnia, & Beamon, 2015).

However, the selection of the most appropriate policy instrument to a particular scenario is not straight forward, as they need to be evaluated on criteria like emission reduction potential, cost effectiveness and political sustainability (Goulder & Parry, 2008). Moreover, the authors explain that the distribution of benefits or costs across income groups and the level of certainty attached are some of the other criteria that need to be looked in to. Simultaneous implementation of two policy instruments interactively is a possibility, but there is also a risk of interference between the

policies which would hinder the realization of objectives of both the policies (Sorrell & Sijm, 2003).

2.4.1 Carbon tax system

Carbon tax is a consumption tax which is based on the carbon content of fossil fuels with the ultimate focus of reduction of carbon emissions (Lin & Li, 2011). In practice, the tax is levied on the fossil fuels based on their carbon content as carbon emissions are proportional to carbon content of the fuel (Goulder, 1992). Thus, according to the author, a tax whose value is based on the carbon content of a given fossil fuel is effectively a tax relative to CO_2 emissions.

Carbon taxes have existed for nearly 30 years (Liu, Ishikawa, Wang, Dong, & Liu, 2010). The first country to implement a carbon tax system was Finland in 1990 (Liu, Wang, Niu, Suk, & Bao, 2015). The basic concept behind carbon tax is Pigouvian principle (see Section 2.2.2) which focuses on internalising negative externalities into the market price to create market signals which would ultimately reduce GHG emissions (Lin & Li 2011; Wang et al., 2016). This concept is found to be successful as the environmental costs associated with fossil fuel use are mostly external to the firms unless otherwise a carbon pricing instrument is used. Hence the introduction of carbon taxation can be perceived as a corrective tax, which would seek to internalize the environmental costs of fossil fuel usage, which are external to market decisions. Thus, this promotes reduced fossil fuel use by firms.

With increased impetus and urgency to international climate negotiations and subsequent actions with national emission reduction pledges of member countries in the Paris Agreement, the carbon tax has received significant attention as an economic instrument for emission reduction (Wang et al., 2016). When a carbon tax is imposed, a firm may look to mitigate emissions and associated energy consumptions by long term investments such as low carbon innovation and installation, which will also make them more competitive in the market (Dong et al., 2017). Moreover, the firms will be motivated to reduce the burning of fossil fuels through energy efficiency and moving away from carbon intensive fuels in the power sector by substituting them with alternative energy sources (Siriwardena et al., 2007). Firms

prefer carbon taxes over other emission reduction policy instruments, as carbon taxes provide certain price signals which are long term, allowing firms to incorporate carbon costs in to forecasts of operating expenses (Sumner et al., 2011).

In addition to inducing behavioural change of firms, collection and utilization of carbon tax revenue is another important aspect that defines the success of a carbon tax system as an emission reduction policy instrument (Kibria, Haroon, & Nugegoda, 2018). The collected tax revenue could be used in many ways, while using it to fund carbon mitigation programmes is the best option from an emission reduction standpoint (Sumner et al., 2011). Moreover, Liu and Lu (2015) emphasise that the selection of proper revenue distribution method is very important for the public acceptability and political sustainability of a carbon tax system. Because, if the firms recognize carbon tax as a just another method that the government use to raise revenue for government budget rather than a genuine effort to combat rising GHG emissions, they would not be willing to pay the stipulated tax (Rausch, Metcalf, & Reilly, 2011).

2.4.1.1 Design considerations of carbon tax system

Despite succeeding as a market-based emission reduction policy instrument in many countries, the implementation of a carbon tax is not a straightforward task as it entails numerous design considerations. Policy design considerations include the sectors from whom the tax to be levied, the tax rate, use of tax revenues, possible impacts on consumers, and tracking the emissions reduction goals (Wang et al., 2016).

Selection of the sectors to be governed

Carbon taxes generally work with other emission reduction policies concurrently to achieve significant emission reductions and hence the scope of carbon tax has been limited to certain sectors (Sumner et al., 2011). Moreover, it is the government that decides the energy sources on which the tax is imposed (Burke, 1997). According to the above author, in general, carbon taxes are imposed on gasoline, coal and natural gas as direct sources and on electricity as an indirect source where CO_2 content of electricity will depend on the composition of country's electricity generation.

Carbon tax rate

When it comes to the tax rate, it is generally determined based on the marginal damages caused by the emissions (Kerkhof, Moll, Drissen, & Wilting, 2008). Conversely, Liang and Wei (2012) suggest that the tax rate could also be based on what is considered as politically feasible, marginal abatement cost of carbon or budgetary requirements of the government. Since the environmental damages caused by emissions depend on the quantity rather than the value of fossil fuels burned, carbon taxes are designed as specific or unit taxes as opposed to designing as an ad valorem tax which is based on the value (Goulder, 1992).

However, determining the ideal tax rate is often difficult as quantifying environmental damage is a strenuous task (Sumner et al., 2011). When the aggressiveness of the carbon tax is increased, or in other words when the tax rate is increased, the capacity of the carbon tax system to induce change in behavior and consumption patterns also increases with it (Wang et al., 2016). While higher tax rates create stronger price signal that can induce behavioural change, the lower tax rates may have lesser influence in changing behavior but can still accumulate tax revenue which can be ideally used to fund carbon mitigation programmes (Sumner et al., 2011). Gerlagh and Lise (2005) hold the opinion that the full use of carbon tax system in reducing emissions will not be experienced if it cannot stimulate technological development, which can only be done by imposing a notable tax rate.

2.4.2 Emission trading system (ETS)

ETS is a market-based system derived from the principle of ‘cap’ and ‘trade’, where ‘cap’ puts a limit and ‘trade’ establishes a market to transact carbon permits between liable entities, who aim to improvise in order to meet or come below their allocated limit (Chaabane, Ramudhin, & Paquet, 2012). In this system, the ‘cap’ is decided by the regulator of the country or the region in line with their emission reduction targets and later distributes the allowable permits among individual firms under in a reasonable manner (Hong et al., 2017). However, Morthorst (2003) emphasized the importance of setting the emission reduction targets at an optimum level, because a policy which is either too rigorous or too liberal could affect the environmental and

economic benefits and the social welfare. On the other hand, Daskalakis, Psychoyios, and Markellos (2009) suggest that the government should continuously look for the feedback of firms and alter the emission reduction targets accordingly to achieve the maximum environmental, economic and social benefits.

European Union Emission Trading System (EU ETS) is the worlds first and oldest carbon trading scheme which was implemented in 2005 (Xiong, Shen, Qi, Price, & Ye, 2016). EU ETS was implemented in two phases, while adding changes progressively. The first phase was the trial phase which took place from 2005 to 2007 and the second phase was the execution phase which was in line with the first phase of the Kyoto Protocol, spanning from 2008 to 2012 (Zhang, 2016). Cong and Wei (2010) described the initiation of carbon markets as a pathway for the Annex 1 (see Section 1.1) countries to realise Kyoto Protocol emission reduction targets. However, with the Parris Agreement coming into effect in 2005, the developing countries are also urged to take steps to combat global warming (Li & Haasis, 2017). Therefore, ETS are being increasingly adopted by countries around the world to achieve emission reductions or NDCs.

2.4.2.1 Design considerations of ETS

Implementation of an ETS requires several bases to be covered, including legal environment, institutional setup, program structure and allocation mechanism (Xiong et al., 2016). Furthermore, Zhang, Wang, Shi, Li, and Cai (2016) state that the regulator needs to pay attention to various design considerations including allowance allocation principles, benchmark carbon prices, penalty rates and subsidy rates to establish an effective ETS. However, Xiong et al. (2016) asserted, allowance allocation and allowance distribution as the two most important aspects to be considered when designing an ETS, as they define the balance between the sustainability of the scheme and the underlying environmental and economic benefits generated by the scheme. Allowance allocation mechanism explains the process of determining total initial emission cap and individual emission caps for firms covered by the ETS while allowance distribution governs the allotment of the derived allowances for firms and continuous management of these allowance in the post distribution period (Cong & Wei, 2010). While there are many factors to be

contemplated when deciding on a total cap, Hong et al. (2017) asserts that environmental bearing capacity is an essential constraint to be considered (see Section 2.3).

Allowance distribution mechanisms

After determining the total emission cap and individual emission allowance, there are two approaches that can be used to distribute carbon permits as grandfathering and auctioning (Benz, Loschel, & Sturm, 2010). However, there are pros and cons attached with both the approaches. According to Sijm, Neuhoff, and Chen (2006), when 100% free distribution or godfathering approach is used, some firms with higher bargaining capacity over consumers would experience windfall profits by passing the opportunity cost of pollution licenses to consumer prices. Moreover, Rose and Stevens (1993) contended that grandfathering can lead to corruption and disputes between firms and between firms and regulator. However, the resistance from firms when implementing the ETS would be less due to the reduced costs to the firms (Cramton & Kerr, 2002). On the other hand, allowance distribution from auctions raises public revenue, which offers the potential to fund emission reduction programmes or reduce distortionary taxes (Zhang et al., 2016). Furthermore, Benz et al., (2010) argue that the auctioning is a fair approach as it avoids the possibility of windfall profits and holds the characteristics of 'polluter pays principle' (see Section 2.2.2) firmly compared to grandfathering. Nevertheless, auctions have the disadvantage of greater management and enterprise costs (Liao, Zhu, & Shi, 2015). From an all-inclusive point of view, Cramton and Kerr (2002) identify auctions as the more advantageous approach which brings more benefits to the society. But when looked at from the firms' side, auctioning is a costlier approach, as the firms have to incur for both abatement and purchasing allowances for residual emissions, whereas in grandfathering, firms only have the cost of abatement (Sorrell & Sijm, 2003).

Alternatively, Xiong et al., (2016) have demonstrated the potential of integrating grandfathering and auctioning overtime, which is identified as an effective approach. A key example for this phenomenon is allowance distribution system used in EU

ETS, where grandfathering, which was used at the beginning, gradually transformed in to auctioning (Martin, Muuls, & Wagner, 2015).

There are two options under grandfathering approach as output-based allocation rule and emissions-based allocation rule (Bohringer & Lange, 2005). Under these two options, free allocation and distribution of carbon permits can be done in proportion to historical emissions or quantity of output (Benz et al., 2010). On the other hand, output based allocation rule assigns an emission cap for each industry and allocate emission permits proportional to the market share of each firm within the industry's output (Bohringer & Lange, 2005).

Price signaling, allocation efficiency, simplicity and revenue raising are the essential criteria that an effective auction should consist (Liao et al., 2015). Reliable price signaling induces behavioural change and allows firms to select abatement measures efficiently (Benz et al., 2010). According to the authors, reliable price signals indicate how scarce the emission allowances are in the system. Generally, auctioning is identified to be capable of revealing information that helps to create dependable price signals (Anger, 2010). As for the allocation efficiency, allowance need to be allotted to firms which need them mostly to comply with their commitment (Liao et al., 2015). Auctioning should be simple and transparent to facilitate the maximum participation of firms and to avoid market manipulation (Benz et al., 2010). Moreover, authors suggest that a simple auction would reduce the cost of entry (training and consulting). Even though raising revenue is another relevant criterion of auctioning, it is not the prime objective and hence should not be given priority at the expense of the criteria (Cong & Wei, 2010). Furthermore, over or under supplied firms will not be that much prevalent in an industry where auctioning is used (Tang et al., 2015). Because, the authors suggest that there will be minimal variations between the firms permit requirement and the allocation, as the firms only purchase permits that cater for the requirement during the auction.

Transaction of carbon allowances

After the initial allocation and distribution of carbon credits, the firms either retain, buy or sell carbon credits based on their requirement in a secondary carbon market

(Tang et al., 2015). At the end of the given period (assume one year), the firms that emit less than the allotted limit may bank the excess permits for future use or may sell them to other firms who are seeking permits (Cong & Lo, 2017; Li & Haasis, 2017). In the secondary market, the price of carbon permits is depended on the subsequent demand and supply created by the firms (Hong et al., 2017: Li & Haasis, 2017). In other words, this suggest that the firms are at the freedom of exchanging carbon permits in the carbon market with a certain price attached. According to Zhang (2016), the prices are uncertain and tend to vary rapidly in the carbon market as the demand changes due to factors such as energy demand, energy price and irregular weather.

The potential penalties attached to non-compliance is significantly high in an ETS (Cong & Lo, 2017). Hence it is imperative for all firms to either acquire adequate carbon permits or to reduce emissions to match the existing permits. According to Hong et al. (2017), firms may either use green technology or regular technology or a combination of the two in the business processes. Author explains that the green technology ensures reduced emissions, however it costs more than the regular technology. Li and Haasis (2017) demonstrate, ETS as a better approach compared to traditional command and control systems, as it offers one solution to firms, in the form of carbon markets, to meet the cap before suffering significant penalties.

2.5 Existing carbon pricing initiatives in the world

The first carbon tax initiative was taken in Finland back in 1990 and the first ETS instrument is EU ETS which commenced in 2005. Since then, with the introduction of NDCs, many countries, states and regions around the world have adopted carbon pricing instruments with the aim of reaching NDCs (Haities, 2018).

As of 2017, 42 national and 25 subnational jurisdictions are putting a price on carbon under 47 carbon pricing initiatives (World Bank, 2017). Moreover, according to World Bank (2017) over the past decade, the number of jurisdictions with carbon pricing initiatives has doubled. These subnational jurisdictions include cities, states, and subnational regions.

Table 1 indicates a list of carbon pricing initiatives which have been implemented in different countries with the aim of achieving emission reductions.

Table 1: Jurisdictions which have implemented carbon pricing instruments

Carbon pricing initiative	**Year implemented**	**Carbon price (US$/tCO2e)**
Carbon tax- Finland	1990	73 (Liquid transport fuels) 69 (Other fossil fuels)
Carbon tax- Poland	1990	<1
Carbon tax- Sweden	1991	140
Carbon tax- Norway	1991	56 (Upper) 4 (Lower)
Carbon tax- Denmark	1992	27
Carbon tax- Slovenia	1996	20
Carbon tax- Estonia	2000	2
Carbon tax- Latvia	2004	5
EU ETS	2005	6
SGER- Alberta	2007	24
ETS- Switzerland	2008	7
ETS- New Zealand	2008	13
Carbon tax- Switzerland	2008	87
Carbon tax- Liechtenstein	2008	87
Carbon tax- BC	2008	24
RGGI	2009	4
Carbon tax- Iceland	2010	12
CaT- Tokyo	2010	14
Carbon tax- Ireland	2010	24
Carbon tax- Ukraine	2011	<1
ETS- Saitama	2011	14
CaT- California	2012	15
Carbon tax- Japan	2012	3
CPM- Australia	2012 - 2014	

Carbon pricing initiative	Year implemented	Carbon price (US$/tCO2e)
CaT- Québec	2013	15
ETS- Kazakhstan	2013	
Carbon price floor- UK	2013	24
ETS- Shenzhen pilot	2013	6
ETS- Shanghai pilot	2013	5
Pilot ETS- Beijing	2013	8
Pilot ETS- Guangdong	2013	2
Pilot ETS- Tianjin	2013	1
Carbon tax- France	2014	36
Carbon tax- Mexico	2014	3 (Upper) <1 (Lower)
Pilot ETS- Hubei	2014	2
Pilot ETS- Chongqing	2014	<1
ETS- Korea	2015	18
Carbon tax- Portugal	2015	8
BC GGIRCA	2016	
ERF Safeguard Mechanism- Australia	2016	
ETS- Fujian pilot	2016	5
CAR- Washington	2017	
CaT- Ontario	2017	15
Carbon tax- Alberta	2017	16
Carbon tax- Chile	2017	5
Carbon tax- Colombia	2017	5
ETS- Massachusetts	2018	
Carbon tax- South Africa	2018	
National ETS- China	2017	

Source: World Bank (2017)

Prices are not necessarily comparable between carbon pricing instruments because of differences in the sectors covered and allocation methods applied, specific exemptions, and different compensation methods (World Bank, 2017).

2.6 Decision alternatives available for firms in response to carbon pricing instruments

The implementation of a carbon pricing instrument is perceived as an addition to the production costs of the firms (Neuhoff, 2010). Hence, authors indicate that the firms need to respond to this additional cost to negate the effect on business profitability. The response of firms to carbon pricing initiatives vary from one firm to another. This is because the availability of numerous decision alternatives for apparel firms in response to carbon pricing instruments. Further, the selection of a suitable decision alternative is influenced by multiple criteria, as it can affect the dynamics of the firm (Goulder & Parry, 2008). Numan-Parsons, Stroombergen, and Fletcher (2011) suggest that understanding firms' responses to carbon pricing initiatives is very important to determine the potential outcomes or aggregate emission reductions of the initiatives. In fact, according to Bumpus (2014), firms' response can vary from adopting highly aspired low carbon retrofits to unproductive absorption of carbon price to current activities. In addition to that, firms could pass the burden to other stakeholders like consumers or suppliers through price manipulations (Henderson et al., 2017). Moreover, firms may even look to adjust inputs, outputs or production processes to reduce impact of carbon pricing (Wang et al., 2016). However, the responses of firms depend on the conditions of the market and the characteristics of the firms.

2.6.1 Shifting cost to consumers

Shifting cost to consumers is one of the straightforward options available to the firms. However, Henderson et al. (2017) explains that the firms' ability to pass the cost to consumer will depend on the price elasticities of demand and supply of a particular good. In a market where the elasticities of demand and supply is low for a particular product, the proportionate change of demand and supply in relation to a change in price is smaller (Sorrell & Sijm, 2003). Hence, it will be easy for firms to

transfer additional cost of carbon pricing to consumers when the price elasticity is low. Moreover, bargaining power of a firm over its consumers is also critical in firms' ability to shift the additional costs to consumers through price adjustments.

2.6.2 Shifting cost to suppliers

Firms have the option of passing the cost of carbon pricing to suppliers by negotiating supplier prices (Henderson et al., 2017). However, again, the firms' ability to influence suppliers will be dependent on the bargaining power of a firm over its suppliers. A superior bargaining power of firms will ensure that the additional costs are passed on to the suppliers.

2.6.3 Adjusting inputs, outputs or production processes

Firms have the option to respond to cost increase due to carbon pricing by adjusting its inputs, outputs and production processes (Wang et al., 2016). According to Bumpus (2014), firms could either avoid high carbon intensive inputs or cease to produce high carbon intensive outputs. Neuhoff (2010) suggests that deep decarbonisations are achievable by shifting to low carbon inputs and products with low life-cycle emissions. Moreover, following low carbon production process also assist in minimising the carbon emissions attached to the production process (Numan-Parsons et al., 2011).

2.6.4 Absorbing the additional costs

As explained earlier, for firms, the price elasticities of their products will determine to a large extent whether they can easily transfer their tax burden to consumers or not. Hence, sectors producing higher price elasticity products and less bargaining power may have to absorb the tax burden (Wang et al., 2016). However, Hoffman (2005) explains that, some firms consider carbon pricing instruments as a compliance cost rather than an opportunity to innovate and adopt low carbon technologies.

2.6.5 Investing in new technologies

This is the most aspired outcome of implementing a carbon pricing instrument, as it ensures long-term emission reductions (Neuhoff, 2010). The firms have the option of

either purchasing new technologies from external suppliers or developing internally (Anderson, Convery, & Maria, 2010). However, usually, low carbon high efficient energy retrofits are considered as massive investments (Bumpus, 2014). Moreover, Martin and Rice (2010) identify low-carbon investments as high-risk options due to the uncertainties attached with the climate policies.

2.7 Carbon pricing revenue utilisation

Both carbon tax and ETS are emission reduction policy instruments which can raise revenue while inducing behavioural change in firms (Sumner et al., 2011). However, the difference is that, while carbon tax system continues to accumulate revenue as long as the tax is imposed, ETS will only collect revenue at the initial allocation phase, that too only if the allowances are auctioned (Wittneben, 2009). After the initial allocation, the governing body does not get any revenue as the allowances are only transferred between the firms in a secondary market.

As mentioned earlier, proper revenue utilization of carbon pricing instruments could ensure technological development targeted at reducing GHG emissions (Gerlagh & Lise, 2005). In a study conducted by Lin and Li (2011), it has been revealed that only few firms in Netherland were aware of the existence of carbon tax after two years of its enforcement, as the carbon tax had been internalized into energy costs of the firms. This means that the cost of carbon tax is considered as a business as usual cost for most firms. Hence, the level of behavioural change expected to be induced by the carbon tax diminishes over the time. As this aspect of carbon tax system is weakening, it is required to have a proper revenue utilisation mechanism to ensure the durability of the system. Moreover, Sumner et al. (2011) have stated that the choice of revenue utilization method at the start would impact the political sustainability of the tax. Moreover, according to Wang et al. (2016), a carbon tax without revenue recycling, tends to be regressive which puts more burden on low income firms. According to authors, this is because the low-income firms lack the high efficient technologies which come at a greater cost.

Throughout literature, below three main revenue utilization options were explained.

2.7.1 Funding carbon mitigation programmes

This is the more perceived approach of utilisng revenues, from an emission reduction perception. In this, governments or the regulating bodies earmark carbon mitigation programmes (Kibria et al., 2018). According to authors, when the carbon mitigation programmes are earmarked, it limits the incentive to regenerate tax revenue or auction revenue, as these projects are aimed at reducing emissions. Sumner et al., (2011) have identified reforestation programs, investment in research and development of low carbon and energy efficient technologies as carbon mitigating programmes on which the collected revenue could be invested.

2.7.2 Using revenue to supplement government budgets

The second approach is to absorb tax revenues into government budgets. This is an approach which can cause political opposition from both public and the industries covered by the tax. Even though it is clear that this approach is not popular among relevant parties, countries such as Sweden and Norway are using tax revenue to enhance government budgets (Sumner et al., 2011). When the revenue is absorbed into the government budget, it is difficult to ensure that the revenue is utilized back to fund carbon mitigation programmes. Because many people argue that, carbon pricing is just another way of raising revenue for government rather than a method to provide environmental benefits (Liang et al., 2016). A fine example for this is the public opposition to carbon tax imposed on vehicles in Sri Lanka, as there is no clear revenue utilization mechanism (Claessen, 2019). Moreover, according to authors, in a scenario where the revenue is not distributed back to the firms in some way, the enforcement of carbon pricing instruments affects the production of energy intensive industries and create a negative impact on GDP.

2.7.3 Reduction of other taxes such as income taxes

This is considered as a revenue neutral approach, as it does not raise revenues for government or other governing bodies or emission reduction programmes. According to Parry (2003), revenue neutral approaches could yield double dividends by reducing emissions and also by mitigating prevailing tax distortions due to taxes such as income taxes. Moreover, Sumner et al. (2011) identified that the cut down of

distortionary taxes as an approach that saves cost than when they are given in lump sums. However, the revenue neutral approaches do not ensure emission reductions, instead they ensure the market competitiveness of firms which are covered by carbon pricing instruments.

2.8 Drawbacks of carbon pricing instruments

As explained in above sections, carbon pricing instruments have been identified as the most cost-effective policy instruments for GHG emission reduction. Nevertheless, like with any other policy, implementation of carbon pricing policy instruments entails drawbacks which need to be identified and addressed.

It is understood that in the short run, there is a possibility for the cost of the firms to go up when a carbon pricing instrument is enforced and this could result in firms shifting the increased costs to consumers through increased prices (Sumner et al., 2011). Hence, according to Lin and Li (2011), carbon pricing will result in increase of fiscal revenue. However, the shift of price is only possible for products with low market elasticity, which also leads to low mitigation effects.

There is also a risk of impacting the profitability of energy intensive industries in the initial stages. According to Liu et al., (2015), when a carbon tax system is enforced for an energy intensive industry, the cost of production increases impacting the profit generating ability of the firms. On the other hand, studies have revealed that carbon tax is regressive, where the tax burden falls more sharply on low income firms (Jiang & Shao, 2014). However, proper utilization of revenue could mitigate the regressive impact of the tax system (Baranzini et al., 2017). On the other hand, if the revenue is absorbed into government budgets, without recycling back to the firms, the cost of firms will be increased which will then decrease the public acceptability of the carbon tax system (Baranzini & Carattini, 2016).

Moreover, Wang et al., (2016) have stated that the carbon pricing creates negative impacts on the international competitiveness of industries. As a solution to this, carbon intensive industries seek to immigrate to countries with more liberal emission boundaries (Lin and Li, 2011). This phenomenon is known as carbon leakage (see Section 2.3.3), where the emission levels of other countries increase due to emission

reduction policies of a particular country (Benz et al., 2010). Even though carbon leakage will not hinder the emission reduction targets of a country, it is still not effective as the global emission levels are not going to be reduced.

In order to enhance the public acceptance and political enforceability, the optimal carbon pricing designs often undergo fiscal cushioning. Nevertheless, the changes to the optimal design such as tax exemptions, initial free allocations and diminished tax rates could result in lower emission reductions (Sumner et al., 2011).

There is a difficulty in quantifying the emission reductions which have occurred due to carbon taxes. Some countries gauge this performance of the carbon tax system by measuring the overall reductions, which can include emission reductions due to other variables as well (Murray & Rivers, 2015). Moreover, authors highlight that some countries measure effectiveness of the carbon tax system by referring to impacts created by emission reduction programmes funded by carbon tax revenues. However, this is only a part of emission reductions as it does not account for reductions due to behavioural changes of firms induced by carbon tax (Sumner et al., 2011).

Despite vast availability of scientific evidence on the effectiveness carbon pricing policy instruments in reducing energy consumption and associated emissions, many countries that are experiencing the pressure to control carbon emissions are still hesitant to take actions to implement a carbon/GHG tax or a carbon ETS due to above drawbacks. Nevertheless, it is important to mitigate above drawbacks by a proper carbon pricing design to address the critical issues of global warming and climate change.

2.9 Sri Lankan apparel industry

Apparel industry is one of the massive energy consumers that causes extensive environment damage (Claudio, 2007). More specifically, the contribution of apparel sector towards overall carbon emissions in the world is a staggering 10% (Conca, 2015). The situation in the Sri Lankan apparel sector in a sustainable perspective is not different to global context.

Sri Lankan manufacturing industry is highly energy intensive with apparel sector accounting for major portion of energy consumption due to its massive growth (Sri Lanka Sustainable Energy Authority, 2016). Apparel manufacturing industry is the largest export industry in Sri Lanka with a contribution of 52% to the total industrial product exports (Sri Lanka Export Development Board, 2018). Due to the high energy intensity and GHG emissions of the apparel sector, it is identified as an industry with massive emission reduction potentials.

2.10 Theoretical framework

The theoretical framework (Figure 4) indicates a summary of key literature findings. It depicts how the international agreements were introduced based on the environmental economics principles and how the emission reduction policy instruments came up after the international agreements. Further, the outcomes of carbon pricing instruments are highlighted as this study is focused on carbon pricing instruments. The decision criteria which will be considered when selecting decision alternatives by apparel firms when responding to carbon pricing instruments were not available in literature and hence were identified through preliminary survey.

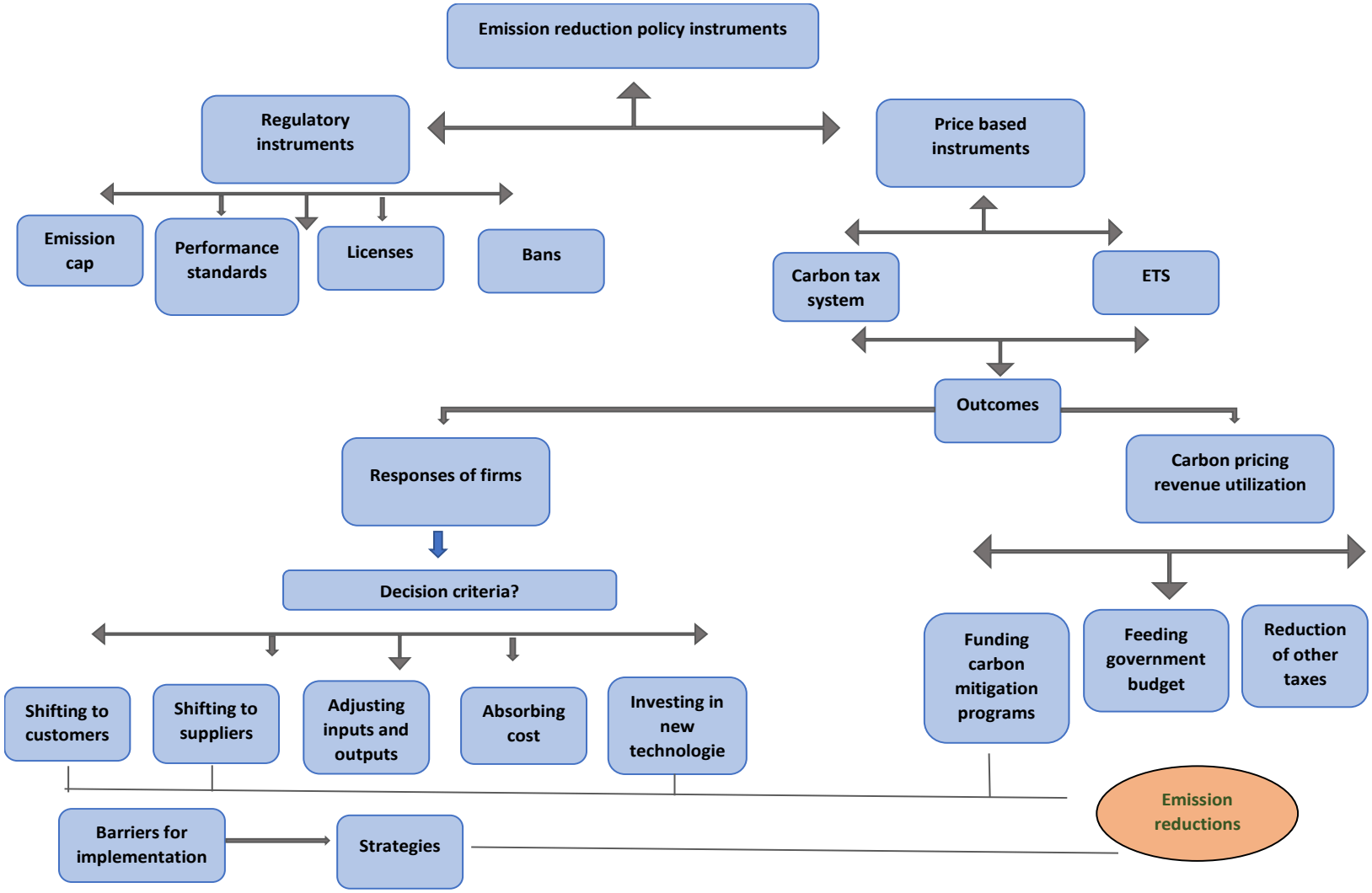


Figure 4: Theoretical framework

2.11 Summary

Carbon pricing instruments are identified to be highly effective in achieving emission reduction goals. With the advent of Paris Agreement and the introduction of NDCs, both developed and developing nations are looking for emission reduction initiatives. Hence carbon pricing instruments are expected to play a significant role in achieving the emission reduction goals of individual countries. Through the literature review, it was identified that the price-based emission reductions are effective in achieving cost efficient and sustained emission reductions. Moreover, carbon tax system and emission trading system are identified as the most productive price-based emission reduction policies. However, the implementation of a carbon pricing instrument is not a simple process. The implementation of carbon pricing instruments is attached with numerous design considerations. Further, the response of apparel firms is also uncertain, which can affect the overall emission reduction capabilities of the carbon pricing instruments. The response of apparel firms is governed by multiple criteria which was not presented in existing literature. As carbon pricing is a comparatively new concept for South Asian countries like Sri Lanka, its potential in terms of emission reduction capabilities should be explored.

3.0 RESEARCH METHODOLOGY

3.1 Introduction

The focus of this chapter is to provide an insight into sequential steps used to achieve the aim of the research. It explains in detail the research methodology used for the research including research approach and research process. According to Fellows and Liu (2008), research methodology refers to the sequence of logical thought processes which are incorporated to a scientific investigation. Further, this chapter explains how different activities; literature review, data collection and data analysis combine to achieve the research objectives. Hence, this chapter elaborates research design, research approach, research process and research techniques. Under research techniques, the data collection and data analysis methods of each step of the research process are explained.

3.2 Research design

Research design is a plan to move from the research problem to conclusion (Tan, 2002). Further, according to Maxwell (2008), research design provides the guidance in conducting the research. In other words, research design consists of principles and procedures of logical thought processes which apply to the research (Fellows and Liu, 2008). Hence, it creates the plan for the collection, measurement and analysis of data (Kothari, 2004). The design of this research includes, initial study through literature survey, literature review, preliminary survey, questionnaire survey, expert opinion survey and data analysis respectively.

3.3 Research approach

The research approach aimed at achieving research aim and objectives through research activities (Tan, 2002). More specifically, research approach aids in organising research activities including the data collection to achieve research objectives. Research approaches are more commonly categorised in to two main approaches as qualitative and quantitative (Kothari, 2004). However, a third approach, which is a mix of

qualitative and quantitative approaches is widely used and known as mixed approach (Amaratunga, Baldry, Sarshar, & Newton, 2002).

Qualitative approach is a subjective approach, and it is associated with data which are expressed in words, in terms of judgements, ideas, feelings and beliefs (Walliman, 2011). Further, according to Yin (2013), adopting a qualitative approach is imperative in an in-depth study on broad topics. In this approach, the open ended and emerging data and opinions are expected (Creswell, 2003).

Quantitative approach is an objective approach, which is associated with numerical or statistical data (Williams, 2007). As it is an objective approach, it facilitates strong comparison and replication (Amaratunga et al. 2002). Further, Yin (2011) indicated that, the approach is restricted since it limits the establishment of necessary research conditions and difficulties in drawing sample respondents.

Mixed approach is a combination of qualitative and quantitative approaches within a single study (Johnson & Onwuegbuzie, 2004). Creswell (2003) stated that, the mixed approach is complex in addressing a research problem; however, the biases created by adhering to one method can be overcome by adopting a mixed approach.

In order to achieve the objectives of this research, a mixed approach was used. A quantitative approach was adopted to fulfill objective 2, as it was focused on evaluating the importance of decision alternatives to apparel firms. However, objectives 3 and 4 were achieved through a qualitative approach. In these objectives, the focus was on determining the suitable revenue utilization options and barriers when implementing carbon pricing instrument and strategies that can be used to overcome them in detail, in Sri Lankan context.

3.4 Research process

Polonsky and Waller (2010), have indicated the preparation of an appropriate research process as the initial step of conducting a research. Research process is described as the series of activities necessary to efficiently accomplish research objectives (Kothari,

2004). In other words, it illustrates the linkage of literature review, data collection and data analysis in achieving the research objectives. The research process adopted in this research is depicted in Figure 5.

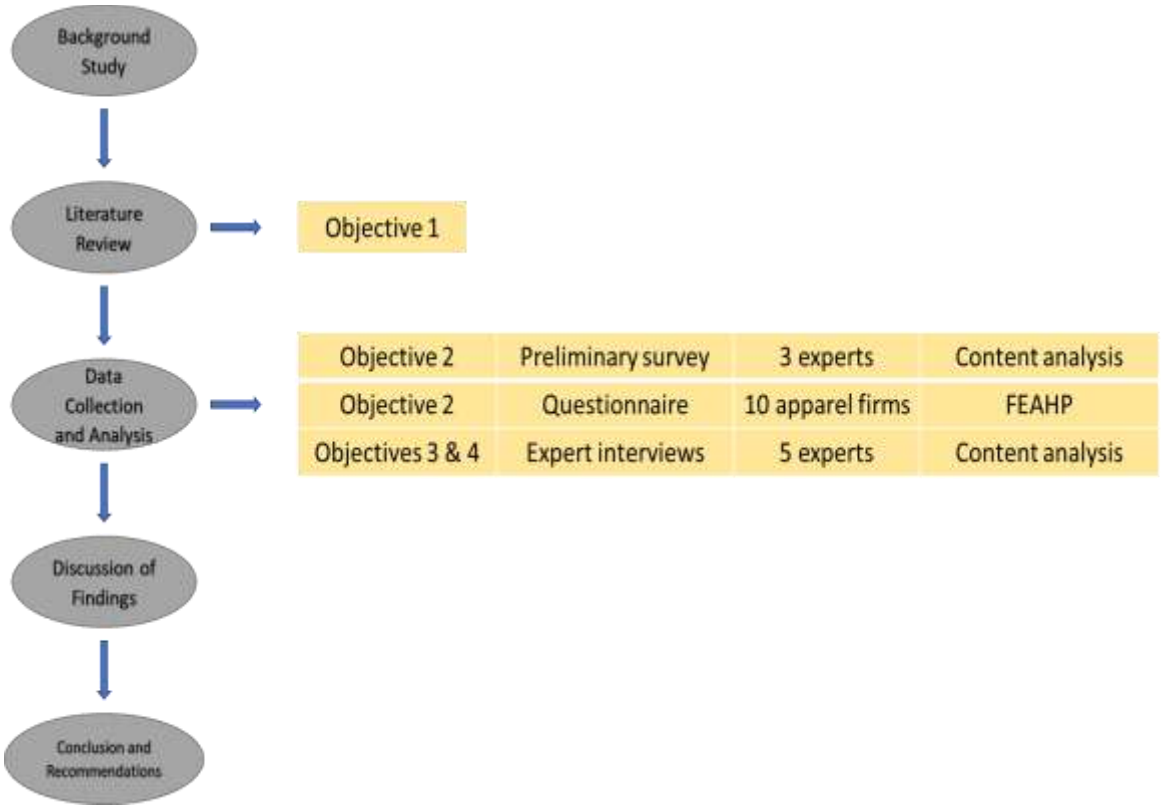


Figure 5: Research process

3.4.1 Initial study (literature survey)

Initial study was conducted mainly to provide the background of the selected research area and to elaborate the research gap and research problem. For this, books, journal articles, conference papers and internet sources were referred. Further, research aim, objectives, scope and limitations are also clarified in the initial study.

3.4.2 Literature review

The purpose of the literature review was to study the research background and research problem in detail by referring to existing knowledge which are published in the forms of books, journal articles, conference papers, reports and online sources.

In this research, the existing literature on key principles of environmental economics, international agreements against global warming, emission reduction policy instruments, and the existing global carbon pricing initiatives were reviewed. More specifically, decision alternatives available for firms in response to carbon pricing instruments and revenue utilisation methods were identified through literature review to support the fulfillment of objectives 2 and 3.

3.4.3 Preliminary survey

Preliminary survey was conducted to validate the literature findings which was carried forward to the questionnaire survey. Accordingly, decisions alternatives available for apparel firms in response to carbon pricing instruments, which were identified through the literature review were validated. In addition, preliminary survey was used to establish the criteria which can be considered by apparel firms when responding to carbon pricing instruments.

For the data collection of the preliminary survey, semi-structured interviews were conducted. Three experts from the sustainability field of the apparel sector in Sri Lanka were consulted as the respondents of the preliminary survey.

The profile of experts is depicted in Table 2.

Table 2: Profile of respondents in preliminary survey

Respondent	Designation	Years of experience
PS1	Senior manager	10-15
PS2	Manager	5-10
PS3	Freelance consultant	15-20

The respondents of the preliminary survey validated the relevance of literature findings to the context of Sri Lankan apparel sector. Therefore, the decision alternatives available for firms in response to carbon pricing instruments which were identified through the literature review were included in the questionnaire. The response of the experts is depicted in Table 3.

Table 3: Applicability of decision alternatives

Decision alternatives	PS1	PS2	PS3
Shifting cost to customers (DA1)	No	✓	✓
Shifting cost to suppliers (DA2)	✓	✓	✓
Adjusting inputs, outputs or production processes (DA3)	✓	✓	✓
Absorbing additional costs (DA4)	✓	✓	✓
Investing in new technologies (DA5)	✓	✓	✓

According to PS1, shifting cost to customers is not an option for export-oriented apparel firms in Sri Lanka, as the customers that they are supplying for are big players with massive bargaining power. However, PS2 and PS3 suggested that, shifting cost to customers is an option which cannot be neglected entirely as there can be negotiations between apparel firms and their customers. The other decision alternatives were validated by all three respondents. Hence, the above five decision alternatives were included into the questionnaire for the pairwise comparison.

3.4.4 Detailed questionnaire survey

Questionnaire survey was conducted to achieve objective 2, which is to evaluate the level of importance of decision alternatives for apparel firms in Sri Lanka when responding to carbon pricing instruments. Ten apparel firms, which were listed as "key players" by the "Sri Lanka Export Development Board" were selected for the study. Hence, the sampling technique for the questionnaire survey was purposive sampling. One expert from each firm was invited to participate in the questionnaire survey and all

the questionnaires were conducted face to face. The questionnaire consisted of a pairwise comparison of decision criteria and decision alternatives (see Annexure 7.4).

3.4.5 Expert opinion survey

An expert opinion survey was conducted to fulfill the last two objectives, which are to determine the suitable revenue utilization options to incorporate with a carbon pricing instrument in Sri Lanka, and to assess the barriers in implementing carbon pricing instruments in Sri Lanka and strategies that can be used to overcome those barriers. Five industry experts who are knowledgeable in the areas of sustainability in apparel sector and carbon pricing instruments were selected for the expert opinion survey. For the data collection, semi structured interviews were conducted (see Annexure 7.5).

3.5 Data analysis techniques

Two data analysis techniques were used to analyse the primary data collected from preliminary survey, questionnaire survey and expert opinion survey. Content analysis was used to analyse data collected from preliminary survey and expert opinion survey, while FEAHP was used as the data analysis technique for questionnaire survey.

3.5.1 Content analysis

In content analysis there are two approaches as inductive approach and deductive approach. According to Bengtsson (2016), in inductive approach, the researcher analyses the text with an open mind to derive ideas from the qualitative answer itself. However, in deductive approach, there are prior studies on a particular subject and are recollected during the analysis process (Heish & Shannon, 2005). According to the above authors, a deductive approach is helpful when the intention of the analysis is to test a previous concept in two different settings or two different time periods. For this research, deductive approach was used where the qualitative answers of experts are transcribed, from which key concepts are derived using the knowledge gathered from the literature review.

3.5.2 Fuzzy Extended Analytic Hierarchy Process (FEAHP)

Analytic Hierarchy Process (AHP) is a data analyzing technique which can be used to rank decision alternatives based on both qualitative and quantitative factors (Golden, Wasil, & Levy, 1989). Further to the above authors, AHP can be used to rank, evaluate, select and predict decision problems. As the objective of the questionnaire survey is to evaluate the level of importance of decision alternatives for apparel firms in Sri Lanka when responding to carbon pricing instruments, AHP can be considered as an appropriate technique for data analysis.

In the traditional AHP, human judgments are denoted as exact or crisp numbers (Kwong & Bai, 2003). However, in a situation where the conditions are uncertain due to lack of information, traditional AHP process is not capable of delivering accurate results (Kilincci & Onal, 2011). Because, in a situation where the conditions are uncertain, it is difficult for the decision makers or the experts to indicate preferences as exact numerical values (Kilincci & Onal, 2011).

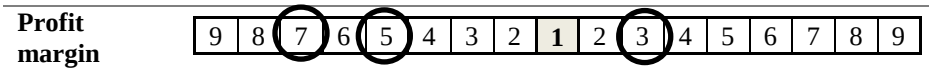
Fuzzy Extended Analytic Hierarchy Process (FEAHP) is an extension of the traditional AHP, where the fuzziness or the uncertainty attached to a decision process is handled effectively (Torfi, Farahani, & Rezapour, 2010). Even though AHP was considered as an appropriate technique for the data anlysis of this study, FEAHP was determined to be more suitable due to the uncertainty experienced by respondents when selecting the importance of decision alternatives and criteria. This uncertainty was mainly due to the lack of information such as the value of carbon price, the extent to which it is applied, the revenue utilization method etc…

In FEAHP, the decision maker's responses for pairwise comparisons of alternatives are denoted in triangular fuzzy numbers (Kilincci & Onal, 2011). For an example, (l, m, u) can be denoted as a triangular fuzzy number (TFN), where l, m and u indicate the smallest possible value, the most promising value and the largest value respectively, in a fuzzy or an uncertain situation (Kwong & Bai, 2003). Here, $l \leq m \leq u$, however, when l=m=u, it is a non-fuzzy number by convention.

In other words, it means that in FEAHP, three digits are selected by the respondent when marking the importance of a decision alternative/criterion.

An example taken from this study is depicted below.

Compare the importance of profit margin with customer retention



- Ranking '3' means, in a scenario where the importance of profit margin is lowest compared to customer retention, customer retention has a moderate importance over profit margin
- Ranking '5' means, in a scenario which is most promising, profit margin has a strong importance over customer retention
- Ranking '7' means, in a scenario where the importance of profit margin is highest compared to customer retention, profit margin has a very strong importance over customer retention

Here, the nine-point scale is defined as depicted in Table 4.

Table 4: FEAHP rating scale

Score	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent judgements

For a given a pairwise comparison, take M1 and M2 as response of two respondents. (M1= l1, m1, u1 and M2 = l2, m2, u2).

The main operational laws for two triangular fuzzy numbers M1 and M2, as given in Chan and Kumar (2007), are indicated by Equations 1,2,3 and 4:

Equation 1

$$M1 + M2 = (l1 + l2, m1 + m2, u1 + u2)$$

Equation 2

$$M1 \otimes M2 \approx (l1l2, m1m2, u1u2)$$

Equation 3

$$\lambda \otimes M1 = (\lambda l1, \lambda m1, \lambda u1), \lambda > 0, \lambda \in R$$

Equation 4

$$M1^{-1} \approx (1/u1, 1/m1, 1/l1)$$

Steps in FEAHP

There are few steps that need to be followed in order to derive the final priority weight of the options. Those steps are explained below.

Step 1- Develop the hierarchical structure to represent the goal, criteria and decision alternatives

Figure 6 indicates the general structure of an AHP hierarchy. Overall objective is placed at the top (level 1), followed by decision criteria and decision alternatives in levels 2 and 3 respectively. Overall objective is to select the best alternative, which is dependent on the criteria.

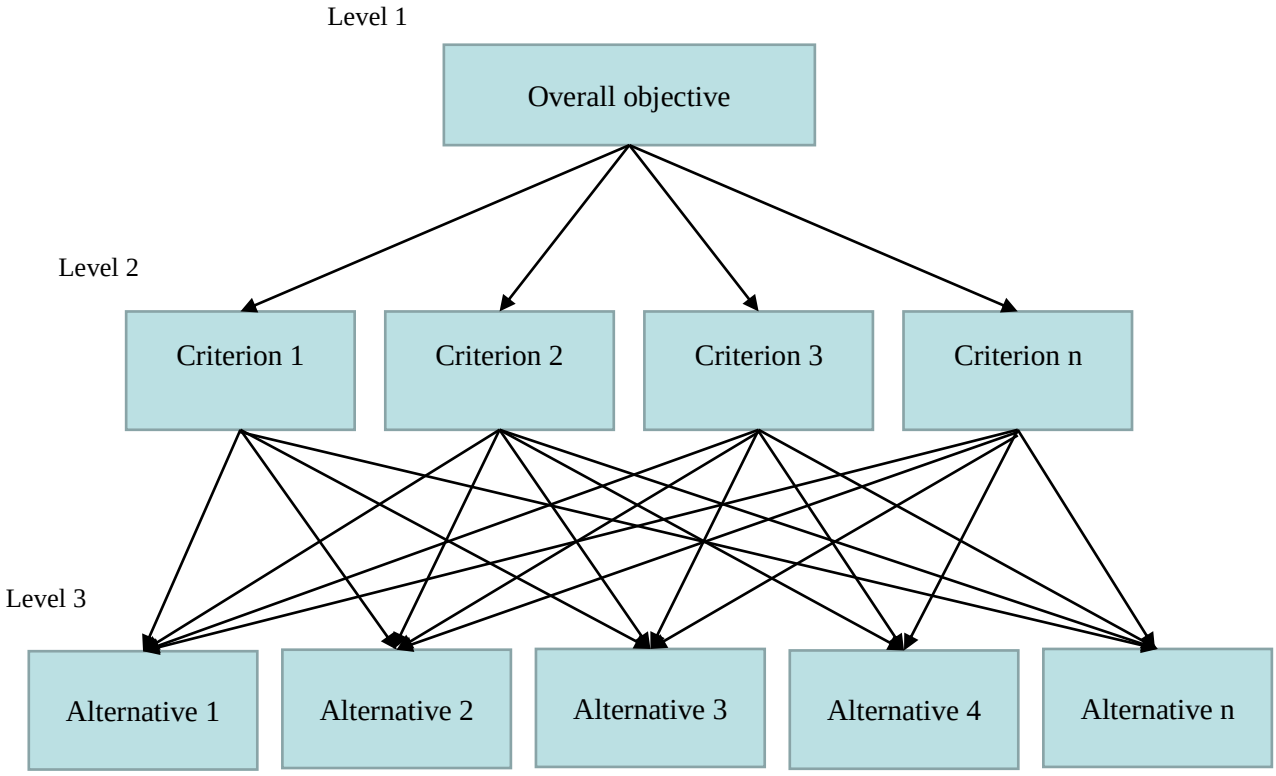


Figure 6: Levels of AHP hierarchy

Step 2- Ask experts to do a pairwise comparison of the elements in each level through questionnaire

This is simply the questionnaire survey where the experts are asked to do a pairwise comparison of the available options for each level. The questionnaire used for the pairwise comparison is indicated in Annexure 7.4.

Step 3- Construct the fuzzy evaluation matrix based on the pairwise comparisons of all the experts

The mean of all responses received for the comparison of each pair of options in each fuzzy comparison matrix (FCM) is taken to develop the fuzzy evaluation matrix. Hence,

if there are ‘n’ number of options (alternatives and criteria in a certain level in hierarchical structure), then there should be ${}^{n}C_2$ number of comparisons.

Step 4- Check the consistency of the pairwise judgement of each comparison matrix

To check the consistency of each FCM, the relevant consistency ratio (CR) is calculated. CR of an FCM indicates the consistency of pairwise comparisons within that particular FCM. If the CR of an FCM is less than 10%, then the pairwise judgement can be considered as acceptable (Kwong & Bai, 2003). If CR is less than 10%, it justifies the order of ranking of alternatives within an FCM.

The consistency index (CI) and CR for a given FCM can be calculated using Equations 5 and 6.

Equation 5

$$CI = (\lambda max - n)/(n - 1)$$

Equation 6

$$CR = (CI/RI(n))100\%,$$

Where,

λmax- Largest eigenvalue of matrix FCM_n

RI- Random index

RI for various comparison matrices was given by (Saaty, 1980)

n	3	4	5	6	7	8	9
RI(n)	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Step 5- Obtain the value of fuzzy synthetic extent (Fi) with respect to each criteria/alternative

Fuzzy synthetic extent value (Fi) is calculated from the developed fuzzy evaluation matrix, by using equation 7.

N_{oi}^{1}, N_{oi}^{2},….., N_{oi}^{m}, where I = 1,2,…., n

Where all the N_{oi}^{j} (j = 1, 2,….., m) are triangular fuzzy numbers

The value of fuzzy synthetic extent with respect to the i^{th} object can be given as in Equation 7,

Equation 7

$$Fi = \Sigma^{m}_{j=1} N_{oi}^{j} \; X \; \{\Sigma^{n}_{i=1} \Sigma^{m}_{j=1} N_{oi}^{j}\}^{-1}$$

Above equation can be solved by using main operation laws of fuzzy numbers given in Equations 1 to 4.

Step 6- Determine the minimum degree of possibility of each fuzzy synthetic extent over the others [min V (Fi ≥ Fk)]

When we have two fuzzy synthetic extent values of two criteria/ alternatives as F_1 and F_2, where,

$F_1 = (n_{11}, n_{12}, n_{13})$ and $F_2 = (n_{21}, n_{22}, n_{23})$, the degree of possibility V,

When $F_1 \geq F_2$ is true

Equation 8

$$V (F_1 \geq F_2) = 1$$

When $F_1 \geq F_2$ is not true

Equation 9

$$V (F_1 \leq F_2) = \{n_{11} - n_{23}\} / \{(n_{22} - n_{23}) - (n_{12} - n_{11})\}$$

For each decsion alternative/ crietrion, minimum degree of possibility (V_{min}) is obtained by comparing the fuzzy synthetic value of that alternative/ criterion against the fuzzy synthetic values of other alternatives/ criteria and using the Equations 8 and 9 accordingly.

Step 7- Normalize the weight vector (Wp) to obtain the priority weight (W) for each decision criteria/alternative

The weight vector consists of min V for all alternatives/ criteria.

If m(Pi) = min V (Fi ≥ Fk)

for k = 1, 2, . . . , n; k ≠ i, then the weight vector is given by,

Equation 10

Wp = (m(P1), m(P2), . . . , m(Pn))

where Pi (i = 1, 2, . . . , n) are n elements

After normalizing Wp, we get the normalized weight vector,

Equation 11

W = (w(P1),w(P2), . . . , w(Pn)),

where w is a non-fuzzy number, and this gives the priority weight of one alternative/ criterion over others.

Step 8- Calculate the final priority weights of each decision alternative

The final priority weight of each alternative is calculated by taking the sum product of normailised weight of alternative under each criterion and the weight of the corresponding criterion.

3.6 Chapter summary

This chapter describes the research methodology that was followed to achieve the objectives of the research. A mixed approach was used where both qualitative and

quantitative data were collected through a questionnaire survey and an expert opinion survey respectively. In addition, a preliminary survey was conducted before the questionnaire survey to finalise the questionnaire. FEAHP was used to analyse quantitative data and content analysis was used to analyse qualitative data.

4.0 RESEARCH FINDINGS

4.1 Introduction

This chapter reveals the research findings which were derived by analyzing the collected primary data. Initially a preliminary survey was conducted to determine the decision criteria for apparel firm's response to carbon pricing instruments. Subsequently, the response of apparel firms to carbon pricing instruments was evaluated using the data collected through the questionnaire survey. Further, the revenue utilization methods, the potential barriers when implementing carbon pricing instruments in Sri Lanka and the strategies that can be used to overcome those barriers were determined through the expert survey.

4.2 Findings of the preliminary survey

Preliminary survey was used to validate the literature findings prior to the development of the questionnaire (see Section 3.4.3). At the same time, decision criteria considered by apparel firms when responding to carbon pricing instruments were also determined through preliminary survey.

4.2.1 Decision criteria considered by apparel firms when responding to carbon pricing instruments

Four decision criteria which will be considered by apparel firms when responding to carbon pricing instruments were established by the responses of the experts. The identified decision criteria are depicted in Table 5.

Table 5: Decision criteria considered by apparel firms when responding to carbon pricing instruments

Decision criteria	PS1	PS2	PS3
Profitability (C1)	✓	✓	✓
Customer retention (C2)	✓	✓	X
Corporate Social Responsibility (C3)	✓	✓	X

Decision criteria	PS1	PS2	PS3
Organisational image (C4)	✓	✓	✓

Profitability is a decision criterion that was suggested by all the respondents. PS1 stated that, "profitability is a criterion considered for any decision in apparel sector as they are profit oriented organisations". According to PS3, "decisions are taken considering both the long term and short-term profitability".

Customer retention is another vital decision-making criterion for apparel firms. According to the experts, most apparel firms are heavily dependent on a few customers with higher bargaining power. PS2 stated that, "losing customers can seriously impact the business continuity". Hence, the apparel firms are vigilant in the decision-making process to avoid any conflicts with the customers.

Corporate Social Responsibility (CSR), indicates the genuine sentiment of apparel firms towards the betterment of the society. Even though it does not generate revenues to the firms, PS1 stated that, "apparel firms practice CSR to a certain extent to trade off their social externalities". Hence, when making decisions, CSR is a criterion considered by the apparel firms.

Every decision made by an organisation positively or negatively influences the image of that organization. It defines how the current customers, potential customers, authorities and general public sees the organization. Hence, according to PS2, "apparel firms are attentive about the impact created by every decision on the organizational image".

4.3 Evaluation of level of importance of decision alternatives

Questionnaire survey was conducted to evaluate the importance of decision alternatives for apparel firms in response to carbon pricing instruments. However, as found from the literature review and preliminary survey, this decision is governed by multiple criteria. Hence, the respondents from apparel firms are asked to carry out a pairwise comparison

of decision criteria and decision alternatives. The subsequent responses were analysed using FEAHP.

One respondent each from the management level of the 10 selected apparel firms participated in the questionnaire survey. The details of the respondents are given in Table 6.

Table 6: Profile of respondents in questionnaire survey

Respondent	Designation	Years of experience
Q1	Senior manager	10-15
Q2	Manager	5-10
Q3	Assistant manager	15-20
Q4	Plant engineer	10-15
Q5	Chief financial officer	10-15
Q6	Senior manager	15-20
Q7	Chief engineer	15-20
Q8	Director	10-15
Q9	Assistant manager	15-20
Q10	Senior manager	10-15

The steps indicated in chapter 3 (see Section 3.5.2) were followed to derive the final priority weight of decision alternatives through FEAHP. The results obtained for fuzzy synthetic extent value of each criteria/alternative (see Step 5 in Section 3.5.2) and minimum degree of possibility of each fuzzy synthetic extent (see Step 6 in Section 3.5.2) are indicated in Annexures 7.1 and 7.2. These values are used to find the final priority weight of decision criteria and decision alternatives (see Table 9).

4.3.1 AHP hierarchical structure

Using the decision alternatives identified by the literature review and the decision criteria established by the preliminary survey, the AHP hierarchical structure was developed. Figure 7 illustrates the AHP hierarchical structure which was used as the basis for evaluation of importance of decision alternatives.

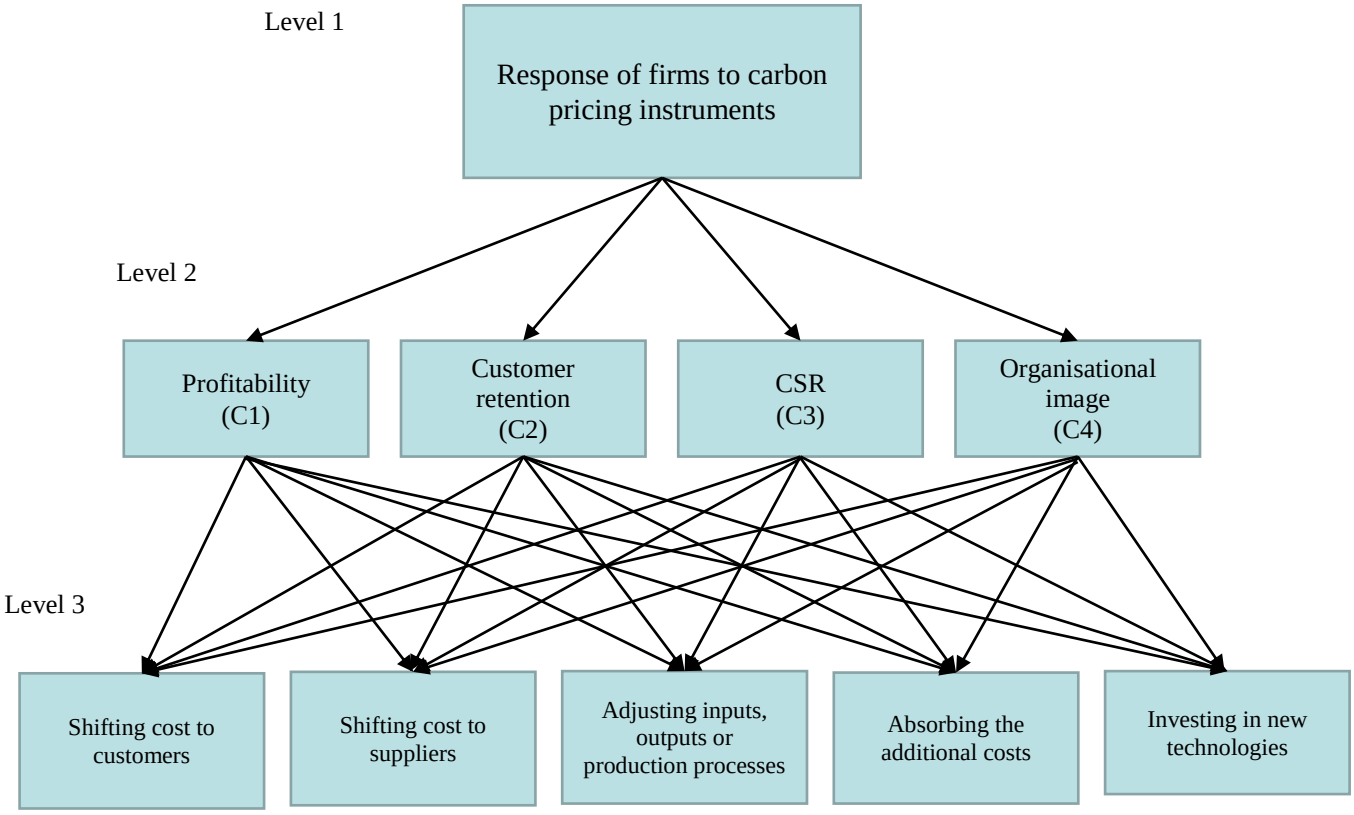


Figure 7: AHP hierarchy

The problem in this study, which is also the goal in the hierarchy, "what is the most important decision alternative for apparel firms in response to carbon pricing instruments?" is broken down to three levels. The main objective is in the first level which is to identify the response of firms to the implementation of carbon pricing instruments. The common criteria applicable for all the decision alternatives are in level two and the decision alternatives are in level three.

4.3.2 Normalised weights of decision criteria/ alternatives

First the weight vector is established by using the minimum degree of possibility values for each fuzzy synthetic extent in each fuzzy evaluation matrix. The weight vector is then normalized to obtain the normalized weight vector with the priority weights of decision criteria and decision alternatives (see Step 7 in Section 3.5.2). This is indicated in Tables 7 and 8 respectively.

Table 7: Normalised weights of decision criteria

Decision criteria	Normalised weight
Profitability (C1)	0.30
Customer retention (C2)	0.27
Corporate Social Responsibility (C3)	0.20
Organisational image (C4)	0.23

Profitability is identified as the highest rated criterion with a weight of 0.30, and this result is not surprising, as all the apparel firms are profit oriented organisations. According to respondent Q2, "profitability is highly important for all the apparel firms to sustain its business". Further, Q5 highlighted that, "apparel firms often face stern competition with many other suppliers from different countries". Hence, maintaining an adequate profitability is important to expand and enhance the quality of the process and outputs. Customer retention is rated as the criterion with second highest importance weight (0.27). This is important for most of the firms, as they supply for well-known brands around the world. Q7 stressed that, "loosing big customers create a massive impact on the continuity of the firms".

Organisational image was ranked above the CSR with a weight of 0.23, as it can help to retain the existing customers and attract potential future customers. CSR is as genuine consideration of some apparel firms towards the wellness of the society. "This is a criterion which is not considered with any benefit for the firm", stated Q1. Instead, it is a voluntary concern of some firms towards the society. Hence, the importance given to it

(0.20), is not that high compared to other criteria which can impact the financial success of the firm.

Table 8 indicates the decision alternatives along with their normalized weights under each criterion.

Table 8: Normalised weights of decision alternatives

Decision alternative	**Normalised weight with respect to,**			
	C1	**C2**	**C3**	**C4**
Shifting cost to customers (DA1)	0.18	0.15	0.19	0.17
Shifting cost to suppliers (DA2)	0.21	0.22	0.20	0.18
Adjusting inputs, outputs or production processes (DA3)	0.20	0.21	0.22	0.22
Absorbing additional costs (DA4)	0.17	0.18	0.15	0.20
Investing in new technologies (DA5)	0.25	0.24	0.23	0.23

As depicted in Table 16, "Investing in new technologies (DA5)" was ranked as the decision alternative with the highest importance (0.25, 0.24, 0.23, 0.23) under all decision criteria. According to Q2, "the long-term emission reductions and reduction of operational costs of firms were regarded as the reasons for DA5 to be the decision alternative with the highest importance". Further, the respondents highlighted that the lower level of emissions also helps to attract and retain green customers towards the firms.

Shifting cost to the customers (DA1), was found to be a decision alternative with lower importance. In fact, it was ranked as the lowest important decision alternative under decision criteria customer retention (C2) (0.15) and organizational image (C4) (0.17). According Q8, "shifting cost to the customers is not an alternative for most of the export-oriented apparel firms as their customers are high end brands with massive bargaining power". Hence, trying to shift the cost to customers could result in losing the

customers all together. Further, the respondents explained that the shifting cost to the customers could negatively impact the organizational image which will result in less future customers.

Absorbing additional cost (DA4) was also ranked as a decision alternative with lower importance. It was ranked as the decision alternative with lowest importance under decision criteria profitability (C1) (0.17) and CSR (C3) (0.15). When the additional cost generated as carbon price is absorbed into the firm's budget without any action, respondents indicate that, it will be a direct impact to the firm's profit. Hence, it will just be an additional cost item to the firm that reduces its profit. Further, respondents highlighted that the lack of effective response of firms, as an indication of firm's inconsiderateness towards CSR.

Both "Adjusting inputs, outputs or production processes (DA3)" and "Shifting cost to suppliers (DA2)", were ranked as decision alternatives with moderate importance. DA2 was ranked as second most important decision alternative under decision criteria, profitability (0.21) and customer retention (0.22). On the other hand, DA3 was ranked as the decision alternative with second highest importance under the criteria, CSR (0.22) and organizational image (0.22). According to respondents, both these decision alternatives eliminate the effect of additional cost that comes as the carbon price and also helps the emission reductions either directly or indirectly.

4.3.3 Final overall weights of decision alternatives

Final overall weights of decision alternatives with respect to all the decision criteria are indicated in Table 9.

Table 9: Final overall weights of decision alternatives

	C1	**C2**	**C3**	**C4**	**W**	**Rank**
	0.30	**0.27**	**0.20**	**0.23**		
DA1	0.18	0.15	0.19	0.17	0.17	**5**
DA2	0.21	0.22	0.20	0.18	0.20	**3**

	C1	C2	C3	C4	W	Rank
	0.30	**0.27**	**0.20**	**0.23**		
DA3	0.20	0.21	0.22	0.22	0.21	**2**
DA4	0.17	0.18	0.15	0.20	0.18	**4**
DA5	0.25	0.24	0.23	0.23	0.24	**1**

Investing in new technologies (DA5) is ranked as the decision alternative with the highest importance (0.24). On the other end, shifting cost to customers (DA1) is ranked as the least important decision alternative with a priority weight of 0.17, which is just above absorbing additional costs (DA4) with a priority weight of 0.18. Adjusting inputs, outputs or production processes (DA3) and shifting cost to suppliers (DA2) are ranked as second and third most important decision alternatives with priority weights 0.21 and 0.20 respectively.

4.3.4 Consistency of the pairwise judgement of each comparison matrix

Consistency of all comparison matrices were checked to validate the acceptability of the findings. The consistency values of each of the FCM are depicted in Table 10.

Table 10: Consistency of comparison matrices

Fuzzy comparison matrix	Consistency ratio
FCM 1	8.65%
FCM 2	4.04%
FCM 3	3.69%
FCM 4	6.75%
FCM 5	4.39%

As depicted in Table 10, the consistency ratio of all the FCMs were found to be less than 10%. Hence, the pairwise comparisons under all the FCMs can be considered as acceptable.

4.4 Findings of expert interviews

Suitable revenue of utilisation options for Sri Lankan context, barriers in implementing carbon pricing instruments in Sri Lanka and the strategies that can be used to overcome the barriers were identified through expert interviews. For this, interviews were conducted with five experts who are experienced in environment sustainability in apparel sector and are thorough with the carbon pricing policy instruments. The profile of respondents is given in Table 11.

Table 11: Profile of respondents in expert interviews

Respondent	Designation	Years of experience
EI1	Senior manager	10-15
EI2	Manager	5-10
EI3	Freelance consultant	15-20
EI4	Senior Manager	10-15
EI5	Manager	5-10

4.4.1 Suitable revenue utilisation options in Sri Lanka

From the expert interviews it was found that the most suitable way of utilising carbon pricing revenue is to fund emission reduction programmes in Sri Lanka. Specifically, it was highlighted that the revenue should be cycled back to the apparel firms to facilitate operational improvements in terms of the adoption of efficient and greener technologies in the factories. This is because the firms are expecting a return for what they pay as a carbon price.

Table 12 indicates the revenue utilisation options described by the experts, as suitable for Sri Lanka.

Table 12: Suitable revenue utilisation options in Sri Lanka

Suitable revenue utilisation options in Sri Lanka	EI1	EI2	EI3	EI4	EI5

Suitable revenue utilisation options in Sri Lanka	EI1	EI2	EI3	EI4	EI5
Introducing energy efficient and cleaner technologies	✓	✓	✓	✓	✓
Providing free renewable energy options for industries	✓	✓	✓	✓	✓
Promoting reforestation projects and forest conservation	✓	✓	✓	✓	✓
Strengthening existing governing bodies related to sustainability	✓		✓	✓	
Providing free consultation and training for firms through relevant governing bodies	✓	✓		✓	
Providing tax benefits to green initiatives		✓	✓	✓	
Establishing an international market to attract green customers by promoting carbon pricing instruments used in Sri Lanka	✓		✓		

- Introducing energy efficient and cleaner technologies

Utilisng carbon revenue to introduce energy efficient and cleaner technologies is an effective revenue utilisation option suggested by all the respondents. EI4 explained the possibility of achieving direct and long-lasting emission reductions from energy efficient and cleaner technologies as critical, and it will result in carbon emission reductions either per product, per hour, per minute or per kW. On the other hand, the introduction of energy efficient and cleaner technologies is expected to result in operational improvements in the firms. According to EI1, "when the cleaner production improvements are done for industries, it will reduce the costs due to low energy use. Cleaner production practices will also improve other aspects like waste management, raw material utilisation and water utilisation. All these aspects reduce the overall cost of

the organization". Further, EI1 stressed that the reduction of all of the above operational costs will nullify the impact created by the carbon price on the bottom line, which is the profit of firms. For example, if the cost is reduced by 5% and the carbon price is 2% cost escalation, the firms will be happy to support the implementation of the policy.

- Providing free renewable energy options for industries

Use of renewable energy sources are well known for its environmental friendliness as it will eliminate the requirement to burn fossil fuels. However, the use of renewable energy sources at industry level, specially solar energy is not widely seen. EI5 has explained that the payback of rooftop solar projects is around 4.5 years and despite having a good payback, there is still difficulty in implementing solar projects due to lack of capital to fund massive initial investment. However, according to EI1, there is a government initiative called "Surya Bala Sangramaya" to promote the use of solar energy. It was suggested by the experts to use carbon pricing revenue in strengthening renewable energy campaigns, in particularly solar energy programmes. EI3 stated that, it is comparatively easy to implement a solar energy initiative at an industry scale rather than a domestic scale. According to EI3, "for domestic scale, maximum we can go for is 2kW or 3kW; there will be a large number of projects and an inverter will have to be installed for each and every home, making it expensive". Further, EI3 explained that, "comparatively, it will be more useful for places having unutilized roof spaces. When we use solar power, in addition to electricity generation, it has the capability to reduce the heat load of the building. It helps to reduce the cooling load of the building and enhances the comfort levels of employees". Moreover, EI1 suggested the implementation of solar power connections in rural areas where there is no grid supply, using carbon pricing revenue. According to EI1, "this can be done by using school roofs and roofs of other public buildings to generate solar energy. The tax revenue generated from the industries in a specific region can be used for solar projects in that same region. This will save cost to relevant authorities, allowing them to use that money for

development of education or health sector". Further, an initiative in this scale would help to enhance the popularity and public acceptance of the carbon pricing instrument.

- Promoting reforestation projects and forest conservation

Allocating funds for reforestation projects and forest conservation within Sri Lanka is identified as another effective way of using carbon pricing revenue by the experts. According to EI4, "focusing on reforestation is important as the forest cover has reduced drastically, and it is now less than 20% and it continues to degrade". Similarly, EI5 explained that, "energy conservation methods usually last for 5- 10 years. After that period the equipment will not be useful. However, forestry projects generate long term benefits. After around 20 years, there will be a carbon emission reduction due to sequestration". Moreover, EI5 highlighted that the benefits of forestry projects will not be limited only to carbon emission reduction. "Other than that, forest plants and animals will be conserved, return of soil carbon back to the atmosphere will be reduced, and air purification will also be increased". Suggesting an effective method of implementing reforestation projects, EI1 stated that, "it is better to implement forestry projects in free lands of industrial zones. That way, the tax income of the zones can be used for forestry projects in the free lands of the same zone. It will help to clean the pollutants at the same place where they are emitted. It will also enhance the ambient quality". Another concept highlighted by EI1 is the "community forest". According to EI1, "community forest is the forest situated close to the village. Restricted areas are situated beyond the community forest. It is different to main forests and restricted forests identified by the forest ordinance". EI1 explained that if the community forest is properly maintained in a way that the farmers can obtain the necessary resources, the main forest and restricted forest area will be conserved. Hence, EI1 suggested to use the tax revenue to pay the farmers for protecting and maintaining the community forest. Further, EI1 stated that, "farmers can also be trained on aspects like organic farming and pesticide use. This will also help to improve livelihood of people. On the other hand, and more importantly, the encroaching on forests will be reduced".

- Strengthening existing governing bodies related to sustainability and providing free consultation and training for firms through these bodies

The experts EI1, EI3 and EI4 explained that there are deficiencies in national bodies overseeing the sustainability aspects of Sri Lanka like National Cleaner Production Center (NCPC), Sustainable Energy Authority (SEA), Central Environment Authority (CEA) and Waste Management Authority. According to EI1, coordination between these bodies could be improved for better outcomes. It is also suggested to strengthen these bodies financially using some of the carbon pricing revenue. Further, EI2 suggested that, "these bodies should be given financial assistance to a level that they will be able to implement free consultation to firms having high carbon footprint". Similarly, EI1 highlighted that some firms are reluctant to obtain consultation from these bodies and participate in training programmes due to the higher cost of participation. However, EI1 is having the opinion that, "if the funds are allocated to these bodies, they will be able to provide free consultation and training for firms. That awareness and education will itself be helpful to implement no cost or low-cost options in the factories". As an example, EI1 referred to an ongoing project initiated by NCPC. "Recently, NCPC initiated a project through a Sri Lanka Export Development Board grant for free implementation of ISO 14001 and cleaner production in small and medium scale industries". Hence, EI1 was confident that if more funds are allocated to these bodies from carbon pricing revenue, there will be more awareness, consultation and training programmes directed towards the emission reduction of factories.

- Providing tax benefits to green initiatives

Providing tax benefits to green initiatives is another method suggested by the experts EI2, EI3 and EI4 for the effective utilization of carbon pricing revenue. According to EI2, "green initiatives will ensure that energy efficient systems are implemented and will be a direct factor leading to emission reduction". Hence, by absorbing some amount of carbon pricing revenue, eliminating taxes on green initiatives would encourage the firms to implement more and more green initiatives within the factories.

- Establishing an international market to attract green customers by promoting carbon pricing instruments used in Sri Lanka

Promotion of the use of carbon pricing instruments implemented in Sri Lanka in international platforms is another effective method suggested by experts EI1 and EI3. According to EI3, "promoting the carbon pricing instruments applied in Sri Lanka to indicate as to what extent Sri Lanka is green as a country will in turn help to enhance the recognition and image of Sri Lankan apparel manufacturers in world market". Even though, this is not a method that will lead to direct emission reductions, EI1 indicated that it will strengthen the position of Sri Lankan apparel firms and enhance their competitiveness in world market. On the other hand, EI3 stated that, "when the recognition for green products is raised in the international market, the manufacturers will be encouraged to adapt green production".

All the experts stressed on the importance of setting the carbon price at an optimum level. Because, the experts opined that setting a higher price would create a massive impact on the profitability of the firms. According to EI2, if the tax rate is at an optimum level and effective revenue utilization methods are used, the effect of carbon price on the profitability of the firms will lasts only for a short period of time. Explaining this further, EI2 stated that, "if the tax revenue is used for emission reduction programmes, the tax payment will be reduced gradually due to reduced emissions". EI2 referred to an example where the renewable energy percentage is increased in firms using the collected carbon revenue, which will gradually reduce the tax payment of the firms due to reduced emissions. Ultimately when the renewable energy use reaches 100%, the tax will become zero theoretically. However, agreeing to the above view, EI4 stated that the revenue accumulation from carbon pricing will not exhaust due to emission reduction improvements of existing firms. According to EI4, "the number of factories will not remain the same in the next 10 to 100 years. They will continue to grow. Therefore, the overall fund accumulated from the carbon tax will not be reduced. Instead, only the tax amount paid by each organization will be reduced". Even if the carbon pricing revenue

accumulation reduces over time, EI4 suggests that it should not be considered as a negative outcome. According to EI4, "even if the fund collected is reduced after a considerable period of time (10 to 15 years), the sustainable targets like reduced carbon emissions and reduced energy usage, that we wanted to achieve, would have been achieved".

However, all the experts indicated the absorption of carbon pricing revenue to government budget as highly ineffective revenue utilization option. According to EI5, "there will be a massive resistance at the initial stages, and it will be difficult to implement the policy. Because in Sri Lanka, people will not be very confident about the way the government is going to use the revenue collected".

Instead, EI1 suggested that it is better to use the revenue generated from a particular sector, to the improvements and benefit of that sector itself. Elaborating this idea further, EI1 stated that, "at least 75% of the revenue should be used for the same sector from where the revenue is collected. The rest of the 25% can be used for the improvement of smaller industries with lower revenue levels". According to EI1, "if the major proportion of the revenue is distributed back to the same sector from which the revenue is collected, taxpayers will be motivated to pay the tax".

4.4.2 Barriers in implementing carbon pricing instruments in Sri Lanka

Experts highlighted that the barriers for the implementation of carbon pricing instruments could be identified in three levels as organizational level, (apparel) sector level and national level. In organizational level, the successful implementation of carbon pricing instrument depends on how the employees at different levels would react and oppose to achieve objectives of a carbon pricing instrument. The sector level barriers indicate the reasons for combined resistance from apparel sector as a whole. Finally, the national level barriers identify the existing limitations and the lack of resources at the government level in implementing and continuing a carbon pricing instrument.

Table 13 depicts the barriers indicated by the experts when implementing a carbon pricing instrument.

Table 13: Barriers for the implementation of carbon pricing instruments in Sri Lanka

Barriers for the implementation of carbon pricing instruments in Sri Lanka	EI1	EI2	EI3	EI4	EI5
Organisational level					
Lack of direction from top management	✓	✓	✓	✓	✓
Lack of awareness of financial decision makers	✓		✓	✓	
Sector level					
Effect on price competitiveness of the sector as a whole	✓	✓	✓	✓	✓
Uneven distribution of benefits as some firms are not firmly based on green customers	✓		✓	✓	
National level					
The ineffectiveness and lack of link of existing governing bodies	✓	✓	✓	✓	✓
Unavailability of a complete database including details about the types of energy sources used and how energy is used in industries	✓	✓	✓		✓
Lack of competent personnel in relevant government bodies	✓		✓	✓	

Barriers at orgnaisational level

All the experts stressed the importance of the involvement of top management of firms in proactively responding to carbon pricing instruments. EI3 stated that the top management has the responsibility of taking effective decisions when responding to

carbon pricing instruments. However, in the existing context, the top management direction would be lacking in Sri Lankan apparel firms. EI1 explained the reason for this lack of direction as the lack of knowledge of managers in understanding the importance of sustainability. According EI1, "even though apparel sector is a manufacturing sector, it is not fully engineered. Instead it is labour oriented. Hence the managers of apparel firms are not that interested in changes to achieve sustainability. The focus is on getting work done from the human resource".

Lack of awareness of financial decision makers about the practical applications of concepts such as green accounting and carbon taxing is found to be a barrier for the implementation of carbon pricing instruments. According to EI4, the view of financial decision makers is short term oriented most of the time. EI4 further explained that the financial decision makers may think of carbon pricing as a situation which will reduce the revenue and eventually the profit. However, EI1 suggested that the implementation of carbon pricing instruments should be considered as an opportunity to reduce operational and energy costs. According to EI3, negative perception of financial decision makers towards the carbon pricing instruments will be a problem when responding to it. EI3 stated that, "financial decision makers will not allocate funds for measures taken towards the reduction of emissions within the firm". This will hamper the effective response of firms towards a carbon pricing instrument.

Barriers at sector level

Impact of a carbon pricing instrument towards the price competitiveness of apparel firms is identified as a major barrier that creates an apprehension in apparel firms during the initial implementation. All the experts agreed on the criticality of protecting the price competitiveness of Sri Lankan apparel firms to ensure their survival in the international market. Hence, EI1 indicated that it is essential to assert to apparel firms that there would be immediate return for what they pay as carbon price. For example, EI1 stated that, "if it is going to take a lot of time to provide returns back to firms, say around five years, then it is not effective". EI2 opined that the longer it takes for the returns to come

back, the doubts of firms towards the transparent management of carbon pricing revenue will also be raised. EI4 suggested that there could threats to the continuity of the pricing instrument, if the profitability of the firms is impacted.

Uneven distribution of benefits among firms is another barrier which will come up from within the apparel sector. EI3 highlighted that, "the entire apparel market is not focused on green customers and hence the firms which are catering to non-green oriented customers will have less benefits". The firms supplying to green conscious customers will have the benefit of using their obedience to a carbon pricing instrument as a tag line to attract customers. However, the other firms which are having non green focused customers will not have the same benefits even though they pay the same carbon price. Hence, there can be some level of opposition to the implementation of carbon pricing instrument from a portion of the apparel sector.

Barriers at national level

Ensuring a proper institutional set up when initiating a carbon pricing instrument is a massive national level barrier as identified by the experts. Hence, at the initial phases of implementation, the involvement of all the relevant existing governing bodies is highly important. However, experts indicate that, in Sri Lanka, these governing bodies who are overseeing the built environment sustainability, are not working in coordination. Governing bodies like NCPC, SEA, CEA, Waste Management Authority, Ceylon Electricity Board (CEB) are mostly working with in their individual agendas. The coordination of these governing bodies towards achieving sustainability goals is not widely seen. This lack of coordination among the relevant governing bodies is indicated as a barrier for the implementation of a carbon pricing instrument by the experts, as the collective effort and input from those bodies are important to get the policy instrument working at the initial stages.

Unavailability of a complete database including details about the types of energy sources used and how energy is used in industries will be a barrier when setting up a carbon price before the implementation of a carbon pricing instrument and when computing the

carbon price to be paid by firms after the implementation of a carbon pricing instrument. According to EI3, “the national green reporting standard is not properly maintained, and the information is not properly reported. Hence, the government does not have the necessary information”. Similarly, EI1 suggested that collecting information from governing bodies will be easier to compute carbon price to be paid by the individual firms, rather than depending on the information provided by firms. For example, EI1 pointed out that, “the electrical energy consumption should be monitored through CEB and the fuel consumption should be monitored through the Ceylon Petroleum Corporation (CEYPETCO)”. Agreeing on this, EI2 stated that, “depending on the information provided by factories to tax the same factories is not effective. There will be issues in transparency due to lack of ability to do verification”. However, EI3 suggested that there should be a method for the individual firms to estimate their emission levels and also a guideline for them to follow to achieve emission reductions both in long term and short term.

The competency of current personnel in the relevant governing bodies is inadequate as indicated by the experts, to manage a carbon pricing instrument. According to EI1, “most of the middle level officials currently working in these governing bodies are not fully equipped with the technical knowledge required to estimate and validate emissions from apparel factories”. EI3 highlighted the problem of this lack of competency as the easy manipulations. EI3 stated that, “the firms will be able to easily manipulate their emission levels if the officials who do the audits and verifications are not competent”. This would be a problem for the survival of a carbon pricing instrument.

4.4.3 Strategies to overcome existing barriers towards the implementation of carbon pricing instruments

The experts suggested some strategies that can be used to ensure smooth implementation and continuity of carbon pricing instruments in Sri Lanka. These strategies could be executed at organizational, sector level or national based on the requirement.

Table 14 indicates these strategies suggested by the experts.

Table 14: Strategies to overcome existing barriers towards implementation of carbon pricing instruments

Strategies to overcome existing barriers towards implementation of carbon pricing instruments	**EI1**	**EI2**	**EI3**	**EI4**	**EI5**
Organisational level					
Raising awareness of top management and other managers on importance, opportunities, world trends and legal requirements of the carbon pricing system	✓	✓	✓	✓	✓
Benchmarking the organization (eg: ranking level in Sustainable Apparel Coalition- SAC) against other organisations which have used green concepts extensively	✓	✓	✓		
Sector level					
Redefining the apparel market to accommodate more green conscious customers	✓		✓	✓	
Aligning all firms on a commonly agreed sustainable platform (eg. SAC)	✓	✓	✓		
National level					
Establishing a forum by gathering all the industry partners, both governmental and non-governmental	✓	✓	✓	✓	✓
Proposing a transparent, open and effective system to utilise carbon pricing revenue with the aim of emission reductions	✓	✓	✓	✓	✓
Rapid turnaround of revenue back to tax paying firms for operational improvements	✓	✓	✓	✓	✓

Strategies to overcome existing barriers towards implementation of carbon pricing instruments	EI1	EI2	EI3	EI4	EI5
Appointing competent personnel to relevant government bodies	✓		✓	✓	
Enhancing education and training in relation to green concepts by including the concepts at school and university levels	✓	✓		✓	
Considering green concept as a part of government's long-term strategy development criteria		✓	✓		✓

Strategies at orgnaisational level

Experts highlighted the importance of educating top management on the positives, opportunities, world trends and legal requirements of carbon pricing instruments. EI1 stated that the operational improvements and the long-term benefits of the carbon pricing instruments should be clearly explained to the top managers. This, according to EI3, would enable the firms to respond effectively to a carbon pricing instrument by achieving emission reductions.

Experts opined that the operational benefits of following green concepts should be indicated to firms using actual examples. According to experts, this could be done by benchmarking individual firms against firms which have extensively used green concepts. EI3 suggested ranking level in SAC as a good benchmark to evaluate the level of green practices used and the operational optimisation of firms.

Strategies at sector level

Redefining apparel market is a strategy suggested by experts to get the support of apparel sector towards a carbon pricing instrument. According to EI4, "more green

customers should be included into the apparel market, so that the firms will see the operation under a carbon pricing instrument as a measure to attract more customers". EI3 pointed out that, "introduction of green customers into the market would help all the firms to supply to green customers which would help for the even distribution of benefits of a carbon pricing instrument among firms".

According to experts, it would be beneficial to align all the firms under one sustainable standard or platform. EI3 suggested SAC as a good platform for this. Once the firms are aligned under a common sustainable platform, EI1 reckons that the sustainable improvements become important to all the firms in a similar way. This is expected to push apparel firms towards more emission reduction improvements which are already induced by a carbon pricing instrument.

Strategies at national level

Bringing all the industry stakeholders together is a strategy suggested by the experts for the smooth initiation of a carbon pricing instrument. According EI5, "the industry stakeholders should be brought into discussion and the relevant information should be transferred to them". Similarly, EI3 stated that, "stage by stage plans and targets should be clearly conveyed to them". On the other hand, EI1 explained the importance of revealing revenue utilization options that will be used. Having an open discussion with all the relevant stakeholders is expected to ensure smooth initiation of a carbon pricing instrument. Further, EI1 suggested that the implementation of a carbon pricing instrument should be done through the collective effort of existing governing bodies, rather than establishing an entirely new department for this purpose. According to EI1, "NCPC, SEA, CEYPETCO, CEB are some of the existing organisations that have the ability to implement and oversee a carbon pricing instrument. All these elements should combine to make decisions such as the process of taxing, which sectors to tax, which steps to take to minimise emissions.". However, EI1 also agreed that "if with time, the workload increases, the government can look for the possibility of establishing a separate entity."

Having a transparent and effective revenue utilization plan which is directed towards achieving emission reductions is critical according to the experts, to minimise the oppositions at the initial stages of a carbon pricing instrument. Accordingly, EI1 suggested that, "revenue utilisation should be transparent and everybody should be able to have a look at how the revenue is utlisilised, so that the people who handle the fund will not be able to do any frauds". Further, both EI2 and EI5 suggested that this would enhance the confidence levels of firms towards the governing body. According to EI1, "it is important to give the firms the feeling that they are going to get something in return for what they pay as a carbon price." This way a carbon pricing instrument will be initiated and continued in an undisturbed manner.

If it is decided to direct the collected revenue back to the firms in some way, experts stressed that it should be done quickly. According to EI3, "financial managers will be changed over a long period, and if the returns are arriving only after a longer period, the current financial decision makers will not like the policy as it will reflect upon their performance". Hence, it is suggested by EI3 and EI4 to provide some benefits to firms to achieve emission reductions or other operational improvements within every six months or quarterly.

Appointing competent and knowledgeable personal who are familiar with green concepts is indicated as an important measure by the experts to conduct a carbon pricing instrument. EI2 stated that "competent personal would be able to estimate or verify emission quantities in an accurate manner". This is an important aspect of conducting a carbon pricing instrument as it decides the carbon prices that has to be paid by the firms. Hence, according to EI4, "if the officials are not competent to do emission quantifications, there could be problems due to inaccurate carbon prices and manipulations by firms to show reduced emissions".

Enhancing education and training towards green concepts is a long-term strategy suggested by experts not only for implementation of a carbon pricing instrument alone, but also as a method to enhance overall awareness of general public towards sustainable

issues. According to EI1, this education and training can be easily improved by including sustainability and green concepts into school and university education.

Considering green concept as a part of government's long-term strategy development criteria is another long-term strategy suggested by the experts. Again, this would not only be focused on implementing a carbon pricing instrument, but also overall improvement of sustainable agenda of the country. According to EI2, "when the green concept and sustainability becomes a part of the strategy development criteria of the country, the importance received by the carbon pricing instrument will be elevated". Hence, the governing bodies will receive more support in implementing the carbon pricing instrument.

4.5 Discussion of results

This research sought to identify the applicability of carbon pricing instruments in Sri Lankan apparel sector. The applicability was examined by evaluating the response of firms for carbon pricing instruments, the suitable revenue utilization options, the barriers for the implementation of carbon pricing instruments and the strategies to overcome the barriers.

Response of apparel firms to carbon pricing instruments

From this study, it was found that the response of firms to carbon pricing instruments is not consistent, as also showed by Numan-Parsons et al. (2011) (see Section 2.6). Bumpus (2014) indicated that this variation of responses was owing to different business-as-usual corporate priorities, financial capacity of firms and geographical orientations. This was similarly visible in Sri Lankan apparel sector as well. Preferred response of firms is varied based on the financial strength of the firms, the types of the customers the firms cater to and the awareness of the financial managers.

Martin and Rice (2010) established that the firms are pushed to take on new technologies to reduce their emissions when a carbon pricing instrument is introduced. Similarly, Spash (2010) showed that the firms take on new technologies to reduce the emissions, as a last resort only when all the other options are not viable. Williams et al. (2012), explained the reason for this as the high cost attached to these investments and the uncertainties attached to climate policies. However, from this study it was found that, the apparel firms in Sri Lanka are willing to take in new technologies to reduce emissions with the support of the government through financial aids in terms of the collected carbon pricing revenue. In fact, investing in new technologies was found to be the most important decision alternative in response to an implemented carbon pricing instrument (see Section 4.3.3). Further, from this study it was proven that most of the apparel firms are aware of the operational cost reductions that can be achieved by adopting new technologies.

On the other hand, Henderson et al. (2017) indicated that, passing the additional cost of carbon pricing to the customers as the easiest and straightforward option for firms with minimum complications. Contrastingly, through this research it was found that shifting cost to customers was the least important decision alternative for Sri Lankan apparel firms (see Section 4.3.3). This was due to the bargaining power of the customers for whom the Sri Lankan apparel firms are supplying. Shifting cost to customers could lead to the risk of losing the customer all together.

Bumpus (2014) has indicated absorbing the additional cost generated by carbon pricing as an easier option for industries like mining which have high price per unit output. However, the current study indicated that absorbing additional cost is a less important decision alternative for Sri Lankan apparel firms. The reason for this is shown as the strong competition among apparel suppliers in the international market. When the cost of carbon price is absorbed, it will impact the profit, which hampers the ability of firms to be competitive.

Carbon pricing revenue utilisation

Revenue utilization is an important aspect that contributes to the overall success of a carbon pricing instrument. Hence, proper selection of revenue utilization options is important to achieve significant emission reductions and maintain these emission reductions over a prolonged period of time. Throughout literature, three main revenue utilization options are explained. They are funding carbon mitigation programmes, supplementing government budgets and reducing other taxes of firms under the pricing instrument. According to Kibria et al. (2018), using the revenue in emission reduction programmes is the most perceived outcome of an implemented carbon pricing instrument. This is because, it ensures that the collected revenue is directly utilized in the emission reduction programmes. On the other hand, Sumner et al. (2011) explains that, some countries like Sweden and Norway are feeding the carbon pricing revenue directly into the government budget. However, from the current study it was found that the apparel firms in Sri Lanka have a strong resistance to feeding carbon pricing revenue

into government budget. According to Liang et al. (2016), the reason for this strong opposition is that, when the revenue is absorbed into the government budget, it is difficult to ensure that the revenue is utilized back to fund carbon emission reduction programmes. The opinion of Sri Lankan apparel firms was similar, as found by the current study. The firms were not confident about the way the allocated revenue will be handled. Firms were strictly on the opinion that the transparency in relation to handling the revenue would be breached if it is absorbed into the government budget.

Using carbon pricing revenue to fund emission reduction programmes was found to be the best possible way of utilizing carbon pricing revenue in Sri Lanka. Sumner et al. (2011) indicated funding new reforestation programmes as one of the best methods of using carbon pricing revenue. However, it was found in the current study that maintaining community forestry is a much better concept to protect the forest cover in Sri Lanka. It is a method which empowers the villagers to main the community forest to strengthen their livelihood. This way it is expected to minimise the encroaches made into the forest reserves. In fact, a community-based forest management programme is already implemented in Sri Lanka with the involvement of government and United Nations Development Programme (De Zoysa, 2017).

Barriers for the implementation of carbon pricing instruments

Lack of direction from top management and lack of awareness from financial decision makers are found to be the organizational level barriers for the implementation of carbon pricing in Sri Lanka. The reason for this could be the increased cost of firms in the short run as explained by Sumner et al. (2011). Further, Liu et al. (2015) explained that the cost of production of firms increases when carbon pricing is introduced. This was identified as a sector level barrier in Sri Lanka as well. The uneven distribution of tax burden is another sector level barrier in Sri Lankan context as identified by the current study. According to Jiang and Shao (2014), the regressive nature of carbon tax impacts more sharply on low income firms. However, in Sri Lankan apparel sector, the uneven distribution of burden is due to market variations. The firms supplying to green

customers would be less impacted compared to a firm supplying for traditional customers. The national level barriers identified through this research are relevant to Sri Lankan context, where the lack institutional framework for a policy instrument like carbon pricing and unavailability of relevant data are found to be the most significant barriers.

Strategies to overcome the barriers

The strategies that can be used to overcome the potential barriers that could come up when implementing a carbon pricing instrument were also found from this research. The identified strategies should be implemented at either the organizational level, sector level or national level based on the specific requirements. At the sector level it is about educating and raising the knowledge level of managers and financial decision makers of firms. In the apparel sector level, the strategies were focused on redefining the apparel market and aligning all firms into a common sustainable platform. In the national level it was found that the involvement of all concerned parties is critical at the initial stages of the implementation of carbon pricing instrument. Further, the effective use of carbon pricing revenue was identified as another strategy that can be used at the national level. On the other hand, enhancing education and training related to green concepts and considering green concept as a part of government's strategy development criteria were found to be long term national level strategies. All the identified strategies were specifically applicable for Sri Lankan context.

4.6 Updated theoretical framework

Figure 8 indicates the updated theoretical framework with the determined decision criteria and importance ranks of decision alternatives.

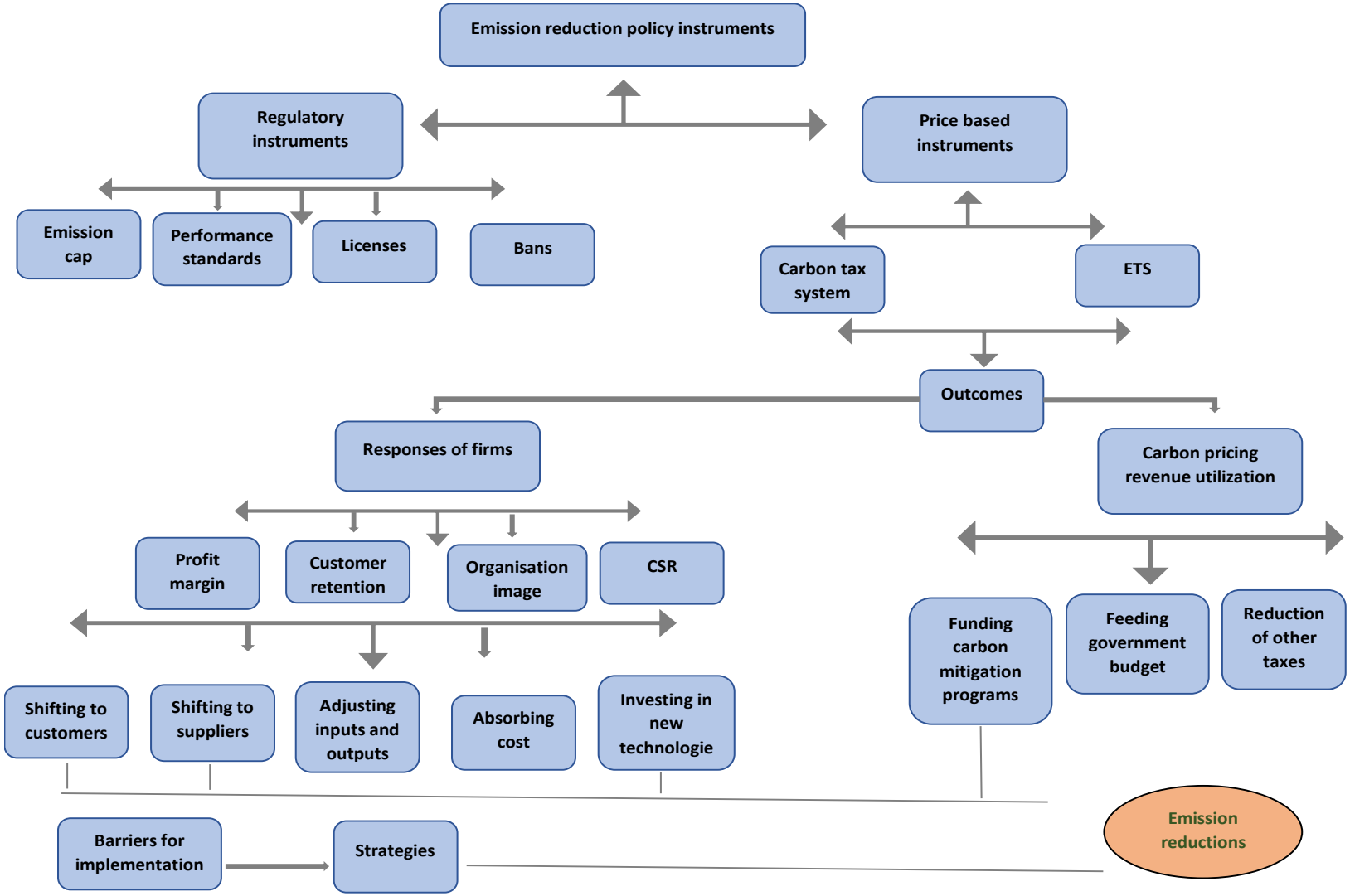


Figure 8: Updated theoretical framework

4.7 Chapter summary

From this chapter it is clear that this research has generated significant and novel findings which will be helpful to identify the applicability of carbon pricing instruments in Sri Lanka, focusing specifically on apparel sector. The decision criteria considered by apparel firms when responding to carbon pricing instruments were established through the preliminary survey. The identified criteria were profitability, customer retention, CSR and organization image. The questionnaire survey revealed that "investing new technologies" as the most important decision alternative for apparel firms. On the other hand, "shifting cost to customers" was identified as the least important decision alternative. "Adjusting inputs, outputs or production processes", "shifting cost to suppliers" and "absorbing additional cost" were identified as second, third and fourth most important decision alternatives respectively. From the expert interviews the most suitable revenue utilization options were identified as introducing energy efficient and cleaner technologies, providing free renewable energy options for industries and promoting reforestation projects and forest conservation. All these revenue utilization options were focusing on transferring the revenue back to firms to reduce carbon emissions. The current study also revealed barriers for the implementation of carbon pricing instruments. It was found that these barriers could occur at three levels as organizational level, sector level and national level. However, it was also recognized that these barriers could be overcome by using proper strategies at the above mentioned three levels.

5.0 Conclusion and Recommendations

5.1 Introduction

This chapter concisely present the key findings of the study as a conclusion. The main focus is given to highlight the findings captured under each research objective. Moreover, recommendations are provided to industry practitioners and academic researchers based on the findings of this study.

5.2 Revisiting objectives

Excessive emission of GHGs has become one of the critical global environmental issues. The subsequent global warming and climate change implications have resulted in environmental ramifications damaging many people. Hence, to control this, emission reduction policy instruments are introduced in many countries. Carbon pricing instruments are found to be an effective way of controlling the excessive carbon emissions. However, the implementation of carbon pricing instrument is not straightforward as it involves many political and socio-economic considerations.

Hence, the aim of this study was to examine the applicability of carbon pricing instruments to reduce energy-based carbon emissions of apparel sector in Sri Lanka. In order to achieve the aim, four research objectives were established. The objectives are,

1. To review,

   I. the decision alternatives available for firms in response to carbon pricing instruments and

   II. revenue utilization options in a carbon pricing instrument

2. To evaluate the level of importance of decision alternatives for apparel firms in Sri Lanka when responding to carbon pricing instruments
3. To determine the suitable revenue utilization options to incorporate with a carbon pricing instrument in Sri Lanka

4. To assess the barriers in implementing carbon pricing instruments in Sri Lanka and strategies that can be used to overcome those barriers

Objective 1 (I)- to review decision alternatives available for firms in response to carbon pricing instruments

The first objective was fulfilled through a thorough literature review. Five decision alternatives for firms in response to enforced carbon pricing instrument were identified through the literature review. The identified decision alternatives were,

- Shifting cost to customers
- Shifting cost to suppliers
- Adjusting inputs, outputs or production processes
- Absorbing the additional costs
- Investing in new technologies

Objective 1 (II)- to review revenue utilization options in a carbon pricing instrument

In addition, three main revenue utilization options were also identified. They are funding carbon mitigation programmes, absorbing revenue into government budgets and reduction of other taxes.

Preliminary Survey

The key literature findings were validated from a preliminary survey before conducting the questionnaires. From the preliminary survey, the identified decision alternatives were validated as applicable to Sri Lankan context.

Moreover, the decision criteria that the apparel firms consider when selecting decision alternatives in this particular context were found from the preliminary survey. The decision criteria identified were profitability, customer retention, CSR and organization image.

Objective 2- to evaluate the level of importance of decision alternatives for apparel firms in Sri Lanka when responding to carbon pricing instruments

Based on the findings of the literature review and the preliminary survey the questionnaire was conducted with ten apparel firms in Sri Lanka. The questionnaire was used to evaluate the level of importance of decision alternatives for apparel firms which is the second objective. The importance level was established by asking the respondents from the selected firms to do a pairwise comparison of decision alternatives under each decision criterion. The collected data were analysed using FEAHP, which enables multi criteria decision making under uncertain circumstances. As carbon pricing is not yet implemented in apparel sector of Sri Lanka and as there are many uncertainties attached to selection decision alternatives, FEAHP was selected as the best method to evaluate the importance of decision alternatives.

From the data analysis, investing in new technologies (DA5) was identified as the most important decision alternative. On the other end, shifting cost to customers (DA1) was found to be the least important decision alternative. This result shows that most firms are willing to invest in new technologies to reduce their emission, when a carbon pricing instrument is implemented. However, respondents highlighted the importance of proper use of carbon pricing revenue to emission mitigation programmes. The reason for this was the massive bargaining powers of the customers of Sri Lankan apparel firms. Hence, shifting cost to customers (DA1) was not an option for most of the firms. Absorbing additional costs (DA4) was also identified as a decision alternative with low importance. This was considered as an outcome which is highly ineffective as it does not result in emission reduction and also impacts the profitability of the firms. Moreover, adjusting inputs, outputs or production processes (DA3) and shifting cost to suppliers (DA2) were ranked as the second and third respectively in the prioritized list of decision alternatives for apparel firms.

Objective 3- to determine the suitable revenue utilization options to incorporate with a carbon pricing instrument in Sri Lanka

Expert interviews were conducted to collect data to fulfill objectives three and four. Objective three was to determine suitable revenue utilization options in Sri Lanka. Introduction of energy efficient and cleaner production technologies and renewable energy sources were found to be the most suitable revenue utilization options. It was suggested that the collected carbon pricing revenue could be used to fund these projects which will enable governing bodies to provide the technologies to firms free of charge or at discounts. Promoting reforestation projects and forest conservation is another important revenue utilization option that was found. It was also suggested to use the collected revenue to strengthen existing governing bodies related to sustainability such as NCPC, SEA, CEA, and waste management authority. which enable these governing bodies to provide free consultation and training for firms. In addition to that providing tax benefits to green initiatives and attracting more green conscious customers to Sri Lankan apparel market were identified as effective methods of using carbon pricing revenue.

Objective 4- to assess the barriers in implementing carbon pricing instruments in Sri Lanka and strategies that can be used to overcome those barriers

Despite the effectiveness of carbon pricing instruments in achieving emission reductions, it is not a straightforward task to implement. From the current study, it was identified that the governing body will have to overcome various barriers at the organizational level, (apparel) sector level and national level. Overcoming these barriers were found to be important in successfully initiating and continuing the carbon pricing instrument.

Lack of top management direction and lack of awareness of financial decision makers were found as the organizational level barriers. Proper guidance from the top management was explained as important in an effective response from firms. If the top management has proper motivation, it could result in proactive actions from firms. However, if the top management does not take proactive actions, carbon pricing will just be another additional cost to firms which will hamper their competitiveness. Proper

awareness of financial decision makers is also important for the successful initiation of a carbon pricing instrument. The importance of long-term benefits of a carbon pricing instrument over its short-term costs should be properly apprehended by the financial decision makers to get their assistance.

Effect on price competitiveness of apparel sector is a critical barrier when implementing a carbon pricing instrument. It was found that in the short run there will actually be an impact on the profitability of the firms. Hence, the price competitiveness of these firms will have some effect. The importance of implementing a carbon pricing instrument in a way that there will be minimum effect on price competitiveness of apparel firms is highlighted. Firms who pay a price for their carbon emissions will have an advantage in attracting and retaining green customers. However, all the apparel firms in Sri Lanka are not catering to green customers in the same way. Hence, the distribution of benefits of an implemented carbon pricing instrument will be uneven among the firms which are governed by the instrument. This will lead to conflicts among firms and the governing bodies, which will hamper the continuation of the carbon pricing instrument.

Ineffectiveness and lack of coordination among governing bodies (NCPC, SEA, CEA, and waste management authority) were found to be national level barriers which can affect the initiation of a carbon pricing instrument. Moreover, unavailability of adequate number of competent personal in these governing bodies were also recognized as a barrier. The importance of competent personal to quantify and validate emission levels for firms was stressed. Further, unavailability of a database including details about the types of energy sources used and how energy is used in industries was also highlighted as a national level barrier when initiating a carbon pricing instrument in Sri Lanka.

In order to overcome the existing barriers and to facilitate successful implementation of carbon pricing instruments, several strategies were proposed through the current study.

At the orgnaisational level, raising awareness and knowledge among top management and financial decision makers on the importance and benefits of carbon pricing instruments was found as a key strategy. This is expected to facilitate smooth

implementation of carbon pricing instrument with minimum resistance from firms. On the other hand, benchmarking firms against other firms which are following green concepts was also expressed as a strategy that will help the firms to realise the benefits of adopting green technologies.

At the sector level redefining apparel firms with more green customers and aligning all firms on a common sustainable platform like SAC were found to be strategies that would both enhance the benefits and ensure fair distribution of benefits.

Gathering all relevant stakeholders and proposing a transparent and effective system to utilise carbon pricing revenue were expressed as key national level strategies to ensure smooth implementation of carbon pricing instruments. On the other hand, enhancing education and knowledge on green concepts at the school and university levels and considering green concept as a criterion in government's strategy development were identified as long-term strategies that could be implemented at the national level.

While fulfilling the four research objectives of this study, the applicability of carbon pricing instruments to reduce emission in apparel sector was proved thus achieved the aim of the study, "to examine the potential of using carbon pricing instruments to reduce carbon emissions of the apparel sector in Sri Lanka". However, in order to ensure the emission reductions and longevity of carbon pricing instrument, the firms and governing bodies have a responsibility to be proactive and environmental conscious.

5.3 Contribution to knowledge

This research has made the below mentioned contributions to knowledge when evaluating the applicability of carbon pricing instruments to reduce energy-based emissions of apparel sector in Sri Lanka.

1. Potential response of apparel firms on implemented carbon pricing instruments
2. Suitable revenue utilisation options in Sri Lanka
3. Barriers to implement carbon pricing instruments in Sri Lankan apparel sector

4. Strategies that can be used to overcome barriers when implementing carbon pricing instruments in Sri Lanka

5.4 Recommendations to practitioners

This study found that the apparel firms are expected to response in a positive manner to carbon pricing instruments which will be effective in ensuring emission reductions. However, this response will be dependent on how the carbon pricing instrument is implemented. Hence, it is recommended to follow suitable revenue utilisation options indicated in this research to get the maximum involvement of apparel firms. Further, the potential barriers for implementation of carbon pricing instruments in Sri Lanka are also identified through this research. In order to overcome these barriers, it is recommended to implement the suggested strategies at organizational level, apparel sector level and national level.

5.5 Areas for further studies

The findings of this research have opened up potential research directions which can be further studied. Accordingly, the possible research directions are indicated below.

- Computing suitable carbon tax rate for apparel sector

Deciding on a suitable carbon tax rate is something that should be studied separately as it is essential to give attention to wide range of economic parameters.

- A study on deciding the most suitable carbon pricing instrument for Sri Lanka- Whether to implement individually or as a hybrid system

The current study focuses on revealing whether the carbon pricing instruments are applicable for Sri Lankan apparel sector. Deciding on the most suitable carbon pricing instrument should done separately. It is also necessary to find whether the carbon pricing instruments should be implemented separately or in combination.

- In depth analysis of suitable revenue utilisation methods in Sri Lanka

An in-depth analysis of the identified revenue utilization methods would help to decide on how to create a win-win situation to both the environment and firms.

6.0 References

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7.0 Annexures

7.1 Fuzzy synthetic extent values

Fuzzy synthetic extent value is obtained by using Equation 7, which can be solved by using the operational laws for two fuzzy numbers given in Equations 1- 4.

Fuzzy synthetic extent values of decision criteria (FCM1)

Decision criteria	Fuzzy synthetic extent value
Profitability (F_{C1})	(0.038,0.515,3.072)
Customer retention (F_{C2})	(0.033,0.299,2.447)
CSR (F_{C3})	(0.026,0.078,1.024)
Organisational image (F_{C4})	(0.029,0.108,1.431)

Fuzzy synthetic extent values of decision alternatives with respect to each decision criterion

Decision alternative	Fuzzy synthetic extent values of decision alternatives with respect to,			
	profitability (FCM2)	customer retention (FCM3)	CSR (FCM4)	organizational image (FCM5)
Shifting cost to customers (F_{DA1})	(0.025,0.091,0.997)	(0.020,0.050,0.661)	(0.024,0.131,1.220)	(0.021,0.060,0.868)
Shifting cost to suppliers (F_{DA2})	(0.029,0.224,1.669)	(0.032,0.247,1.620)	(0.026,0.168,1.432)	(0.023,0.091,1.003)
Adjusting inputs, outputs or production processes (F_{DA3})	(0.026,0.168,1.261)	(0.030,0.180,1.401)	(0.033,0.262,2.035)	(0.032,0.306,1.832)
Absorbing additional costs (F_{DA3})	(0.023,0.058,0.890)	(0.025,0.101,1.020)	(0.017,0.041,0.684)	(0.028,0.182,1.297)

Decision alternative	Fuzzy synthetic extent values of decision alternatives with respect to,			
	profitability (FCM2)	customer retention (FCM3)	CSR (FCM4)	organizational image (FCM5)
Investing in new technologies (F_{DA4})	(0.032,0.459,2.589)	(0.035,0.421,2.383)	(0.028,0.399,2.405)	(0.033,0.361,2.281)

7.2 Minimum degree of possibility

The degree of possibility of each decision criterion/ alternative can be computed using either Equation 8 or 9, by considering the fuzzy synthetic value of that alternative/ criterion against the fuzzy synthetic values of other alternatives/ criteria. Subsequently, the minimum degree of possibility for each decision criterion/ alternative is derived based on the degree of possibility values.

Minimum degree of possibility of decision criterion in FCM1

	Degree of possibility	Minimum degree of possibility
V ($F_{C1} \geq F_{C2}, F_{C3}, F_{C4}$)	(1, 1, 1)	1
V ($F_{C2} \geq F_{C1}, F_{C3}, F_{C4}$)	(0.92, 1, 1)	0.92
V ($F_{C3} \geq F_{C1}, F_{C2}, F_{C4}$)	(0.69, 0.82, 0.97)	0.69
V ($F_{C4} \geq F_{C1}, F_{C2}, F_{C3}$)	(0.77, 0.88, 1)	0.77

Minimum degree of possibility of decision alternatives in each FCM2- FCM5

	Minimum Degree of possibility			
	FCM2	FCM3	FCM4	FCM5
V ($F_{DA1} \geq F_{DA2}, F_{DA3}, F_{DA4}, F_{DA5}$)	0.72	0.63	0.82	0.74
V ($F_{DA2} \geq F_{DA1}, F_{DA3}, F_{DA4}, F_{DA5}$)	0.87	0.9	0.86	0.78
V ($F_{DA3} \geq F_{DA1}, F_{DA2}, F_{DA4}, F_{DA5}$)	0.81	0.85	0.94	0.97

	Minimum Degree of possibility			
	FCM2	**FCM3**	**FCM4**	**FCM5**
V ($F_{DA4} \geq F_{DA1}, F_{DA2}, F_{DA3}, F_{DA5}$)	0.68	0.76	0.65	0.88
V ($F_{DA5} \geq F_{DA1}, F_{DA2}, F_{DA3}, F_{DA4}$)	1	1	1	1

7.3 Preliminary survey- Interview guideline

General Information

Name of the Respondent (Optional): …….

Designation of the Respondent: ……

Years of Experience: ……

E-mail Address (Optional): …….

Telephone (Optional): ……

Decision Alternatives for Apparel Firms in Response to Carbon Pricing Instruments

- Please indicate the applicability of below mentioned decision alternatives for apparel firms in response to carbon pricing instruments.

(Please mark "X" for applicable barriers)

Decision Alternative	Applicability
Shifting cost to consumers	☐
Shifting cost to suppliers	☐
Adjusting inputs, outputs or production processes	☐
Absorbing the additional costs	☐
Investing in new technologies	☐

- What are the other decision alternatives for apparel firms in response to carbon pricing instruments, which are not included in the above list?

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Decision Making Criteria When Responding to Carbon Pricing Instruments

- What are the decision making criteria that would be considered by firms when taking decisions in response to carbon pricing instruments?

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7.4 Questionnaire

Section A- General Information

Name of the Respondent (Optional): …….

Designation of the Respondent: ……

Years of Experience: ……

E-mail Address (Optional): …….

Telephone (Optional): ……

Section B- Instruction to Respondents

- Please answer all questions based on your knowledge and perception
- This will be take up to 30 minutes.
- You are required to **mark the importance** of **decision criteria** (section C) and **decision alternatives** (section D), by pairwise comparison of given options.

Score	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values between the two adjacent judgements

- Please circle 3 numbers in 9-point scale to indicate the relative importance of each option over other in the pairwise comparison. Three selections represent the smallest possible value, most promising value and the largest possible value from right to left (see the example).

Example:

01. Compare the importance of profit margin with customer retention

Profit margin	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	**Customer retention**

- Ranking '3' means, in a scenario where the importance of profit margin is lowest compared to customer retention, customer retention has a moderate importance over profit margin
- Ranking '5' means, in a scenario which is most promising, profit margin has a strong importance over customer retention
- Ranking '7' means, in a scenario where the importance of profit margin is highest compared to customer retention, profit margin has a very strong importance over customer retention

Section C- Criteria for Decision Making

Compare the importance of profit margin over customer retention when deciding on a response method to an implemented carbon pricing instrument.

Profit margin	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Customer retention

Compare the importance of profit margin over Corporate Social Responsibility when deciding on a response method to an implemented carbon pricing instrument.

Profit margin	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Corporate Social Responsibility

Compare the importance of profit margin over organisational image when deciding on a response method to an implemented carbon pricing instrument.

Profit margin	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Organisational Image

Compare the importance of customer retention over Corporate Social Responsibility when deciding on a response method to an implemented carbon pricing instrument.

Customer retention	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Corporate Social Responsibility

Compare the importance of customer retention over organisational image when deciding on a response method to an implemented carbon pricing instrument.

Customer retention	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Organisational Image

Compare the importance of Corporate Social Responsibility over organisational image when deciding on a response method to an implemented carbon pricing instrument.

Corporate Social Responsibility	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Organisational Image

Section D-1- Decision Alternatives with Respect to Profitability

Compare the importance of shifting cost to customers over shifting cost to suppliers in response to an implemented carbon pricing instrument with respect to profitability.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Shifting cost to suppliers

Compare the importance of shifting cost to customers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to profitability.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or production processes

Compare the importance of shifting cost to customers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to profitability.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to customers over investing in new technologies in response to an implemented carbon pricing instrument with respect to profitability.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of shifting cost to suppliers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to profitability.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or

																	production processes

Compare the importance of shifting cost to suppliers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to profitability.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to suppliers over investing in new technologies in response to an implemented carbon pricing instrument with respect to profitability.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of adjusting inputs, outputs or production processes over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to profitability.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of adjusting inputs, outputs or production processes over investing in new technologies in response to an implemented carbon pricing instrument with respect to profitability.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of absorbing the additional costs over investing in new technologies in response to an implemented carbon pricing instrument with respect to profitability.

Absorbing the additional costs	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Section D-2- Decision Alternatives with Respect to Customer Retention

Compare the importance of shifting cost to customers over shifting cost to suppliers in response to an implemented carbon pricing instrument with respect to customer retention.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Shifting cost to suppliers

Compare the importance of shifting cost to customers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to customer retention.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or production processes

Compare the importance of shifting cost to customers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to customer retention.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to customers over investing in new technologies in response to an implemented carbon pricing instrument with respect to customer retention.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of shifting cost to suppliers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to customer retention.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or production processes

Compare the importance of shifting cost to suppliers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to customer retention.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to suppliers over investing in new technologies in response to an implemented carbon pricing instrument with respect to customer retention.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of adjusting inputs, outputs or production processes over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to customer retention.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of adjusting inputs, outputs or production processes over investing in new technologies in response to an implemented carbon pricing instrument with respect to customer retention.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of absorbing the additional costs over investing in new technologies in response to an implemented carbon pricing instrument with respect to customer retention.

Absorbing the additional costs	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Section D-3- Decision Alternatives with Respect to Corporate Social Responsibility

Compare the importance of shifting cost to customers over shifting cost to suppliers in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Shifting cost to suppliers

Compare the importance of shifting cost to customers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or production processes

Compare the importance of shifting cost to customers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to customers over investing in new technologies in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of shifting cost to suppliers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or production processes

Compare the importance of shifting cost to suppliers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to suppliers over investing in new technologies in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of adjusting inputs, outputs or production processes over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of adjusting inputs, outputs or production processes over investing in new technologies in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of absorbing the additional costs over investing in new technologies in response to an implemented carbon pricing instrument with respect to Corporate Social Responsibility.

Absorbing the additional costs	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Section D-4- Decision Alternatives with Respect to Organisational Image

Compare the importance of shifting cost to customers over shifting cost to suppliers in response to an implemented carbon pricing instrument with respect to organisational image.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Shifting cost to suppliers

Compare the importance of shifting cost to customers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to organisational image.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or production processes

Compare the importance of shifting cost to customers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to organisational image.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to customers over investing in new technologies in response to an implemented carbon pricing instrument with respect to organisational image.

Shifting cost to customers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of shifting cost to suppliers over adjusting inputs, outputs or production processes in response to an implemented carbon pricing instrument with respect to organisational image.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Adjusting inputs, outputs or production processes

Compare the importance of shifting cost to suppliers over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to organisational image.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of shifting cost to suppliers over investing in new technologies in response to an implemented carbon pricing instrument with respect to organisational image.

Shifting cost to suppliers	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of adjusting inputs, outputs or production processes over absorbing the additional costs in response to an implemented carbon pricing instrument with respect to organisational image.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Absorbing the additional costs

Compare the importance of adjusting inputs, outputs or production processes over investing in new technologies in response to an implemented carbon pricing instrument with respect to organisational image.

Adjusting inputs, outputs or production processes	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

Compare the importance of absorbing the additional costs over investing in new technologies in response to an implemented carbon pricing instrument with respect to organisational image.

Absorbing the additional costs	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Investing in new technologies

7.5 Expert Opinion Survey- Interview guideline

General Information

Name of the Respondent (Optional): …….

Designation of the Respondent: ……

Years of Experience: ……

E-mail Address (Optional): …….

Telephone (Optional): ……

Revenue Utilisation Options

- In your opinion what are the best suited carbon pricing revenue utilisation methods for Sri Lanka?

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Barriers for the implementation of carbon pricing instruments in apparel sector of Sri Lanka

- In your opinion what are the organizational level barriers for the implementation of a carbon pricing instrument in apparel organisations in Sri Lanka?

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- What are the strategies that can be used to overcome the above barriers?

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- In your opinion what are the sector level barriers for the implementation of a carbon pricing instrument in apparel sector of Sri Lanka?

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- What are the strategies that can be used to overcome the above barriers?

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- In your opinion what are the national level barriers for the implementation of a carbon pricing instrument in Sri Lanka?

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- What are the strategies that can be used to overcome the above barriers?

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