INVESTIGATION OF CAUSES FOR INCREASED GREENHOUSE GAS EMISSIONS FROM THE LOGISTICS VEHICLE FLEET OF SRI LANKA ARMY

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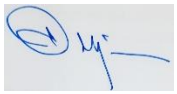
Signature:  Date: 31 August 2021

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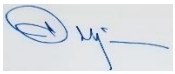
Signature:  Date: 31 August 2021

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STATEMENT OF THE SUPERVISOR

The candidate has carried out research for the MBA in Supply Chain Management in the Department of Transport and Logistics Management of University of Moratuwa under my supervision.

Signature of the supervisor: ..... Date: 31 August 2021

Dr HN Perera

ABSTRACT

Being the largest service organization in the country, the Sri Lanka Army (SLA) is not only responsible to ensure the internal or external threats to the national security of Sri Lanka, but also to ensure the environmental security. In line with that the researcher carefully undertaken this research titled ‘measuring the carbon footprint of the logistics vehicle fleet of the SLA. Since this subject covers a several technical terms, the researcher conducted a comprehensive literature review; referring to various books, journals and paper articles, internet sources, and scholarly articles to discover the research gap which was considered essential element to explore research. Based on that, the researcher defined research objectives, research questions, and research hypotheses.

The methodology was illustrated comprehensively with the adopted research methods and designs. Later a conceptual framework was formulated and the same was operationalized to formulate the questionnaire which was circulated amongst 10 selected senior officers in the SLAOC since it is of strategic importance. Moreover, the researcher consulted professionals in the ministry of environment to discover the impact of carbon footprints that emit from substandard vehicles to pollute the environment.

Since this is qualitative research, the researcher used Microsoft Excel and SPSS software in coding and analysing the data. All the opinions, views, and comments were summarised to excerpt the essence of their ideas. The selected questions of this research were then tested and managed to identify the means of getting rid of the old fleet of vehicles to create a healthy vehicle fleet that emits no or reduced greenhouse gasses.

Having concluded the data presentation and analysis, the researcher described the significant findings through an effective discussion. Questions testing in detail, testing of hypotheses, and the achievement of research objectives were more clearly described to make the reader clearer about the significance of this research.

Recommendations were carefully filtered facilitating the authorities of SLA to initiate the creation of an environmentally friendly GHG-free vehicle fleet. Future researchable areas were also documented for interested parties to conduct further studies.

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LIST OF ABBREVIATION

Abbreviation	Description
AHQ	Army Headquarters
SLA	Sri Lanka Army
SLAOC	Sri Lanka Army Ordnance Corps
IPCC	Intergovernmental Panel on Climate Change
UNFCCC	United Nations Framework of convention on Climate Change
NDCs	Nationally Determined Contributions
CFCs	Chlorofluorocarbons
EV	Electric Vehicle
GM	General Motors
EPA	Environment Protection agency
GHG	Green House Gasses
STA	Swedish Transport Administration
CEA	Central Environmental Authority
MTO	Mechanical Transport Officer
NCO	Non-Commissioned Officer
OC	Officer Commanding
DI	Daily Inspections
MT	Mechanical Transport

ACRs	Annual Confidential Reports
SLEME	Sri Lanka Electrical and Mechanical Engineers
BER	Beyond Economics Repair
RHQ	Regimental Head Quarters
SLASC	Sri Lanka Army Service Corps
SLCMP	Sri Lanka Corps of Military Police
QMG	Quarter Master General
DST	Directorate of Supply and Transport
FMA	Forward Maintenance Area
BAQ	Brigadier Admin and Quartering
HQ	Headquarters
YOM	Year of Manufacture
YOR	Year of registration

CHAPTER ONE

INTRODUCTION

1.1 Background of the research

Sri Lanka Army (SLA) is the largest service organization in the country with an approximate strength of 166,000 Officers and soldiers. It consists of 24 regiments,14 training centres and many other establishments. Of which, Sri Lanka Army Ordnance Corps (SLAOC) is responsible for the provision, procurement, storage, distribution, maintenance and disposal of all ordnance items including arms, ammunition, and logistics vehicles. The establishment of SLAOC dates back to 1949 and has been developing steadily to cater to all logistics requirements of the organization. As of now, the SLAOC comprises 188 dedicated logistics vehicles that include large, medium, and small trucks, vans, buses, high-bed trailers, low-bed trailers, etc. (SLAOC, 2021). The rest of the vehicles are administered by the Directorate of Supply and Transport established at Army Head Quarters (AHQ) which contains more than 300 logistics vehicles that are assigned for logistics operations on request. When SLAOC needs heavy vehicles such as 40 feet Containers, 20 feet Containers, 13 x 13 tons Truck, 12 x 10 tons Truck, TATA 709 Truck, 40-45-Seater Bus, (AC/Non-AC), Double Cabs, Single Cabs, Water Browsers, and Tractors, the SLAOC requests the Directorate of Supply and Transport to assign those vehicles for logistics operations (Samarakoon, 2021).

Unlike other times, the societies across the world pay higher concentration to preserve the environment. Of the various reasons that lead to spoil the environment, the pollution from the emission of greenhouse gases takes precedence. Therefore, being a responsible service organization, SLA has to concentrate on avoiding the environmental pollution from the emission of greenhouse gases, therefore a right

mechanism has to be introduced to measure the carbon footprint of SLA vehicles that are used for logistics operations to protect the environment.

1.2 Justification for the research topic

Greenhouse gas has become a highly discussed subject in the present-day. Therefore, it has taken a significant place in the field of environmental pollution. Since the vehicles of the SLA produces greenhouse gases beyond the expected level, the researcher referred academic literature to identify/benchmark best practices adopted in other organizations or the world in this research. This helped the researcher to fill the research gap.

The outcome of this research will certainly benefit SLAOC and the Directorate of Supply and Transport to introduce best practices to reduce greenhouse gases produced from its vehicle fleets. This facilitates the SLA to maintain a healthy vehicle fleet that can be employed in any logistics mission. This further warrants the SLA to reduce the running cost in terms of fuel usage, repair and maintenance costs. Finally, this research will help the researcher to establish his name in the SLA as an outstanding inventor.

1.3 Significance of the research

When fossil fuels like coal, gasoline, oil and natural gas are burnt, CO_2 will be released to the atmosphere (Nunez, 2019). This leads to increase global warming and the greenhouse effect. Generally, these emissions trap heat close to the surface of the earth. Therefore, if people need to reduce the greenhouse effect in the atmosphere, they need to devise a strategy to reduce the use of fossil fuels. Greenhouse effect often leads to increasing the earth's temperature rapidly resulting high sea levels and extreme storms coupled with further climatic problems ((MacCracken, Moore and Topping, 2008). Due to this reason, SLA has a responsibility to secure the atmosphere from increased emission of greenhouse gases from its substandard logistics vehicles.

This research attempts to introduce a mechanism to ensure zero or low greenhouse gases emissions from logistics vehicles. Moreover, an effort will be taken to discover

modes to decrease the present production of greenhouse gases from logistics vehicles of the SLA. In addition, this study attempts to propose a method for the SLA deviate from its old fleet of logistics vehicles that produce excess greenhouse gases. The recommendations to have a sustainable logistics vehicle fleet with zero or reduced greenhouse gases will add value to this study. In that sense, this study carries a significance in reducing CO_2 that helps the battle against the global warming and reduced carbon footprint.

The evidence accumulated over 30 years suggests that the global climate is considerably being changing due to human activities; significantly due to release of greenhouse gases from fossil fuels (Moellendorf, 2012). Moreover, Moellendorf (2012) illustrates that the global average land and sea surface temperature has risen by 0.6 ±0.2 C since the mid-19th century. Patterns of rainfall have also changed: dry and semidry regions are becoming drier, while other areas, especially mid-to-high latitudes, are becoming wetter. When the rainfall has risen, there has been an unbalanced rise in the rate of the heaviest rainfall events. Therefore, Intergovernmental Panel on Climate Change (IPCC) warns that if no precise actions were taken to lessen the greenhouse gas emissions, global temperatures would likely to be increased between 1.4 and 5.8 C from 1990 to 2100 (Moellendorf, 2012). If so, this will lead to lose several liveable resources and will make the life difficult to human beings around the world.

1.4 Statement of the problem

Gases that trap heat in the atmosphere are called greenhouse gases or ozone-depleting substances (US EPA, 2021). Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), and Fluorinated Gases are mainly considered greenhouse gases. CO_2 often enters the atmosphere through burning of fossil fuels (oil, natural gas, and coal), trees, solid waste, and other biological material, and through chemical reactions like the manufacturing of cement. CH_4 enters into the atmosphere when transporting oil, natural gas, and coal and through livestock and other agricultural practices, and by the decay of organic waste in solid waste landfills. N_2O is emitted during agricultural and

industrial activities, combustion of fossil fuels and solid waste, and during the treatment of wastewater. Fluorinated gases like Hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and nitrogen trifluoride are emitted to the environment from a variety of industrial processes (US EPA, 2021).

By looking at the above, CO_2, and CH_4 are the two main types of greenhouse gases that are emitted into the atmosphere through the operation of logistics vehicles. It is a fact that the logistics vehicle fleet is quite old and produce extra greenhouse gases (Refer: table 2.1 and 2.2 of the Literature Review). Since the demand for logistics vehicles remains high all the time, the maintenance crew does not have sufficient time to maintain the engines into good operating conditions.

During the last couple of decades, several control measures have been introduced by the AHQ for optimum utilization of the vehicles but no proper records have been documented through researches to maintain the logistics vehicle fleet to the expected standard. Some of the measures that had been tested during the past include technical measures to reduce the emission of greenhouse gases, improved efficiency of end-use devices and energy conversion technologies, shift to low-carbon and renewable biomass fuels, zero-emission technologies, and improved energy management. Since these measures involve a huge financial cost, the implementation of such measures has been delayed for years.

Government of Sri Lanka (GoSL) by signing the Paris Agreement on 22nd April 2016, strive to prevent the increase in global temperature of more than 2 degrees Celsius (3.6 degrees Fahrenheit) with a national target beginning from 2020, this includes mandatory reporting and non-binding transparency in implementing the Agreement (Permanent Mission of Sri Lanka to the United Nations, 2016). Moreover, GoSL is taking all possible measures to protect the environment from various types of pollution that include the reduction of greenhouse gases. In line with that, SLA has to introduce measures to reduce the production of greenhouse gases through logistics vehicles and transportation of oil, natural gas, and coal. Since there is no prior research conducted under this title, the researcher believes that this will be a starting point to identify the

sources of greenhouse gases that emanate from SLA vehicles to reduce the environmental pollution.

In that sense, the focal problem of this research is ***'Due to what reasons does the logistics vehicles produce extra greenhouse gases to the atmosphere?'*** and ***'How does the SLA introduce zero greenhouse gas emissions technology or reduce the current emission of greenhouse gases from its logistics vehicles?***

1.5 Hypotheses of the research

The hypotheses of this research are as follows.

H_1 If SLA upgrades/replaces its vehicle fleet with a new vehicle fleet or a sufficiently maintained vehicle fleet, the emission of greenhouse gases to the atmosphere from logistics vehicles can be reduced.

$H0_1$ If SLA upgrades/replaces its vehicle fleet with new vehicle fleet or sufficiently maintained vehicle fleet, the emission of greenhouse gasses from logistics vehicles cannot be reduced/avoided.

1.6 Questions of the research

The questions of this research are as follows.

a. What are the reasons that lead to emit extra greenhouse gases from logistics vehicles to the atmosphere?

b. What is the capacity/possibility of SLA to introduce zero greenhouse gas emissions technology?

c. What is the possibility of the SLA in removing old vehicles by replacing them with new on yearly basis to reduce the current emissions of greenhouse gases from its logistics vehicles?

1.7 Objectives of the research

The objectives of this research are as follows.

1.7.1 **General Objective**. To identify reasons why vehicles of SLA emit excessive greenhouse gases to the atmosphere.

1.7.2. **Specific Objectives**. The specific objectives of this research are as follows.

a. To propose a zero-greenhouse gas emissions technology for logistics vehicles of the SLA for the next five years.

b. To identify the means of reducing the current emission of greenhouse gasses from logistics vehicles of the SLA.

c. To propose a method for the SLA to get rid of the old fleet of logistics vehicles that produce extra greenhouse gasses to the environment.

d. To make recommendations for the SLA to sustain with the logistics vehicles that emit zero or reduced greenhouse gases in the next ten years.

1.8 Methodology

Based on the objectives, a questionnaire was designed to collect primary data for this research. Moreover, primary data was obtained by conducting interviews with relevant officials of the Central Environmental Authority, superiors of SLAOC and Directorates of Supply and Transport SLA. Additionally, a prioritization matrix was incorporated to compare choices and to figure out what to prioritize. Secondary data was collected by referring books, journal and paper articles, research papers and internet sources. In this research, the researcher used coding system. In qualitative research, coding is the way one defines the data to facilitate easy analysing (Green et al., 2007). It is a process of classifying a passage in the text or photograph,

or image, searching and identifying concepts and finding relations between them (Joshi, Kale, Chandel and Pal, 2015).

1.8.1. The basic outline of the methodology is as follows.

a. **Research Method**. Inductive approach.

b. **Philosophy**. Interpretivism.

c. **Sampling Method**. Stratified sampling method.

d. **Population**. The Officers in the SLAOC and the Directorate of Supply and Transport.

e. **Sample Size**. 10 senior Officers of SLAOC and the Directorate of Supply and Transport and 5 Officials of the Ministry of Environment and the Central Environment Authority of Sri Lanka.

f. **Data Collection Method**. Questionnaires, interviews and secondary data.

g. **Method of Data Analysis**. Prioritization Analysis, Frequency Analysis, Microsoft Excel and SPSS.

h. **Conceptual Framework**. Conceptual framework was designed incorporating independent and dependent variables.

1.9 Ethical considerations

The researcher conducted questionnaire survey and interviews to collect primary data only with the consent of the population. Those who were unwilling to furnish details were filtered out. All the collected data will be used for academic purposes and the secrecy of data will be guaranteed until the destruction of the same after the completion of the research.

1.10 Scope of the Research

Carbon footprints are generally produced not only by heavy vehicles that are used for logistics operations but also from other vehicles in the SLA. But, in this research, the

researcher focused only on logistics vehicles due to the lack of time to explore the level of greenhouse gases produced by the other fleet of vehicles in the SLA.

By conducting this research, the researcher identified the present status of the logistics vehicles fleet and what vehicles should be discarded through the board of surveys to acquire new vehicles that produce no or less greenhouse gases. Moreover, the researcher proposes new methods to reduce the emission of greenhouse gases from logistics vehicle fleet which will be an eye opener for a new beginning to preserve the environment.

1.11 Limitations of the research

The researcher will encounter following limitations during the process of the research.

a. Hesitation of providing fool proof answers during the questionnaire and interview process.

b. Reaching the sensitive and higher-level information of the environmental authority and the superiors of the SLAOC.

c. Having less freedom to meet all who take part in this data collection process.

1.12 Conclusion

In this chapter, the researcher described the background of the study, justification for the research title, significance of the study, statement of the problem, research hypotheses, research questions, research objectives, methodology, ethical considerations, scope of the study and the limitations of the study. The next chapter will be dedicated for the literature review.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This literature review is conducted to measure the carbon footprint of the logistics vehicle fleet. In this effort, the researcher incorporated books, journal articles, paper articles, legal documents, and Word-Wide-Web to collect secondary data for this study. Moreover, interviews with selected specialists were conducted to obtain more reliable data for this study. This review of literature further provides scientific theories and cited various literature that was conducted elsewhere concerning the impact of the carbon footprint of vehicle fleets. This provides a theoretical foundation which in turn facilitates to determine the nature of the research in a broader context. Irrelevant works were discarded and those which were peripheral were looked at critically.

Various definitions related to the study Albeck-Ripka (2021) states that a carbon footprint is the total amount of greenhouse gas emissions (CO_2, CH_4, N_2O, and Fluorinated Gases) that come from transportation, housing, and food. Wada (2010) states that a clean environment can only be ensured by creating a Low Carbon Society. However, a sustainable and liveable society cannot be ensured only by the reduction of carbon footprint but also by the reduction of ecological footprint, radioactive footprint, prolonged impact management footprint, and water-warming footprint. Transportation produces the highest amount of greenhouse gases.

At this point, it is viable to learn the effects of greenhouse gases. Maizland (2021) shows that it is a natural process accountable to keep the earth at the temperature essential to withstand life. Greenhouse gases act as imaginary glass walls that prevent the emission of carbon dioxide, methane, and nitrous oxide escaping into space while deflecting the sun's radiation. A pictorial illustration of the impact of greenhouse gas is as follows. Lange (2000) states that greenhouse gas (GHG or GhG) is a gas that

engrosses and discharges radiant energy within the thermal infrared range, producing the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3) are considered the key greenhouse gases in Earth's atmosphere. The average temperature of the Earth's surface without greenhouse gases would remain at −18 °C (0 °F), however the present average is about 15 °C (59 °F). Further, Lange (2000) states that most of the anthropogenic CO_2 emissions come from burning of fossil fuels, mainly coal, petroleum and natural gas, with extra assistances from deforestation and other changes in land use.

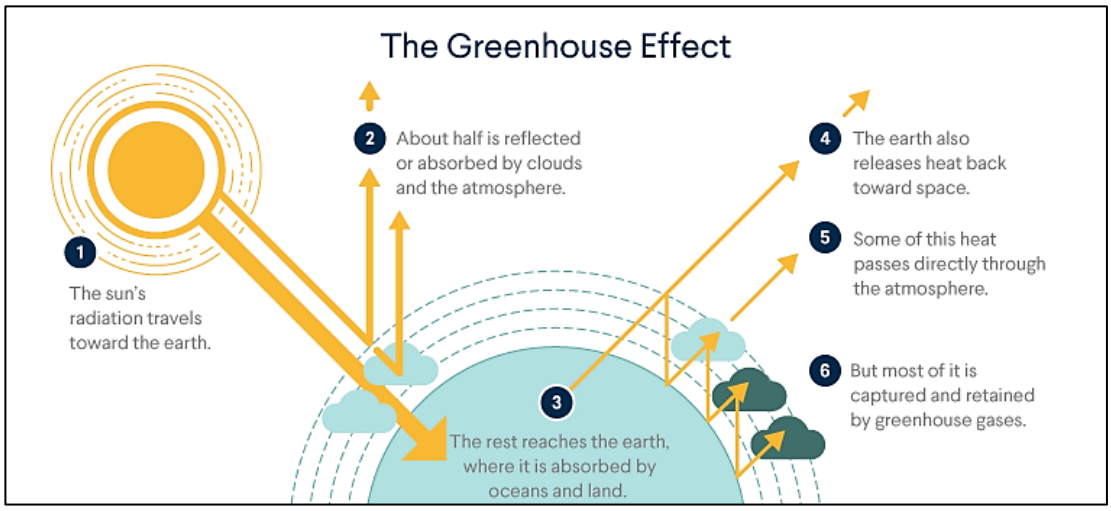

Figure 2. 1- Effect of greenhouse gasses

Source: Reuters (2010)

Establishing and running an effective, self-contained transport network are considered two pillars of logistics operations (UK Army, 2021). To ensure Army's guns firing, tanks driving and soldiers fighting need a huge quantity of fuel, food, and ammunition. Logistic vehicles offer the power of machines to ensure the Army's operational status at the highest level. The amount of greenhouse gases produced by logistics vehicles differs from country to country and level of logistics operations. Sometimes the emission of greenhouse gases in one country may be higher than the other mainly due to aforesaid factors. In Sri Lanka, it seems that emissions from logistics vehicles remains low than from vehicles from other sources, however, as a responsible

organization, SLA cannot neglect it as it pollutes the environment leading to long-term effects.

Logistics vehicles of SLA generally comprise large, medium, and small trucks, vans, buses, high-bed trailers, low-bed trailers, etc. (SLAOC, 2021). These vehicles are heavily used for day-to-day activities, therefore there is little time available for the technicians to get these vehicles serviced or checked for the level of greenhouse gas emission. This leads to worsening the condition of these vehicles. Hence, these vehicles will produce more greenhouse gasses to the environment.

2.2 Various Protocols, Agreements entered into the limit and reduce Greenhouse Gasses

Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change (UNFCCC) by getting industrialized countries and economies committed to limit and reduce Greenhouse Gas (GHG) emissions. The Convention gets the countries committed to adopting policies and measures to mitigate the emission of greenhouse gases and to report periodically to make improvements (UNFCCC, 2021). Though Kyoto Protocol insists countries take measures to reduce greenhouse gas emissions, the amount of carbon dioxide in the environment keeps growing, resulting in heating the globe at a shocking speed. If this warming continues further, it will bring environmental tragedy across the world, in terms of rising sea levels, droughts and floods, and loss of vital species (Maizland,2021).

The Paris Agreement is also a legally binding international treaty on climate change that was entered into force with effect from 4 November 2016. The treaty aims to control global warming between 1.5 – 2 degrees Celsius by reaching global peaking of greenhouse gas emissions swiftly to achieve a climate-neutral world by mid-century. Since 196 parties agree to exert a common effort to combat climate change, the Paris Agreement seems to be productive in all aspects. Paris Agreement tries to establish an economic and social transformation through existing science and technology within a 5 – year cycle, hence, the treaty encouraged the parties to submit

their plans for climate action known as Nationally Determined Contributions (NDCs) (UNFCCC, 2021).

The Paris Agreement invites countries to formulate and submit long-term low greenhouse gas emission development strategies (LT-LEDS) by 2020. This extends a long-term contribution to the NDCs. This Agreement offers an outline for countries to obtain financial, technical, and capacity-building support (UNFCCC, 2021).

Maizland (2021) states that Montreal Protocol – 1987 invites countries to ratify it to arrest elements like chlorofluorocarbons (CFCs) that harm the ozone layer, to which almost all the countries across the world complied. This helps the world remove approximately 99% percent of ozone-depleting substances. The Montreal Protocol was considered a historic environmental accord as it acts as a model for future diplomacy on the issue. Maizland (2021) states that the Kigali Amendment in 2016 was prepared to reduce the production of hydrofluorocarbons (HFCs), and greenhouse gases that contribute to climate change to which all the countries ratified the same.

Sri Lanka is in a process of preparing measures to ensure the successful implementation of NDCs to achieve the set GHG emission reduction targets by 2030. A readiness plan for the execution of the NDCs of Sri Lanka has been developed in consultation with line Ministries, and other stakeholders to obtain relevant information and recommendations. This facilitates the team to recognize institutional gaps, policy gaps, the necessity to improve human and technical capacity,

and financial and technical support to implement the NDCs by 2020 (Ministry of Mahaweli Development and Environment Sri Lanka, 2016).

2.3 Reasons why vehicles emit extra greenhouse gases to the atmosphere

The emission of greenhouse gases is not only polluting the environment but also makes the planet warmer through heat that traps in the atmosphere. For the last 150 years, it was found that human activities often contribute to increasing the greenhouse gases in

the atmosphere. Substantiating the fact, the USA shows that burning fossil fuels, and transportation as the main contributing factors to produce a higher rate of greenhouse gases (US EPA, 2021). Shaheen and Lipman (2007) also show transportation as a key contributor of carbon dioxide (CO_2), however, greenhouse gas or CO_2 are produced from human activities that count for nearly 14% of total anthropogenic emissions globally and approximately 27% in the USA.

Kakouei, Vatani, and Idris (2012) state that in Tehran vehicles like buses, private cars motorcycles, and taxies are considered major sources of anthropogenic carbon dioxide (CO_2) producers. Moreover, approximately 2.4 million private cars exhaust CO_2 heavily into the atmosphere.

Quiros et al. (2017) point out that heavy vehicles run on the road are responsible for 70% of all freight transport which emits approximately 20% of GHG emissions. The main three types of GHG emissions from those vehicles are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Most of them operate either from diesel and compressed natural gas (CNG). It was also revealed that CO_2 emission is much higher in higher-speed routes than that of lower-speed routes, generally, in the USA it was calculated as high as 20–27% of the total greenhouse gas production.

2.4 Is there a zero-greenhouse gas emissions technology

Shaheen and Lipman (2007) indicate that there are strategies like automotive and fuel technologies, intelligent transportation systems (ITS), and mobility management strategies to reduce the use of private vehicles emerging in the world to arrest emissions of greenhouse gases. The invention of innovative engines with the latest technologies helps manufacturers to produce vehicles that emit zero or low greenhouse gases with less fuel consumption. Moreover, studies have proven that traffic signal control, electronic toll collection, bus rapid transit, traveller information, and mobility management approaches like road pricing policies (congestion and cordon) and car sharing (short-term auto access), low-speed modes, integrated regional smart cards, park-and-ride

facilities, parking cash-out, smart growth, telecommuting, and carpooling are greater measures for CO_2 reduction production (Shaheen and Lipman, 2007).

Vehicular exhaust emission limits for every motor vehicle that is imported or assembled or manufactured in Sri Lanka were already published where emission standards were clearly set out for petrol and diesel vehicles (The Gazette of the Democratic Socialist Republic of Sri Lanka, 2018). The emission standards for petrol, diesel, heavy and construction vehicles are attached as 'Annex A' to this research.

An electric vehicle (EV) is either to some extent or fully motorized by electric power. It is a fact that electric vehicles have fewer running costs as they have fewer moving parts. Moreover, they are environmentally friendly as they use little or no fossil fuels like petrol or diesel (TWI Ltd, 2021). Pohl and Elmquist (2010) state that the Volvo Cars have made a substantial progress in its Hybrid Electric Vehicles (HEV) using technology from the internal combustion engine to electric propulsion that resulted in manufacturing low cost and low risk vehicles. No tailpipe carbon dioxide or nitrogen oxide emissions while driving. Volvo has introduced an electric car technology that significantly changed the discipline of motor vehicles which emit no tailpipe while driving, but pure electric progression (Volvo, 2021). Meanwhile, General Motors (GM) GM is on its way to an all-electric future with an assurance to 30 new global electric vehicles by 2025 (Barra, 2021). Further, GM is committed to create a meaningful impact toward building a zero-emissions in future by allowing millions of EVs on the road.

2.5 Means of reducing greenhouse gasses emitted from vehicles

Though it is difficult to curtail the production of CO_2 from vehicles, the following types of vehicles can reduce it drastically helps to maintain a healthy atmosphere (Shaheen and Lipman, 2007).

a. Combustion engine (typically Otto, Diesel, or Atkinson-cycle) vehicles running on gasoline, diesel, bio-diesel, ethanol, methanol, compressed natural gas, liquefied propane gas, or hydrogen (or some blend of these fuels).

b. Electric-drive vehicles, powered by batteries, ultracapacitors, fuel cells, or a combination of power sources.

c. Hybrid gasoline-electric vehicles that combine both of the above, with a wide range of potential ratios between the combustion engine and electric drive; and

d. Other "kinetic" storage/propulsion systems, such as those based on compressed air or mechanical flywheels.

The following good practices help countries to reduce the production of greenhouse gasses.

a. Facilitating ideal route planning and timing.

b. Smoothing accelerations/decelerations and stop-and-go driving.

c. Reducing congestion.

d. Enabling pricing and demand management strategies.

e. Increasing attractiveness of public transportation mode use.

f. Adjusting vehicle transmission for varying road conditions and terrain.

g. Facilitating small platoons of closely spaced vehicles (i.e., safer vehicles could enable weight reduction without compromising occupant safety).

To practice above, a country should formulate a sound transportation policy and invite the countrymen to abide by the same. This needs lots of hard work and commitment.

A country-wide awareness is key to promoting these good practices to battle against the rising and threatening level of greenhouse gasses that emit into the atmosphere daily.

Introducing a renewable fuel standard program is an ideal method to reduce greenhouse gas emissions. Concurrently, the USA convinced its countrymen to use renewable fuels produced from plants, crops, and other biomass to reduce greenhouse gas emissions (US EPA, 2021).

2.6 Possibility of eliminating the old fleet of logistics vehicles of SLA that produce greenhouse gases

The Environmental Protection Agency (EPA) of the USA issued a joint rule to cut down the amount of GHG produce by cars, light trucks, and heavy-duty trucks (US EPA, 2021).

a. Cut 6 billion metric tons of GHG emissions by selling vehicles cross their lifetimes and allowing manufacturers to produce new vehicles meeting EPA standards.

b. Double the fuel efficiency while protecting consumer choice.

c. Reduce dependence on oil and provide significant savings for consumers at the pump.

d. Reduce CO_2 emissions by about 270 million metric tons over the life of vehicles built under the program, saving about 530 million barrels of oil.

e. Improve the fuel efficiency of medium and heavy-duty trucks.

As of the above facts, the USA mainly has been taken measures to reduce the production of GHG from its vehicles by eliminating the old and substandard vehicle fleets. Benchmarking this, SLA also can take measures to eliminate the existing old vehicle fleets to reduce the emission of GHG to the atmosphere.

Meanwhile, UK is in the process of designing and manufacturing zero emission vehicles that will be producing zero emission by 2040 (UK Department for Transport, 2021). In addition, UK is committed to have cars and vans to be zero emission by 2050. Moreover, UK Prime Minister has exclusively decided to not to sell new cars and vans powered by diesel and petrol from 2030 (Harrabin, R., 2020).

It is informed that the legislation of EU sets targets to cut CO_2 emissions from its cars by 37.5 % and vans by 31 % to approve electric vehicles by 2030 (European Environmental Authority, 2021). People in Japan by considering the increasing global warming and rising petroleum prices are presently placing trust on the concept of electric vehicles. The earlier issue of fewer battery capacity or charging time is now replaced with powerful batteries like lithium-ion which are said to be lightweight, smaller and undead early (Japanese Car Trade, 2021).

Fernandez (2021) states that Costa Rica is offering incentives to purchase used or new electric vehicles to promote green vision of the country and the carbon free environment. To promote this effort, Costa Rica has established over 100 electric car charging stations within its national territory (Zúñiga, 2021).

Santos (2017) states that if the world needs to stay within the safety threshold of a 2°C upsurge in normal temperature agreed by all governments, the transport sector requires to be decarbonized. However, two main obstacles to that effect were identified as the absence of a global legally binding deal and the high relative cost of clean vehicle/energy technologies. The Paris Agreement has almost resolved the first obstacle and flagged the way for countries to implement environmental taxes and subsidies to change the virtual costs of clean alternatives, which would eventually resolve the second obstacle. For all these efforts, it is required to invest in clean infrastructure and policy regulations to decarbonize the transport sector (Santos, 2017).

Krantz (2017) states that site construction actions during transport infrastructure projects are considered key contributors to the emission of GHG. Moreover, actions

are on the way in Sweden as the Swedish Transport Administration (STA) has already taken measures to reduce GHG

emissions to zero from its transport infrastructure projects by 2050. It was also revealed that a considerable CO_2 reduction can be attained if project substitutes are assessed methodically all through the planning process. Therefore, key decisions have to be taken at the initial stages of the planning process, later stages should not be overlooked as these create opportunities to take account of more decisive project data and thus expand the confidence of the evaluations. Since SLA is heavily involved in construction projects both within and outside the SLA, the promulgation of proper policies concerning curtailing the emission of GHG is essential.

Dong, Xu, and Gu (2020) state that CO_2 emissions are the main reason for global warming. They further point out that trucks have become the key contributor to CO_2 emissions. In reducing the emission of CO_2 one can follow and adopt the law of conservation of mechanical energy, the first law of thermodynamics, and the vehicle longitudinal dynamics theory. If someone of the SLA can invest time to identify the drawbacks of the existing vehicle fleet and incorporate these three laws/theories to come up with a better solution to reduce the emission of CO_2 from its vehicle fleet.

In an interview, Samarakoon, J., (2021) furnishes following details related to the existing logistics vehicle fleet of the SLAOC.

Model	Type	No	YOM	YOR	Fuel type	Age	Fuel efficiency
Ashok Leyland 40-45 Seated	Bus	1	2011	2012	Diesel	9	4
Tata LPO 1512 41-Seater A/C	Bus	2	2011	2011	Diesel	10	2
Nissan UD	Crain	1	1982	1982	Diesel	39	5L/1 hr
Nissan	C-Cab	1	2010	2010	Diesel	11	7

Mitsubishi FUSO	FFV	2	2013	2013	Diesel	8	4
Isuzu 210	FFV	1	2013	2013	Diesel	8	5
Toyota	FFV	1	2013	2013	Diesel	8	4
Isuzu	FFV	1	2009	2009	Diesel	12	4
Isuzu	FFV	2	2010	2010	Diesel	11	4
Toyota DIANA	FFV	1	2007	2007	Diesel	14	4
Nissan SAFARI	FFV	2	2007	2007	Diesel	14	5
Isuzu	FFV	2	2007	2007	Diesel	14	4
Nissan SAFARI	FFV	1	2009	2009	Diesel	12	5
Toyota DIANA	FFV	2	2009	2009	Diesel	12	6
Isuzu ELF	FFV	1	2009	2009	Diesel	12	4
Isuzu MORITA	FFV	1	2013	2013	Diesel	8	4
Nissan SAFARI	FFV	1	2007	2007	Diesel	14	4
Mitsubishi	FFV	1	2013	2013	Diesel	8	4
Nissan SAFARI	FFV	1	2013	2013	Diesel	8	5
Mitsubishi FUSO	FFV	1	2010	2010	Diesel	11	4
GODREJ	Forklift	1	2012	2012	Diesel	9	2L/1hr
Mitsubishi	Forklift	1	1987	1987	Diesel	34	5L/1 hr
KOMATSU	Forklift	1	2010	2010	Diesel	11	2L/1hr
CATERPILLAR	Forklift	1	1998	1998	Diesel	23	5L/1 hr
CATERPILLAR	Forklift	2	2000	2000	Diesel	21	2L/1hr
CATERPILLAR	Forklift	1	2013	2013	Diesel	8	2L/1hr
Nissan	Forklift	2	2000	2000	Diesel	21	2L/1hr
ACE (AFD)	Forklift	1	2011	2011	Diesel	10	2L/1hr
Ashok Leyland 1613	Lorry	1	2012	2013	Diesel	8	4
Tata	Lorry	2	2011	2011	Diesel	10	4
JAC CANTER	Lorry	1	2020	2020	Diesel	1	5
Ashok Leyland	Lorry	1	2008	2008	Diesel	13	3
Tata	Lorry	2	2019	2019	Diesel	2	4

Tata LPT 16 x 15	Lorry	1	2010	2011	Diesel	10	4
Ashok Leyland	Lorry	1	2011	2012	Diesel	9	3
Ashok Leyland	Lorry	1	2010	2010	Diesel	11	3
Tata 1109	Lorry	1	2018	2018	Diesel	3	4
Ashok Leyland	Lorry	1	2018	2018	Diesel	3	4
Ashok Leyland	Lorry	1	2016	2017	Diesel	4	5
Tata LPT 709	Lorry	1	2012	2012	Diesel	9	4
A/L E-COMET	Lorry	1	2009	2009	Diesel	12	4
TAFE	Tractor	1	2010	2010	Diesel	11	3L/1hr
TAFE	Tractor	1	2018	2018	Diesel	3	3L/1hr
TAFE	Tractor	1	2005	2005	Diesel	16	3L/1hr
TAFE 45DI	Tractor	1	1996	1996	Diesel	25	3L/1hr
45 DI	Tractor	1	2018	2018	Diesel	3	3L/1hr
46 DI	Tractor	1	2010	2010	Diesel	11	3L/1hr
Mahendra	Tractor	1	2006	2007	Diesel	14	3L/1hr
Mahendra	Tractor	1	2015	2015	Diesel	6	3L/1hr
TAFE	Tractor	1	2016	2016	Diesel	5	3L/1hr
Tata LPT 709	Truck	7	2011	2011	Diesel	10	4
Tata SA 1212	Truck	1	2011	2012	Diesel	9	4
Ashok Leyland	Truck	1	2011	2012	Diesel	9	4
Ashok Leyland	Truck	1	2009	2009	Diesel	12	4
A/L CARGO 10	Truck	1	2004	2004	Diesel	17	4
Ashok Leyland	Truck	1	2005	2005	Diesel	16	2
Tata 1313	Truck	1	1990	1991	Diesel	30	4
A/L COMET	Truck	1	2011	2012	Diesel	9	4
Ashok Leyland	Truck	1	2013	2013	Diesel	8	4
Tata LPT 709	Truck	1	2014	2014	Diesel	7	4
Ashok Leyland	Truck	1	2009	2012	Diesel	9	4
Tata LPT 1109	Truck	1	2013	2014	Diesel	7	4
16 x 13	Truck	1	2007	2008	Diesel	13	3
LPT 1615	Truck	1	2012	2012	Diesel	9	4
Tata LPT 709	Truck	1	2016	2016	Diesel	5	4

Tata 13 x 13	Truck	1	2000	2000	Diesel	21	4
Tata 12 x 10	Truck	1	1978	1978	Diesel	43	5
A/L COMET SUPER	Truck	1	2011	2012	Diesel	9	3
Tata LPT 709	Truck	1	2018	2018	Diesel	3	6
Tata 16 x 13	Truck	2	2007	2007	Diesel	14	4
Tata LPT 1615	Truck	1	2004	2004	Diesel	17	4
Ashok Leyland	Water/B	1	2007	2007	Diesel	14	4
Tata 13x13	Water/B	1	1982	1982	Diesel	39	4
A/L ST	Water/B	1	2017	2018	Diesel	3	4
Tata	Water/B	1	2008	2008	Diesel	13	4
EICHER	Water/B	1	2018	2018	Diesel	3	4
Mitsubishi	Water/B	1	2016	2016	Diesel	5	4
Ashok Leyland	Water/B	1	2012	2012	Diesel	9	4
Ashok Leyland	Water/B	1	2005	2006	Diesel	15	4
A/L ST	Water/B	1	2009	2009	Diesel	12	4

Table 2.1 – Existing Logistics vehicles in SLAOC
Source: Samarakoon, J., (2021)

Based on the above table, the ages of vehicles are as follows.

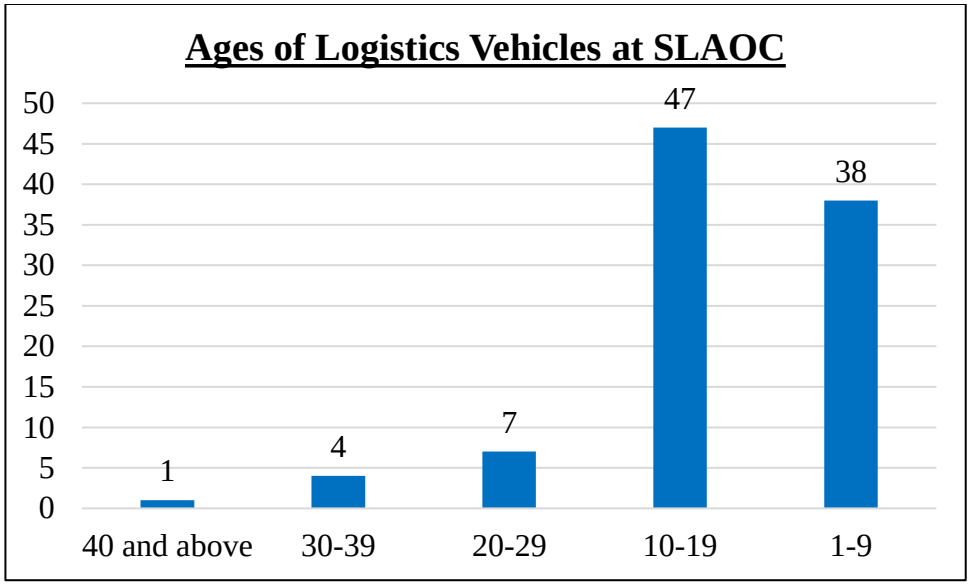

Figure 2. 2- Ages of Logistics Vehicles at SLAOC
Source: Researcher's work

The above table and the bar graph illustrate that most of the logistics vehicles available in the SLAOC inventory are fairly old and are ‘beyond economical repairs. Of the total number, 47 vehicles fall within the bracket of 10 to 19 years and 12 vehicles fall within the bracket of 20 to 43 years.

In an inquiry, Samarakoon, J., (2021) furnishes following details related to the existing logistics vehicle fleet of the directorate of Supply and Transport of SLA.

Model	Type	No	YOM	YOR	Fuel type	Age	Fuel efficiency
Isuzu	Car carrier	1	2017	2017	Diesel	4	4
Mitsubishi FUZO	Water Bowser	2	2016	2016	Diesel	5	4
Kia Buddy	Truck	2	2015	2015	Diesel	6	4
A/l	Tank lorry	2	2014	2014	Diesel	7	4
HOWO CINO	Truck	2	2014	2014	Diesel	7	4
Man	Container lifter	2	2014	2014	Diesel	7	1.5
A/l	Water Bowser	5	2013	2013	Diesel	8	3
A/l	Water Bowser	1	2013	2013	Diesel	8	3
A/L 6500 l	Water Bowser	1	2013	2013	Diesel	8	3
A/L COMMET 4x4	Truck	3	2013	2013	Diesel	8	4
LPK 2516/38	Dump truck	4	2012	2013	Diesel	8	4
Tata 1212 6600l	Water Bowser	1	2013	2013	Diesel	8	3
Tata LPTA 713 4x4	Truck	11	2013	2013	Diesel	8	4

A/L	Bus	12	2011	2012	Diesel	9	4
A/L 12000l	Water Bowser	5	2012	2012	Diesel	9	4
A/L 13000l	Water Bowser	1	2012	2012	Diesel	9	3
A/L Comet	Garbage truck	1	2011	2012	Diesel	9	4
A/L Comet 4/4 13000l	Fuel Bowser	1	2012	2012	Diesel	9	3
A/L Comet 4x4	Truck	1	2011	2012	Diesel	9	4
DIMO	Truck	1	2012	2012	Diesel	9	4
Man	Fuel Bowser	2	2012	2012	Diesel	9	2
Tata	Water/B	1	2012	2012	Diesel	9	3
Tata 1212	Truck	1	2011	2012	Diesel	9	4
Tata 1212	Water/B	1	2011	2012	Diesel	9	3
Tata LPK 1615	Truck	7	2012	2012	Diesel	9	4
2.5 T	Forklift	9	2011	2011	Diesel	10	2L/1 hr
A/L 3516	Prime mover	1	2011	2011	Diesel	10	2
A/L 4923	Prime mover	4	2011	2011	Diesel	10	2
A/L Cargo 1614	Truck	1	2011	2011	Diesel	10	4
A/L Comet 4/4 13000l	Fuel Bowser	1	2011	2011	Diesel	10	3
A/L Comet 4/4 13000l	Water Bowser	1	2011	2011	Diesel	10	3
ACE/f50d 15t	Forklift	2	2011	2011	Diesel	10	2L/1 hr
FAW 4/4	Garbage truck	1	2001	2011	Diesel	10	4
Man TGS 33.360	Prime mover	9	2011	2011	Diesel	10	1.5

Tata	Car carrier	2	2011	2011	Diesel	10	4
Tata 13 x13	Truck	2	2011	2011	Diesel	10	4
Tata 13 x13	Water bowser	2	2011	2011	Diesel	10	4
Tata LPO 1512	Bus	29	2011	2011	Diesel	10	2
Tata LPT 709	Truck	21	2011	2011	Diesel	10	4
Tata LPT 713-38	Bus	1	2011	2011	Diesel	10	2
A/L	Freezer truck	1	2010	2010	Diesel	11	4
A/L Comet 4/4 13000l	Fuel bowser	1	2010	2010	Diesel	11	3
A/L Comet 4/4 13000l	Water bowser	2	2010	2010	Diesel	11	3
Isuzu	Car carrier	1	2010	2010	Diesel	11	4
Mitsubishi	M/c carrier	1	2010	2010	Diesel	11	4
Mitsubishi FUZO	Freezer truck	1	2010	2010	Diesel	11	4
Tata 709	Truck	1	2010	2010	Diesel	11	4
Tata 715	Truck	1	2009	2010	Diesel	11	4
A/l	Bus	3	2009	2009	Diesel	12	4
A/L	Truck	4	2009	2009	Diesel	12	4
A/L 1613	Freezer truck	1	2009	2009	Diesel	12	4
A/L 4923	Prime mover	1	2008	2009	Diesel	12	2
A/L Comet	Truck	4	2009	2009	Diesel	12	4
A/L Comet 4/4	Water Bowser	1	2008	2009	Diesel	12	3
A/L Comet 912	Truck	3	2009	2009	Diesel	12	4
Tata	Truck	1	2009	2009	Diesel	12	4
Tata 1314	Truck	2	2009	2009	Diesel	12	4

Tata 4 x 4	Truck	4	2009	2009	Diesel	12	4
Tata LPT 709	Truck	2	2009	2009	Diesel	12	4
Tata LPT 709 4x2	Truck	2	2009	2009	Diesel	12	4
Tata Utility Cargo	Truck	20	2009	2009	Diesel	12	4
A/L Comet 4/4	Fuel Bowser	1	2008	2008	Diesel	13	3
A/L Comet 1112	Garbage truck	1	2008	2008	Diesel	13	4
Isuzu	Car carrier	1	2008	2008	Diesel	13	4
Mitsubishi FUZO	Garbage truck	1	2008	2008	Diesel	13	4
UD Nissan CKB 450	Prime mover	3	2007	2008	Diesel	13	1.5
A/L Comet 4/4	Water Bowser	1	2007	2007	Diesel	14	3
Tata LPT 713-38	Bus	1	2007	2007	Diesel	14	2
A/L	Bus	1	2006	2006	Diesel	15	4
A/L 4/4	Water Bowser	1	2006	2006	Diesel	15	4
A/L comet 4x4	Truck	1	2006	2006	Diesel	15	4
A/L Viking	Bus	3	2005	2006	Diesel	15	4
Mitsubishi FUZO	Freezer truck	1	2006	2006	Diesel	15	4
Tata 1510	Bus	5	2006	2006	Diesel	15	4
A/L	Bus	1	2005	2005	Diesel	16	4
A/L Comet 4x5	Truck	1	2005	2005	Diesel	16	4
A/L	Truck	2	2004	2004	Diesel	17	4
A/L 4x4	Truck	2	2004	2004	Diesel	17	4
A/L Cargo 2.5	Truck	6	2004	2004	Diesel	17	4
A/L Comet	Bus	8	2004	2004	Diesel	17	4

A/L Comet 1614	Truck	3	2004	2004	Diesel	17	4
A/L Comet 4x4	Truck	9	2004	2004	Diesel	17	4
Tata	Truck	3	2004	2004	Diesel	17	4
Tata 6338	Bus	1	2004	2004	Diesel	17	4
Tata LPT 1615	Truck	8	2004	2004	Diesel	17	4
Tata LPT 1615	Truck	14	2004	2004	Diesel	17	4
Tata LPT 709	Truck	1	2004	2004	Diesel	17	4
Toyota	Bus	1	2004	2004	Diesel	17	4
A/L	Freezer truck	1	2003	2003	Diesel	18	4
Tata Cargo 16/14	Truck	1	2003	2003	Diesel	18	4
A/L Comet	Bus	1	2001	2002	Diesel	19	4
A/L Viking	Bus	1	2002	2002	Diesel	19	2
UD Nissan CKB 454	Prime mover	1	2002	2002	Diesel	19	1.5
A/L 10 Wheel	Truck	1	2001	2001	Diesel	20	4
Tata	Bus	2	2001	2001	Diesel	20	4
UD Nissan CKB 450	Prime mover	1	1998	1999	Diesel	22	1.5
Tata	Bus	1	1997	1997	Diesel	24	4

Table 2.2 - Ages of Logistics Vehicles at Directorate of Supply and Transport of SLA
Source: Samarakoon, J., (2021)

Based on the above table, the ages of vehicles are as follows.

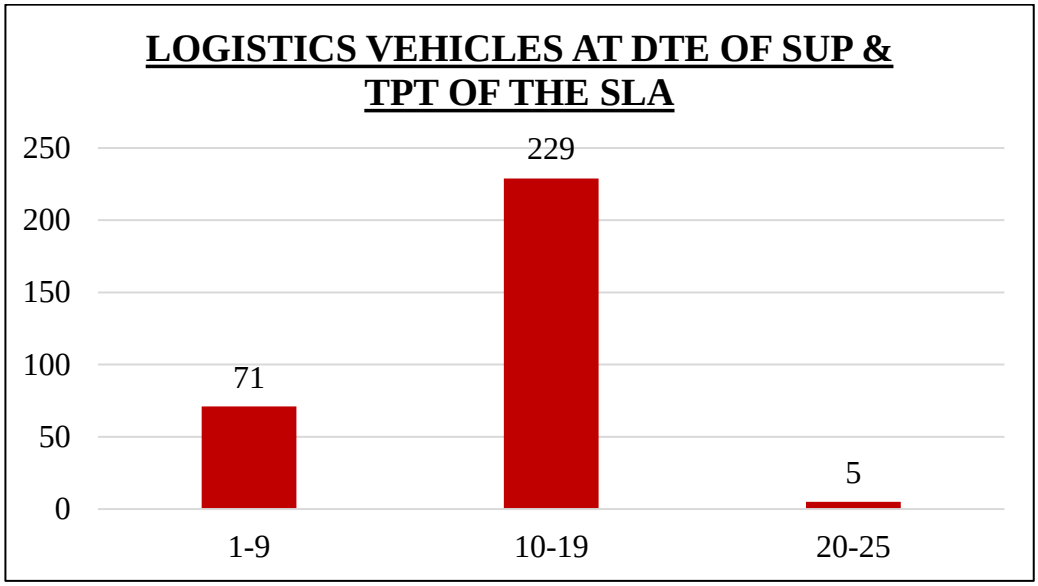

Figure 2. 3- Ages of Logistics Vehicles at Directorate of Supply & Transport of SLAOC
Source: Researcher's work

To substantiate the fact that logistics vehicles of SLA run restlessly, the researcher would like to table average odometer readings of different categories of vehicles.

Type	Standard Mileage/Month	Average Mileage/month
Bus	5000	7500
Car carrier	2500	4000
Container lifter	250 hours	400 hours
Crain	250 hours	450 hours
Crew Cab	4500	7000
Dump truck	5000	8000
FFV	As per the requirement	-
Forklift	250 hours	350 hours
Freezer truck	5000	7000
Fuel Bowser	5000	6000

Garbage truck	5000	7000
Lorry	5000	6000
M/C carrier	4000	5000
Prime mover	5000	7500
Tank lorry	5000	7000
Tractor	1000	1500
Truck	4000	5000
Water Bowser	3500	4500

Table 2.3 - Average odometer readings of different categories of vehicles
Source: Samarakoon, J. (2021)

As of above, it is clear that almost all the logistics vehicles run more than the standard mileage per month. That may be a key contributing factor to turn vehicles into bad condition and to emit excess GHG.

As per the above table, 75% of the vehicles (229 vehicles) belongs to the category of 10-19 years and 2% are above 20 years. Unlike normal vehicles, these vehicles have run restlessly. Therefore, the condition of these vehicles is depleted. One of the reasons inclined to this situation may be the absence of a sound vehicle maintenance policy in the SLAOC and the Directorate of Supply and Transport of the SLA. Therefore, it is essential to revisit the existing vehicle maintenance policy with the experts of SLA and the ministry of environment to redesign a new vehicle maintenance policy that suits to protect the environment. This will certainly make an impact on the new vehicle fleet that is in the process of procurement for the financial year 2021. Treasury approval has already been granted for the following fleet of vehicles.

Type	**No**	**Allocation in millions**
Earth Moving Vehicles	Within the given budget	1102
5 Ton Trucks	50	2150
10 Ton Trucks	200	

All-Terrain Vehicles	100	250
Truck Tractor 6 x 4 with Flat Bed Trailers	10	200
Motor Cycle	200	160
Gully	5	220
Bowser	5	
Multi Task Truck	15	
Total		**4082**

Table 2.4 – Vehicles approved to purchase in 2021
Source: Mettananda (2021)

Upon the procurement of above vehicles, SLA has to take initiatives to discard the old fleet of vehicles systematically through a board of survey without creating any hazards to the environment. Further, the funds generated from discarding of vehicles have to be transferred to the joint fund of the Ministry of Finance (Samarthunga, 2018).

2.7 Identification of research gap

Many scholars across the world have conducted various studies and researches to identify the danger of greenhouse gases to the environment. Most of them have suggested conducive methods to reduce the emission of greenhouse gases from transportation. The world leaders have entered into various protocols and agreements to get countries to agree on the reduction of greenhouse gases from their countries. Having studied thus far, the researcher realized that vehicles that SLA use to convey goods in bulk produce more CO_2 to the environment due to various reasons, of which emission occurs from vehicle fleet takes precedence. Having said that the researcher invested time to find some R&D projects conducted under this scheme to eliminate the present rate of emissions, but the researcher was failed the attempt as there is no evidence to that effect. Therefore, there is a vacuum in this particular area of study ‘measuring the carbon footprint of the logistics vehicle fleet’ and that can only be fulfilled through research of this nature.

2.8 Conclusion

Having introduced the chapter, the researcher described various definitions related to the study, various Protocols, Agreements entered into the limit and reduce Greenhouse Gases, reasons why vehicles emit extra greenhouse gases to the atmosphere, the existence of a zero-greenhouse gas emissions technology, means of reducing greenhouse gases emitted from vehicles and the possibility of eliminating the old fleet of logistics vehicles of SLA that produce greenhouse gasses. The next chapter will be dedicated to describing the methodology comprehensively.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

At the outset, it is essential to underline the method of conducting this research to interpret the results. This study uses qualitative data that had been collected by way of administering questionnaire. In this chapter, the research methodology along with data collection methods are discussed in length to test the validity of hypothesis proposed to enhance the value of the research. The principles of methods, rules, and postulates employed are further discussed and represented in a clear manner of understanding. Since this study is an experimental one, the primary data as much as, possible was collected by way of administering questionnaires. Moreover, interviews and telephone discussions were conducted to collect some other sensitive data essentials for this study. In the empirical part of the thesis, the data related to measuring carbon footprint of the logistics vehicle fleet was collected from the Officers of the SLAOC and AHQ. Mostly the questionnaire comprised of closed ended questions since direct answers were expected. However, a few open-ended questions were included to facilitate Officers to come up with their ideas and comments on the subject area. In addition, interviews were conducted with the senior officials of the Ministry of Environment and the Central Environmental Authority (CEA) of Sri Lanka.

This chapter discusses the research design, research methods, sampling methods, data collection instruments, conceptual framework with independent and dependent variables, operationalization of variables, description of variables, hypotheses and methods of hypotheses testing and questionnaire survey.

3.2 Research design

Creswell (2014) indicates that research design exemplifies the overall strategy that the researcher chooses to integrate the different components of the study in a coherent and

logical way, thereby, ensuring that the researcher effectively addresses the research problem; which often constitutes the blueprint of the collection, measurement, and analysis of data. Nevertheless, one should not forget the fact that the research problem often determines the type of design that a researcher should use. Given this, the length and complication of explaining research designs in the research paper can vary considerably, but this research design leads to achieving the following;

a. Identify the research problem clearly and justify its selection, particularly in relation to any valid alternative designs that could have been used.

b. Review and synthesize previously published literature associated with the research problem.

c. Clearly and explicitly specify hypotheses and research questions relevant to the identified problem.

d. Effectively describe the data that are necessary for an adequate testing of the hypothesis and explain how such data has been obtained.

e. Describe the methods of analysis applied to the data in determining whether or not the selected hypothesis is true or false.

Establishment of a theory is a vital action in most of the research studies (Rajakaruna & Wijeratne, 2019). Usually, researchers construct theories from cases, previously developed theories, using knowledge and experience. Though, the tough part is to narrate and relate them with the data actually collected from field surveys (Golicic and Davis, 2012). Bearing in mind the factors specified in the literature survey, it is vital to measure the carbon footprint of the logistics vehicle fleet in a systematic way. After, identifying the actual reasons leading to the emission of CO_2 excessively from logistics vehicles, the researcher attempts to develop a valid theory or scenario to have a zero-emission technology or minimizing the present level of emissions.

Since this study aims to measure the carbon footprint of the logistics vehicle fleet, a causal research method was applied to investigate the relationships. Causal research, as the name specifies, tries to determine the cause underlying a given behaviour. It finds the cause-and-effect relationship between variables. It seeks to determine how the dependent variable changes with variations of the independent variable. Although quantitative study and qualitative study are both appropriate for such research, this research is conducted as a qualitative study.

3.3 Research method

In this research, the researcher adopted the inductive approach as it moves from a specific level of observations and findings to make broader generalizations. It is also called a 'bottom-up' approach whereby analysis is undertaken to detect patterns in the data from which discoveries can be made (Thomas, 2006).

As described, the researcher adopts a qualitative technique in this research as measuring the carbon footprint of the logistics vehicle fleet involves the ideas, opinions, feelings, emotions of involved parties.

3.4 Research Philosophy

The philosophical paradigm of this research is interpretivism as it is an inquiry of a social science and related disciplines. Further, measuring the carbon footprint of the logistics vehicle fleet is a social phenomenon which should be accomplished by social actors.

3.5 Population, sampling, data collection and analysis

Kumar (2014) indicates that there are two types of random sampling techniques; simple random sampling method and stratified sampling method. Simple random sampling is a technique that gives equal opportunity for each member of the population to get themselves selected for the survey randomly. Stratified sampling method, on the

other hand, is purposive and subjective, there is no control mechanism to ensure each element in the population has the equal chance of being selected. Since the simple random sampling method is relatively expensive and time-consuming compared to the stratified sampling method, the researcher decided to use stratified sampling method in this study. The key advantage of stratified sampling technique in comparison to the random selecting technique is that stratified sampling method more often provides unbiased information.

a. **Population**. Approximately 3,500 Officers and soldiers are working in the regiment of SLAOC. This changes with the service, time and space. However, the researcher consulted only selected Officers of the SLAOC as this is an advanced phenomenon which all staff members do not understand.

b. **Sample Size**. A sample of 10 Officers representing different ranks of SLAOC and the Directorate of Supply and Transport is selected for this survey. Moreover, 5 Officials of the Ministry of Environment and the Central Environment Authority of Sri Lanka were consulted to obtain essential information for this study. The reason for this selection is to acquire more realistic information.

c. **Sampling Technique.** As explained, the stratified sampling technique was used in this research to gather information from Officials of the SLAOC, the Directorate of Supply and Transport and the Ministry of Environment and the Central Environment Authority of Sri Lanka. Accordingly, questionnaires were circulated. Moreover, structured interview questionnaires were designed to collect information from 5 Officials of the Ministry of Environment and the Central Environment Authority of Sri Lanka.

d. **Sample Size**. 10 Officers of the SLAOC, the Directorate of Supply and Transport and 5 Officials of the SLAOC and the Ministry of Environment and the Central Environment Authority of Sri Lanka were enquired to acquire more realistic information.

e. **Data Collection Method**. The researcher used questionnaires and interviews to gather primary data and literature surveys to extract secondary data.

f. **Method of Data Analysis**. Both descriptive and inferential statistics were used to analyse data in this study. SPSS was used where necessary to perform descriptive statistics such as frequencies, percentages, mean values, and standard deviations and to screen data in terms of data coding.

3.6 Regression Analysis

Regression analysis is a consistent technique of recognizing which variables have an impact on a dependent variable or the topic of interest. The procedure of execution of a regression allows one to assertively conclude which factors matter most, which factors can be overlooked, and how these factors make an impact on each other. To comprehend regression analysis completely, it is vital to understand the following terms;

a. **Dependent Variable**. This is the main factor that one strives to comprehend or envisage.

b. **Independent Variables**. These are the factors that one hypothesizes to having an impact on one's dependent variable.

3.6.1 **Correlation between Variables**. Correlation is a measure of strength on a relationship between two variables. This analysis is useful to a researcher when she/he wants to establish if there are **possible connections** between variables. If correlation is found between two variables, it means that when there is a systematic change in one variable, there is also a systematic change in the other and the variables alter together over a certain period of time. If there is correlation found, depending upon the numerical values measured, this can be either **positive** or **negative**.

a. Positive correlation exists if one variable increases simultaneously with the other (i.e., the high numerical values of one variable relate to the high numerical values of the other).

b. Negative correlation exists if one variable decrease when the other increases (i.e., the high numerical values of one variable relate to the low numerical values of the other).

3.6.2 R-Square. R-squared is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination, or the coefficient of multiple determinations for multiple regressions. In a data analysis of a research, the R-square value ranges from zero to one. In a minimum R-square value of 0.15 is a required standard. In multiple linear regressions, the R-Square value is often adjusted for the number of independent variables and the sample size of the population. This is done to avoid over fitting of a model. The adjusted value is known as the Adjusted R-square which contains the same interpretation.

3.7 Conceptual Framework

The conceptual framework for this research is as follows.

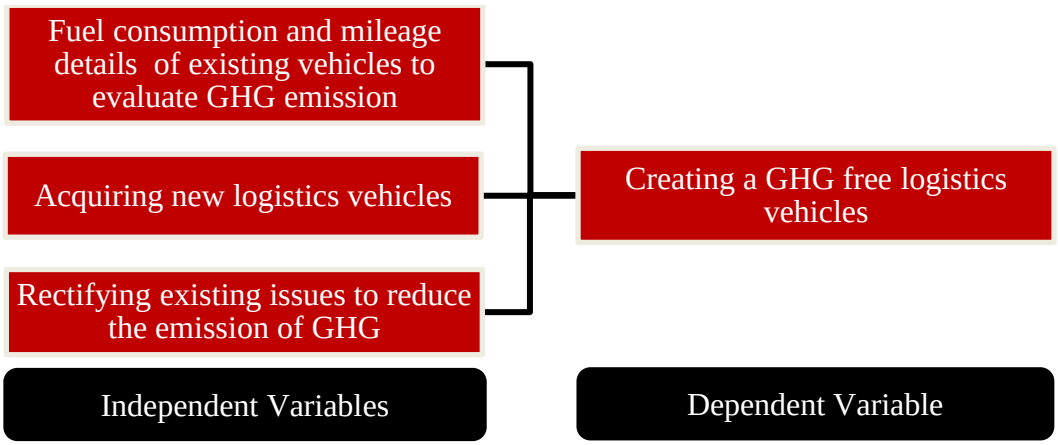

Figure 3.1 - Conceptual Framework
Source: Formulated by the researcher

3.8 Operationalization

The operationalization of the above conceptual framework is as follows.

VARIABLE	POINTER	MEASUREMENT CRITERIA
Fuel consumption and mileage details of existing vehicles to evaluate GHG emission	Assessment	Test against the standard rate of fuel consumption
		Checking monthly inspection charts
		Checking annual inspection charts
		Monthly serving
		Daily inspections and check-ups
		Knowledge of the drivers and technicians
		Reporting system
Acquiring new logistics vehicles	Replacement	Possibility of getting approvals
		Appointment of board of surveys
		Action plan to do away from old fleet
		Lifetime of acquiring fleet
		Funds required for maintenance
Rectifying existing issues to reduce the emission of GHG	Fixing	Higher rate of usage
		Poor maintenance
		Continue to use lifespan elapsed engines
		Undoing greenhouse gas emission tests yearly

		Ideal route planning and timing
		R & D to enhance the performance of existing engines
Creating a GHG free logistics vehicles	Triumph	Proper evaluation on GHG emission
		Acquiring new vehicle fleet
		Rectifying issues of existing vehicle fleet
		Responsibility in preserving the environment
		Setting an example to the society
		Identifying the importance of maintaining vehicles that do not harm the environment

Table 3.1 – Operationalization of variables
Source: Developed by the researcher

3.9 Description of variables

The description of variables is as follows.

a. **Fuel consumption and mileage details of existing vehicles to evaluate GHG emission**. Since there is a strong relationship existing between fuel consumption and mileage details, measuring that is important to evaluate the rate of GHG emission from the existing vehicles of SLA. Often, if the fuel consumption is high the emission of CO_2 from those vehicles are high. There are some other reasons that give rise to increasing the level of CO_2 emissions, however, it can easily be measured by analyzing the rate of fuel consumption.

b. **Acquiring new logistics vehicles**. It is ideal if SLA is able to replace its old fleet of vehicles with a new fleet to curtail the CO_2 emissions. Since this

involves a huge fund, getting them approved through the treasury needs proper justification. This eventually enhances the level of performance along with the capacity of environmental protection.

c. **Rectifying existing issues to reduce the emission of GHG**. Poor maintenance is the key to this issue. Higher rate of usage without attending vehicles' day-to-day checkups is another issue to this effect. Continuing to use the engines that surpass the lifetime is another problem to be considered. Not conducting greenhouse gas emission tests yearly also gives rise to this.

d. **Creating a GHG free logistics vehicles**. Being the largest service organization in the country, SLA is having a greater responsibility in preserving the environment by arresting the emissions of greenhouse gases from its vehicle fleet to the environment. It is a known fact that the military should set an example to the society as done before to get the society aware of the importance of maintaining vehicles that do not harm the environment.

3.10 Hypotheses

The alternate and null hypotheses of this research are as follows.

H_1 If SLA upgrades/replaces its vehicle fleet with a new vehicle fleet or a sufficiently maintained vehicle fleet, the emission of greenhouse gases to the atmosphere from logistics vehicles can be reduced.

$H0_1$ If SLA upgrades/replaces its vehicle fleet with new vehicle fleet or sufficiently maintained vehicle fleet, the emission of greenhouse gasses from logistics vehicles cannot be reduced/avoided.

3.11 Method of hypotheses testing

Statistical parameters can be used to determine whether the probability of a given hypothesis is true or not (Harrison et al., 2020). This is called hypothesis testing. There are four steps usually involved in a process of hypothesis testing and they are;

a. Formulation of the null hypothesis $\mathbf{H_0}$ (the hypothesis that states there is no significant difference between specified populations, any observed difference being due to sampling or experimental error) and the alternative hypothesis $\mathbf{H_a}$ (hypothesis used in hypothesis testing that is contrary to the null hypothesis (Anderson, Burnham, and Thompson, 2000). It is usually taken to be that the observations are the result of a real effect (with some amount of chance variation superposed).

b. Identify test statistics that can be used to assess the truth of the null hypothesis.

c. Computing the P-value, which is the probability that a test statistic at least as significant as the one observed would be obtained assuming that the null hypothesis was

true. If the p-value is less than 0.05, it is strong evidence against the null hypothesis (Nagarajan, Jones, and Keich, 2005).

d. Compare the p-value to an acceptable significance value (sometimes called an alpha value – α). If, $p = \geq \alpha$, that the observed effect is statistically significant, the null hypothesis is ruled out, and the alternative hypothesis is accepted.

Hypothesis testing refers to the formal actions used by statisticians to accept or reject hypotheses. The finest way to decide whether a statistical hypothesis is true would be to study the whole population. From the time when that is often

unusable, researchers typically study a random sample from the population. If sample data was not reliable with the statistical hypothesis, then the hypothesis would be rejected. There are two categories of statistical hypotheses.

a. **Null hypothesis**. Represented by $\mathbf{H_0}$, is usually the hypothesis that sample observations result only from chance.

b. **Alternative hypothesis**. Represented by $\mathbf{H_1}$ or $\mathbf{H_a}$, is the hypothesis that sample observations are influenced by some non-random reason.

3.12 Ethical aspects of the study

The consent of the participants in this interview and questionnaire survey was taken in advance, hence there was no intention to pose any offensive, discriminatory, or other unacceptable questions in this process. Moreover, it was ensured to maintain the privacy of the sample group members. It is pertinent to mention that all excerpts of different scholars and authors had been rightly acknowledged using Harvard referencing style.

All the discussions were based on the findings of this research and an attempt was taken to maintain a high level of objectivity during the entire process of the discussions and analyses.

3.13 Conclusion

In this chapter, the researcher discussed about research design, research method, sampling method, data collection method, conceptual framework, operationalization, description of variables, hypotheses, method of hypotheses testing and methods of conducting questionnaire survey. The next chapter will be fully dedicated to data presentation and analysis.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 INTRODUCTION

This data presentation with analysis is presented based on the title ‘measuring carbon footprints of the logistics vehicle fleet of the SLA. The researcher utilized Microsoft Excel and SPSS 23 to analyse data in terms of frequencies to test the validity of the ideas, opinions, and views of this area of study.

4.1.1 Data Analysis. Since the researcher used a mixed-method, the qualitative data that had been collected from the sample population was converted to quantitative data for easy analysis. Moreover, the data was coded to excerpt the essential information required for this study. It is a method of detecting a passage in the text to search and identify concepts and finding relations between them. Therefore, coding is not just labelling; it is linking data to the research idea and back to other data. All the data gathered through questionnaires were processed through Microsoft Excel and SPSS 23 to conduct the analysis.

4.1.2 Sample Size. The sample size is the act of picking the sum of opinions to include in a statistical sample. The sample size is an important feature of any experimental study in which the goal is to make inferences about a population from a sample. With that understanding, the sample size of this study was limited to 10 Officers representing different ranks of SLAOC, and the Directorate of Supply and Transport is selected. Moreover, 5 Officials of the Ministry of Environment and the Central Environment Authority of Sri Lanka were consulted to obtain essential information for this study. The purposive sampling technique is used in this research as it is a non-probability sampling method in which researchers count on their judgments when selecting members of the population (Lavrakas, 2008).

4.2 Analysis of the basic details of the questionnaire

As informed, the researcher picked up 10 senior officers of the SLA to collect sensitive data for this study. Participation is represented as follows.

S/No	Rank	Number	Regiments	No of years in service
1.	Major General	2	SLAOC /SLASC	Over 31 years
2.	Brigadier	3	SLAOC/SLASC	26 – 30 years
3.	Colonel	2	SLAOC/SLASC	21 – 25 years
4.	Major	3	SLAOC/SLASC	21 – 25 years
	Total	10		

Table 4.1 – Excerpts of senior officials' answers
Source: Constructed by the researcher

The above representation includes two retired Major Generals and three serving Brigadiers, Colonels, and Majors. The reason for such selection is to get a real insight into the level of carbon footprints in the logistics vehicle fleet of the SLA. Moreover, the number of years in service matters a lot to authenticate their ideas, opinions, and views. Since all of them with more than 21 years of experience, the researcher can satisfy with the reliability of the data.

4.3 Analysis of the ideas, opinions, and views of the senior officials of SLAOC

Altogether 10 senior officials participated in the questionnaire survey and the researcher directed twenty-four (24) broader questions to come out with their views. Since some of the answers were lengthy, the researcher excerpts the essence of them for easy analysis.

4.4 Independent variable 1 – fuel consumption and mileage details of existing vehicles to evaluate GHG emission

The first question of this research is ***'98% of the logistics vehicles in SLA run only 2 – 4 km/Ltr which is well below the standard rate of fuel consumption resulted in a high rate of GHG emission. How do you justify this?'*** and their views are as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Have to replace with new vehicles	√	√	√	√	√	√	√	√	√	√
Do away from old vehicles	√		√	√			√	√	√	
Old vehicles emit a high rate of GHG	√	√	√	√	√	√	√	√	√	√
Readjust the categorization of KM per hr			√							
Poor management/maintenance of vehicles	√				√			√		
Lack of vehicles as per scales			√		√	√			√	√
Subjected to frequent repairs	√	√	√	√	√	√	√	√	√	√
Transform the attitudes of Drivers/ Staff	√				√		√	√		
No specific drivers for vehicles	√	√	√		√	√	√			√
Usage of low-quality fuel (barrel fuel)	√								√	
Delay in repairs			√			√				
Use for multiple purposes	√	√		√			√		√	√
Operation in bad terrains with heavy loads					√			√		
Required to generate greater high engine power				√			√			

Table 4.2 – Excerpts of senior officials' answers
Source: Constructed by the researcher

As of above, all were in the opinion that it is high time has to replace old vehicles with new vehicles to reduce the high rate of GHG emission. Due to this, most of the existing vehicles had been subjected to frequent repairs. Moreover, they stated that the existing fleet is being used for multiple purposes in difficult terrains that demand greater engine power resulted in more fuel consumption with a higher rate of GHG emission. Lack of vehicles for day-to-day operations is another reason.

for this state. Therefore, most of the vehicles run continuously without proper maintenance and servicing. Meanwhile, they indicated that no specific drivers are assigned for vehicles resulted in this state of vehicles. Poor management and maintenance are another issue therefore the management at every level have to adhere to and implement strict measures to create professional fleet management. Transforming the attitudes of the drivers and the staff of the transport fleet is essential to have vehicles with fewer emissions of GHG.

The second question of this research is '***Checking monthly inspection charts is a mandatory need to ensure a high rate of vehicle performance. However, due to heavy workload and fewer turnaround times, most of the vehicles miss monthly inspections on time. This might have led logistics vehicles to emit a high rate of GHG. What can you state about this?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Monthly inspection is mandatory	√	√	√	√	√	√	√	√	√	√
Due to heavy commitments, the monthly inspections cannot be done on time	√	√	√	√	√	√	√	√	√	√
Undoing monthly inspections lead to heavy emission of GHG	√	√	√	√	√	√	√	√	√	√
Poor management			√		√		√	√		√

Heavy workload and fewer turnaround times lead to frequent repairs	√	√	√	√	√	√	√	√	√	√
Have to rectify with proper remedial/practical management techniques			√		√				√	√
Lack of knowledge of drives	√	√	√	√	√		√			√
Lack of commitments of staff towards duties	√	√	√	√	√		√	√	√	
Lack of responsibility of officers					√	√	√			

Table 4.3 – Excerpts of senior officials' answers
Source: Constructed by the researcher

The above table substantiates that the majority count on those monthly inspection of vehicles is repetitively being neglected due to the heavy workload assigned for such vehicles. Poor management is also leading logistics vehicles to emit a high rate of GHG and a high rate of fuel consumption. The application of proper remedial/practical management techniques is another option that the authorities of SLAOC can test to have a healthy vehicle fleet. Moreover, they stated that monthly inspections that are done on time help the management to make the right evaluation of the conditions of the vehicles.

The third question of this research is ***'Checking annual inspection charts is also a mandatory need to ensure a high rate of vehicle performance. However, a heavy workload leads to avoid annual inspections on time. This leads logistics vehicles to emit a high rate of GHG. What can you state about this?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Agreed with the statement	√	√	√	√		√	√	√	√	√
Need to assign at least a day from a year for annual inspection			√	√						

Lack of coordination and communication	√	√	√	√	√			√	√	√
Inspections are not conducted as per the laid down criterions			√		√	√	√	√		
Drivers and staff should be educated on the importance of service	√	√	√	√	√	√	√	√	√	√

Table 4.4 – Excerpts of senior officials' answers
Source: Constructed by the researcher

As of above, almost all are agreed with the statement highlighting the importance of monthly and annual servicing of vehicles. They count on those undoing inspections on time leads to emit high rate of GHG. Meanwhile, an Officer is in the view that assigning a day from 365 days for annual inspection is not difficult since there are ample holidays in a year. Moreover, they believed that proper coordination and communication are also necessary to maintain a vehicle fleet with fewer emission of carbon footprints. Some other Officers believe that these inspections are to be conducted as per the laid down criterion to reduce carbon footprints. In addition, all were of the view that the proper education of the drivers and staff is essential to do away from this issue.

The fourth question of this research is ***'Monthly servicing is essential to keep vehicles in an accurate running condition. However, most of the vehicles run bypassing the maximum km for servicing due to heavy workloads. This badly affects to increase in the emission of greenhouse gases. How can you control this?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Get MTO responsible for servicing on time	√				√	√				√
Priority should be given for servicing	√	√	√	√	√	√	√	√	√	√

Educate drivers and staff on the importance of vehicle servicing	√	√	√	√	√		√	√	√	√
Servicing has to be done on the right mileage	√	√	√	√	√	√	√	√	√	√
Poor management	√	√		√	√	√		√		
Need proper coordination and communication		√	√		√	√			√	√
Monitor vehicle running charts for timely servicing		√				√	√		√	
Assign permanent drives for vehicles		√	√		√	√	√	√	√	√
Make officers in the chain of command responsible		√	√		√	√	√			√
Introduce an electronic vehicle maintenance reminder to drivers									√	

Table 4.5 – Excerpts of senior officials' answers
Source: Constructed by the researcher

As of the above table, all believe that priority should be given for timely servicing of vehicles at the right mileage. Making the drivers and staff aware of the importance of vehicle servicing is another method to reach this target. Few other officers stated that the authorities should get the driver, section NCO, Senior NCO, Mechanical transport officers (MTO), OC Admin who falls on the chain of command responsible for monthly and annual servicing of vehicles. A high cost involved in monthly servicing is also highlighted by an officer but he was also of the opinion that monthly servicing is mandatory. Not monitoring of vehicle running charts was also highlighted as a reason for higher GHG emissions. Assigning permanent drives for vehicles was also emphasized to have a vehicle fleet with fewer GHG emissions. The introduction of electronic vehicle maintenance reminders to make the drivers alarmed on time was another point that an officer indicated to reduce the higher rate of GHG emissions.

The fifth question of this research is '***Daily Inspections (DI) and check-ups are essential to keep vehicles in sound operational conditions. However, most of the***

vehicles start daily runs early in the morning with fewer turnaround times, so the drivers and technicians at times forget to conduct daily inspections and check-ups. This leads to an increase in the emission of greenhouse gases. How can you justify this?' and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Section i/c has to conduct DI under the supervision of MTO	√			√					√	√
Drivers and technicians are responsible to conduct DI	√	√	√	√	√	√	√	√	√	√
Due to heavy commitments and shortage of vehicles	√	√	√	√	√		√	√	√	√
Streamline system by identifying shortcomings			√		√	√		√		
Introduce lean management system by optimizing resources	√				√					
Transform a "System centric" approach.									√	√
Assign timings with proper monitoring	√	√	√	√		√	√		√	√
Maintain a record of DI and forward to Officer i/c weekly	√		√	√	√		√	√	√	√

Table 4.6 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Most believe that drivers and technicians are responsible to conduct DI on daily basis and due to lack of interest and responsibility daily DI is undone. Assigning timings with proper monitoring and maintaining a record of DI and forwarding it to Officer i/c weekly are some of the good options to ensure daily DI on time. Some believe that heavy commitments and shortage of vehicles demand a higher number of tasks that prevented DI on time. Introducing a lean management system by optimizing resources

to transform the SLA transport mechanism to a "system-centric" approach was suggested by an officer to gain better results.

The sixth question of this research is '***It a fact that the knowledge of the drivers and technicians of today's context remains low due to lack of interest and lack of opportunities to brush up their skills. Training opportunities have also remained low. This situation leads to turn even good vehicles into bad conditions. How can you rectify this?***' and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Conduct refresher courses for drivers to improve their technical skills	√	√	√	√	√	√	√	√	√	√
Encourage drivers and staff to conduct DI on time under the supervision of O i/c, MT Sgt, MTO, etc.	√	√	√	√	√	√	√	√	√	√
Conduct continuous training to change attitudes of drivers	√	√	√	√	√	√		√	√	√
Create opportunities for adequate training	√	√	√	√	√	√	√	√	√	√
Get drivers and staff to persuade leadership, management skills, and a system-centric approach.	√				√			√	√	
Introduce "Doing the right thing right" by top to bottom with proper monitoring and supervision.					√	√				
Create interest through motivation	√				√				√	√
Have strict inspections	√	√	√		√	√	√	√	√	√
Evaluate the performances of each individual and take corrective measures through punishment and reward	√	√	√		√	√	√			√
Educate drivers on fault identification to ensure the		√	√	√	√		√	√	√	√

proper running condition of vehicles										

Table 4.7 – Excerpts of senior officials' answers
Source: Constructed by the researcher

All believe that conducting refresher courses and continuous training for drivers is essential to improve their technical skills and change attitudes to commit them to maintain a healthy vehicle fleet free from GHG emissions. Encouraging drivers and staff to conduct DI on time under the supervision of O i/c, MT Sgt, MTO, etc. is another technique to improve the standards of the vehicle fleet. Some officers believe that getting drivers and staff to persuade leadership, management skills, and a system-centric approach is ideal to improve the standards. They highlighted the fact that doing the right thing right from top to bottom with proper monitoring and supervision is essential to maintain a healthy vehicle fleet. While motivating drivers to maintain their vehicles properly, the officers have to conduct strict inspections. Evaluating the performances of individuals and taking corrective measures through punishment and reward will also improve the present conditions of vehicles. Educating drivers on fault identification is necessary to ensure the proper running condition of vehicles.

The seventh question of this research is ***'Poor reporting system leads to turn the conditions of vehicles into bad. What do you suggest to improve this situation to maintain a good fleet of logistics vehicles which emit fewer GHG?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Maintain daily and weekly records of mileage fuel consumption	√		√				√	√	√	√
Educate all drivers and staff about the effect of GHG	√	√	√	√	√	√	√	√	√	√
Educate MT staff regarding the importance of a proper reporting system	√	√	√	√		√	√	√	√	√

Close supervision of MTO and MT Sgt is required	√	√	√	√	√	√	√	√	√	√
Introduce continuous training, awareness programs, on-the-job training, and motivation sessions to change the attitudes of drivers/transport staff/technicians.	√	√	√	√	√	√	√	√	√	√
Introduce daily task parade in the morning		√				√				
Make servicing at every 5000km and periodical inspection by management staff (OC once a month, 2 i/c once a quarter, CO once in six months, etc) mandatory	√	√	√	√	√	√	√	√	√	√
Make annual inspection by SLEME/Area Logistic Command mandatory	√	√		√	√	√	√	√	√	√
Introduce a system to evaluate effective maintenance performance annually by publishing the merit-based ranking					√	√	√			
Introduce specific procedures and timeframe for reporting	√				√		√		√	
Introduce punishments to those who violate the procedures and timeframes		√	√	√		√		√		
Get drivers and staff to report any incident/fault on time	√	√		√	√		√		√	√

Table 4.8 – Excerpts of senior officials' answers
Source: Constructed by the researcher

All believe that maintenance of fuel consumption and mileage details of existing vehicles, educating all drivers and staff about the effect of GHG is essential to evaluate the emission of GHG, introducing continuous training, awareness programs, on-the-job training, and motivation sessions to change the attitudes of drivers/transport

staff/technicians, making servicing at every 5000km and periodical inspection by management staff (OC once a month, 2 i/c once a quarter, CO once in six months, etc) are mandatory to reduce the emission of GHG. Moreover, they believe that making annotations in the ACRs of all drivers/transport staff based on a ranking system is necessary to enhance motivation. Encouraging and educating drivers and staff to report any incident/fault on time is also essential to streamline the reporting system.

4.5 Independent variable 2 – acquiring new logistics vehicles

The eighth question of this research is ***'Getting approvals to acquire new vehicles from GoSL is a difficult task unless proper justification is made. Reduction of low GHG emissions is one of the good strategies to propose in this regard. In your opinion, what is the best strategy to acquire new vehicles to SLA?'*** and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Align SLA with the GoSL's sustainable development goals to acquire new vehicles						√				
Insert the vehicle requirement in the SLA's 'way forward strategy 2025'	√	√	√	√	√	√	√	√	√	√
Conduct a proper study with an estimated budget to get approval	√	√	√	√	√	√	√	√	√	√
Since hiring logistics vehicles is costly, ask for a new fleet of vehicles	√		√	√	√	√	√		√	√
Use railway wagons to reduce GHG emissions	√		√		√			√		
Identify priorities and get step-by-step approvals	√	√	√		√	√			√	√
Consult the Ministry of Finance and arrange a credit line with a grace period						√		√		√

with a long-term repayment plan										
Arrange a long-term leasing program that facilitates the SLA to get the ownership after completion of the leasing period	√	√	√	√		√	√	√	√	√
Maintenance costs and life cycles of vehicles should be calculated and submit a fresh proposal to the ministry of finance for approval	√	√	√		√	√	√	√		√

Table 4.9 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Many officers stated that the new vehicle requirement should be included in the SLA's 'way forward strategy 2025' after conducting a proper study with an estimated budget to get approval from the GoSL. Some others believe that arranging a long-term leasing program that facilitates the SLA to get the ownership after completion of the leasing period is an ideal option to replace the old with new vehicles. Aligning SLA's goals with the GoSL's sustainable development goals is also highlighted by a few to get approval to purchase new vehicles. A majority believe that hiring logistics vehicles is costly so that it can be informed to the GoSL to get approval for new purchases. A few suggested using railway wagons to reduce GHG emissions but that does not address the present issue. Therefore, identifying priorities and get step-by-step approvals is one of the best options at hand. Moreover, the SLA has to work in close liaison with the Ministry of Finance to get a credit line with a grace period with a long-term repayment plan to acquire new vehicles. Some others said that a new proposal that will be constructed based on maintenance costs and life cycles has to be submitted to the ministry of finance to get approval.

The ninth question of this research is ***'Board of Surveys are to be appointed to discard the old fleet of vehicles and the considerable fund can be generated by selling them to right buyers. If this would be done generously, a proposal for a new fleet of***

vehicles can be approved. Explain the best way to get approval to procure a new fleet of vehicles.' and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
The scale of vehicles in SLA should bring down by categorizing unsuitable vehicles as unserviceable to get new approval	√	√	√		√	√	√	√	√	√
Justify the advantages of acquiring new vehicles	√	√	√	√	√	√	√	√	√	√
Inform that SLA will use funds generated from tendering vehicles, donations, and credit lines will be used to acquire new vehicles	√	√	√		√			√	√	
SLEME has to classify existing vehicles as X, Y, Z, BER, etc. to make the right proposal	√	√	√	√	√	√	√	√	√	
Conduct an age analysis of the fleet with an efficient disposal procedure	√	√		√	√				√	√
Calculate wastage of funds due to poor standard of the fleet	√		√	√	√	√			√	√
Prepare a long-term vehicle acquiring plan to be tabled at the ministry of finance	√				√					√

Table 4.10 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Many believe that the scale of vehicles in SLA should bring down by categorizing unsuitable vehicles as unserviceable to get new approval. Moreover, they said that it is required to make the right justification about the advantages of acquiring new vehicles to SLA. In addition, SLA can ask for new purchases highlighting the use of funds generated from tendering vehicles, donations, and credit lines. A few stated that

SLEME has to classify existing vehicles as X, Y, Z, and BER and conduct age analysis to make the right proposal. Informing the wastage of funds due to maintenance of poor standard vehicles is another viable option that SLA can play to get new approval. To materialize it, SLA has to prepare a long-term vehicle acquiring plan and table it with the ministry of finance to replace the old fleet of vehicles with new ones.

The tenth question of this research is ***'What is the action plan to do away with the old fleet of vehicles?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Vehicles are to be condemned based on beyond economic repairs / beyond local repairs conditions	√	√	√		√	√	√	√	√	√
Condemned vehicles should be auctioned annually with the GoSL approval	√	√	√	√	√	√	√	√	√	√
Get recapturing value of vehicles beyond economical repairs	√	√	√		√			√	√	
SLEME has to conduct G11 inspections timely to initiate disposal action by SLAOC	√	√	√	√	√	√	√	√	√	

Table 4.11 – Excerpts of senior officials' answers
Source: Constructed by the researcher

All believe that the logistics vehicles in SLA are to be condemned based on beyond economic repairs and beyond local repairs conditions to demand new vehicles. Moreover, they said that all condemned vehicles should be auctioned annually with the GoSL approval and transfer the recapturing value to the treasury to acquire new vehicles. Most importantly, they indicated that conducting inspections by SLEME is necessary to initiate disposal action by SLAOC.

The eleventh question of this research is ***'There are different makes of logistics vehicles in the market (E.g., Japanese, Indian, Chinese, Korean, etc.). If the authority of SLA procures cheap, the lifespan of the vehicles remains low and vice versa, but if SLA opts for a better vehicle the cost per unit is higher. So, what is the strategy of acquiring a new fleet?'*** and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Buying Japanese vehicles is economical and beneficial in the long run	√	√	√	√	√	√	√	√	√	√
Better to go for Japanese and Korean vehicles instead of Chinese and Indian to get advantages in the long run	√	√	√	√	√	√	√	√	√	√
Better to go for vehicles with lengthy lifespans though the unit price is high	√	√	√	√	√	√	√	√	√	
Use the objective of Government (Public) Procurement in Sri Lanka "Value for money" to go for better vehicles	√		√			√	√	√	√	
List specifications of respective vehicles prior hand	√	√	√			√	√	√	√	√
Since Japanese and Korean vehicles remained high, it is advisable to acquire good quality vehicles from Indian based company					√					

Table 4.12 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Many believe that buying Japanese or Korean manufactured vehicles is economical and beneficial in the long run than buying Chinese and Indian vehicles. A majority believe that the decision-making authority should consider the lifespans of the vehicles

than the cost factor to acquire vehicles with good condition. A few officers highlighted the objective of the Government (Public) Procurement in Sri Lanka "Value for money" (Ref Clause 1.2.1 in Government Procurement Guideline/Manual 2006), as it is unessential to go for the lowest since the requirement can be justified. Since the procurement Guidelines/Manuals/Circulars highlight the importance of accepting "Substantially technically responsive, evaluated, lowest Bid" (Clauses 7.8.6 & 7.9.10 in Government Procurement Guideline 2006), the purchasing division can go for better vehicles. Moreover, listing the right specifications of vehicles prior hand is necessary to acquire quality vehicles. Meanwhile, an officer suggested acquiring good quality vehicles from Indian based company, if the price factor limits the purchasing power.

The twelfth question of this research is ***'Most of the time, the decision-making authorities consider acquiring new vehicles in bulk but pay less consideration to its maintenance cost. Therefore, what is the plan to demand additional funds for the maintenance of logistics vehicles?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
As funds are given considering the number of vehicles, SLA has to manage the limited funds given for purchasing and maintenance	√	√	√	√	√	√	√	√	√	√
Submit a report highlighting the disadvantages of not being able to maintain vehicle fleet properly	√	√	√	√	√	√	√	√	√	√
Request additional funds from the government treasury	√	√		√			√	√	√	
Conduct a comprehensive life cycle costing during evaluation process by the TEC	√			√	√	√	√	√	√	√
Ensure uninterrupted supply chain for spares,	√	√	√			√	√	√	√	√

after sale service at reasonable costs										
Ask for additional funds for recurrent expenditure			√			√				
Correctly forecast the maintenance cost and table for approval	√	√			√	√	√			√
Maintenance agreement should be signed between local agents indicating warranty periods					√		√	√		

Table 4.13 – Excerpts of senior officials' answers
Source: Constructed by the researcher

A majority believe that as the funds are given considering the number of vehicles, SLA has to manage the limited funds given for purchasing and maintenance. Moreover, SLA has to submit a report highlighting the disadvantages of not being able to maintain the vehicle fleet properly. Meanwhile, some said that SLA should request additional funds from the government treasury. However, conducting a comprehensive life cycle costing during the evaluation process by the TEC is important before making new purchases. In addition, ensuring an uninterrupted supply chain for spares, after-sales at reasonable costs are also essential to reduce the maintenance cost. Asking for additional funds for a recurrent expenditure vote enhances the buying capacity of the SLA. Therefore, forecasting accurate maintenance is needed to get the ministry's approval. cost Correctly the and table for approval. Moreover, signing maintenance agreements between local agents indicating warranty periods and SLA leads to reduce the maintenance cost.

The thirteenth question of this research is ***'What is the strategy to control the higher rate of usage paying less consideration to vehicles' excess emission of GHG?'*** and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Conduct regular inspections, random checking of vehicles by an expert team	√	√	√	√	√	√	√	√	√	√
Obtain GHG emission certificates	√	√	√	√	√	√	√	√	√	√
Couple journeys to reduce the number of vehicles	√	√	√	√		√	√	√	√	√
Plan and assign tasks for vehicles	√	√	√	√	√	√		√	√	√
Execute proper maintenance program and coordinated transport	√		√		√		√	√		√
Use alternative transports like trains for Goods/Troops			√		√	√			√	√
Implement a procedure to demand transport facilities in advance	√	√		√	√		√	√	√	√
Establish centralized control	√				√		√	√		
Introduce a coordinated mechanism to minimize the daily use of vehicles for routing activities at unit/HQs levels		√	√	√		√				

Table 4.14 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Many suggested that higher usage of vehicles can be cut down by conducting regular inspections, and random checking by expert teams. All agreed that obtaining GHG emission certificates is essential for all SLA vehicles to be aware of the carbon footprints. Careful planning and coupling journeys are considered ideal measures to reduce the number of vehicles on the road. Executing proper maintenance program, coordinated transport routes, using alternative transports like trains for Goods/Troops, demanding transport facilities in advance, establishing centralized control, and introducing a coordinated mechanism to minimize the daily use of vehicles for routing activities at unit/HQs levels would lead to maintaining a better vehicle fleet.

The fourteenth question of this research is ***'Do you agree that the main reason for excess emission of GHG is poor maintenance of logistics vehicles? If so, what is the strategy to improve the present system of vehicle maintenance? How to improve the skills of technicians?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Recruit well-qualified technicians and drivers for logistic vehicles	√	√	√	√	√	√	√	√	√	√
Conduct regular lectures regarding greenhouse gasses and their effect	√	√	√	√	√	√	√	√	√	√
Get staff attended to courses and workshops that impart knowledge on GHG at least once in three months	√	√	√		√	√	√	√	√	√
Increase the number of vehicles on the run	√	√	√	√	√		√	√	√	√
Proper inspections and monitoring of vehicle running charts	√		√	√	√			√		
Organized time schedules for inspections			√		√	√			√	√
Conduct training sessions to improve the knowledge and skills of drivers and staff	√	√	√	√	√			√	√	√
Nominate permanent drives for vehicles	√				√		√	√		
Reward drivers and staff who maintain their vehicles properly			√		√	√				√
Use quality spare parts	√		√	√	√				√	
Enhance the knowledge of technicians about maintenance			√		√	√	√		√	

Table 4.15 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Many believe that recruiting well-qualified technicians and drivers for logistic vehicles will lead to reducing the excess emission of GHG. Conducting regular lectures, courses, and workshops regarding greenhouse gasses and improving the knowledge and skills of drivers is essential to improve the knowledge on GHG and its effect. Assigning more vehicles for daily operations helps technicians to attend to the maintenance of other vehicles. Proper inspections and monitoring of vehicle running charts, organized time schedules for inspections, nominating permanent drives for vehicles, rewarding drivers and staff who maintain their vehicles in proper conditions will also lead to reducing the GHG emissions. A few others suggested using quality spare parts to improve the conditions of vehicles. Moreover, enhancing the knowledge of technicians about the right maintenance will also lead to improving the conditions of the existing vehicle fleet.

The fifteenth question of this research is ***'It is a fact that lifespans elapsed engines are still in operation to meet the given deadlines. What is the strategy to do away or overhauling and using such engines for the betterment of the SLA?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Consider not only the economic benefits but also the environmental friendliness when overhauling engines									√	√
Since the SLA is having a limited budget, overhaul, and reuse engines	√		√	√	√	√	√	√	√	
Do not use overhauled engines for logistics runs as they often carry valuable/security items to long distances	√	√	√	√	√	√	√	√	√	√
Conduct annual inspections considering lifespans of vehicles,	√	√	√		√	√	√	√	√	√

projected/intended schedule for overhauling by SLEME on time										
Maintain an annual overhauling calendar and inform respective RHQs with copies to QMG, to enable hiring during overhauling	√	√	√		√		√	√		
If the repair is BER, dispose of vehicles through the right procedure	√	√	√				√	√	√	√
Ensure quality of overhauling and repairs considering lifespans after repairs	√	√	√	√	√	√	√	√	√	√
Ensure using quality spares for overhauling by local agents	√	√	√	√	√	√	√	√	√	√

Table 4.16 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Most of the participants stated that overhauled engines should not be used for logistics runs as they often carry valuable/security items to long distances. Ensuring the quality of overhauling and repairs considering the lifespans after repairs and the utilization of quality spares for overhauling by local agents are important to fix the unserviceable engines. Since the SLA is having a limited budget, SLA has to overhaul and reuse engines until approval for new acquisition is received. Conducting annual inspections considering lifespans of vehicles, projected/intended schedule for overhauling by SLEME on time is also necessary to improve the present conditions of the vehicles. Moreover, a few indicated that when overhauling engines, the authorities should consider not only the economic benefits but also the environmental friendliness as excess GHG emissions pollute the environment. However, if the repair is BER, disposal of vehicles should be done adhering to the right procedure. Meanwhile, a few highlighted the importance of maintaining an annual overhauling calendar to inform respective RHQs about overhauling on time.

The sixteenth question of this research is ***'The surge in carbon dioxide levels due to burning of fossil fuels is now causing an overall warming of the planet that is having impacts around the globe. To reduce this, all vehicles need to be subjected to greenhouse gas emission tests yearly. Unfortunately, several vehicles of SLA do not practice this on time. What is your view on this?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Greenhouse gas emission test is mandatory for all vehicles	√	√	√	√	√	√	√	√	√	√
Make sure all vehicles are repaired and run using the limited budget	√							√	√	
Establish right supervision of the authority	√	√	√	√	√	√	√	√	√	√
SLCMP has to check randomly the availability of greenhouse gas emissions test reports and restrict movements without it	√		√		√	√			√	√
SLASC should not allow vehicles to pump fuel without the greenhouse gas emission test certificate	√	√	√		√		√	√		√
All vehicles should do greenhouse gas emissions test as per scheduled timings and punish those who violate it	√	√	√	√	√	√	√	√	√	√

Table 4.17 – Excerpts of senior officials' answers
Source: Constructed by the researcher

All said that greenhouse gas emission tests should be made mandatory for all vehicles through the right supervision of the authorities of SLASC, SLEME, and SLAOC. Another feasible measure is to not allow vehicles to pump fuel without the greenhouse

gas emission test certificates. They further informed that the authorities should make sure that all vehicles are repaired and in operation using the limited budget. Random checking by SLCMP about the availability of greenhouse gas emissions test reports and restricting the movements without them is another measure to maintain the standards of the vehicles. Moreover, scheduled timings should be given for all vehicles to get greenhouse gas emissions tests on time and introduce suitable punishments to those who violate the rule.

The seventeenth question of this research is ***'Route planning often saves time and transportation cost that helps SLA to enjoy a flexible budget. This increases the number of destinations SLA can reach in a day, effectively saving SLA's time and money on the road. What strategies are in the pipeline to address this issue?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Centrally control the movements of logistics vehicles at SFHQ levels	√	√	√	√	√	√	√	√	√	√
Encourage using expressways, railways, inland water, and sea routes			√					√	√	
QMG in liaison with DST and Command FMA in liaison with BAQs should work out a practical overall strategy	√	√	√	√	√	√	√	√	√	√
Proper application of procedures is essential			√	√	√			√	√	√
Introduce a coordinated mechanism	√	√	√	√	√	√	√	√	√	√

Table 4.18 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Most believe that the movements of logistics vehicles should be centrally controlled through a coordinated mechanism at SFHQ levels. For this, the application of procedures is essential. Moreover, they said that the authorities should encourage using expressways, railways, inland water, and sea routes as alternative measures. Further, they said that a practical overall strategy should be worked out by QMG in liaison with DST and Command FMA in liaison with BAQs.

The eighteenth question of this research is ***'Poor or lack of R&D projects inhibit the opportunity for staff to come out with innovative measures to enhance the performance of existing engines resulted in fewer emission of GHG. What is your plan to encourage the staff to get engaged with more R&D projects to address this issue?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
The directorate of R&D should encourage doing more R&D projects	√	√	√	√	√	√	√	√	√	√
Give priority in annual promotion boards to those who innovate new strategies	√		√	√		√	√	√	√	
Research should be undertaken by the Research Centre of the Ministry of Defence	√	√				√	√		√	√
Provide training courses and skill development programs to encourage innovations	√	√	√	√	√	√	√	√	√	√
Annual budgetary allocations should be reserved for this	√		√	√	√			√		

Table 4.19 – Excerpts of senior officials' answers
Source: Constructed by the researcher.

All believe that the directorate of R&D should get involved in this to encourage personnel to conduct R&D projects. For this, SLA has to offer training courses and skill development programs on innovations. Further, they said that more priority in annual promotion boards should be given to those who innovate new strategies. Some believe that it should be done under the Research Centre of the Ministry of Defence to facilitate the strategies for all tri-services. To get this right annual budgetary allocation should be reserved for this.

The nineteenth question of this research is ***'Poor evaluation on GHG emission has resulted SLA to retain with old fleet of logistics vehicles that emit excess GHG. What is your opinion on this?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Proper evaluation in this regard was not conducted by SLA to date	√	√	√	√	√	√	√	√	√	√
A proper mechanism should be introduced to identify and resolve this problem	√	√	√	√	√		√	√	√	√
Should be changed to new vehicle fleet	√	√		√	√	√	√	√	√	√
Make greenhouse gas emission tests mandatory for all vehicles	√	√	√	√	√	√	√	√	√	√
Adopt proper maintenance procedures	√	√	√	√	√		√	√	√	√

Table 4.20 – Excerpts of senior officials' answers
Source: Constructed by the researcher

All believe that it is high time to conduct a proper evaluation to test greenhouse gas emissions as it has not been initiated by the SLA to date. Moreover, they said that SLA should make greenhouse gas emission tests and proper maintenance procedures mandatory for all vehicles to resolve this problem. Moreover, the majority said that the existing vehicle fleet should be replaced with new.

The twentieth question of this research is ***'Acquiring a new vehicle fleet will help SLA to reduce the environmental pollution by operating GHG free logistics vehicles. Will this be a possibility considering the present mechanism of maintenance?'*** and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
This is the most suitable and feasible solution	√	√	√	√	√	√	√	√	√	√
Educate staff on proper maintenance	√		√	√	√	√	√	√	√	√
Strict procedures should be implemented for inspections	√	√	√	√	√	√	√	√	√	√
Prevailing economic and social conditions do not permit GoSL to spend			√				√			

Table 4.21 – Excerpts of senior officials' answers
Source: Constructed by the researcher

Almost all agreed that moving to a new vehicle fleet is the ideal solution to this. Many others said that encourage staff to conduct proper maintenance through practical procedures and inspections. However, a few believe that this is not practical considering the prevailing economic and social conditions in the country.

The twenty-first question of this research is ***'It a mandatory need to rectify the issues of the existing logistics vehicle fleet of SLA. But it requires a huge fund. Will the authorities of SLA manage to get an additional fund approved for this?'*** If not, what is your plan?**'** and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Introduce a 10-year plan to replace vehicles	√	√	√	√	√	√	√	√	√	√
Since approving an additional fund is not possible, initiate the right maintenance mechanism	√		√	√	√	√	√	√	√	√
Project a statistical proposal with the right justification	√	√	√	√	√		√	√	√	√

Table 4.22 – Excerpts of senior officials' answers
Source: Constructed by the researcher

All believe that SLA should introduce a 10-year plan with a statistical proposal to replace the existing vehicles as getting approval for an additional fund is not possible at this point due to the prevailing economic situation in the country. Therefore, all believe that the right maintenance mechanism is the ideal solution at present.

The twenty-second question of this research is ***'Being the largest service organization in the country, SLA stands a huge responsibility to preserve the environment from GHG. However, the majority of logistics vehicles of SLA have not satisfied this need. If so, what is your strategy to preserve the environment from excess emission of GHG?'*** If not, what is your plan?**'** and the summary of answers is as follows.

Opinion/View/Idea	Comments of the responders									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Minimize unnecessary movements of vehicles at the unit, HQ levels	√	√	√	√	√	√	√	√	√	√
Introduce a proper maintenance mechanism on time	√	√	√	√	√	√	√	√	√	√
Conduct awareness programs to all staff including drivers	√	√	√	√	√	√	√	√	√	√

Use quality spares for repairs	√	√	√	√	√	√	√	√	√	√
Develop the skills of technicians	√	√	√			√				√

Table 4.23 – Excerpts of senior officials' answers
Source: Constructed by the researcher

As of above, all suggested minimizing the unnecessary movements of vehicles at the unit, HQ levels. Moreover, they suggested implementing proper maintenance of vehicles timely using quality spare parts. Conducting awareness programs for all staff including drivers is mandatory to develop the skills of technicians.

The twenty-third question of this research is ***'Being the largest service organization in the country, SLA has to set an example to the society by maintaining GHG free logistics vehicle fleet, but it was beyond the reach with this fleet. If so, what is your strategy to set an example to maintain GHG free logistics vehicle fleet?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Obtain GHG emission certificates yearly	√	√	√	√	√	√	√	√	√	√
Introduce a proper mechanism to maintain the vehicle fleet and initiate action against those who violate it	√	√	√	√	√	√	√	√	√	√
Have a proper schedule for vehicle movements at the unit, HQ levels	√	√	√	√	√	√	√	√	√	√
Conduct continuous inspections	√	√	√	√				√	√	√
Offer proper training to develop the skills of staff	√	√	√	√	√	√	√	√	√	√
Utilize funds effectively	√	√	√	√	√	√	√	√	√	√
Use quality spare parts for repairs	√	√	√	√	√	√	√	√	√	√
Hire good vehicles on a requirement basis	√	√				√	√	√		√

Table 4.24 – Excerpts of senior officials' answers
Source: Constructed by the researcher

All said that obtaining GHG emission certificates yearly and proper maintenance of vehicles should be made mandatory and should take action against those who violate them. Introducing a proper

schedule for vehicle movements at the unit, HQ levels, conducting continuous inspections, offering proper training to develop the skills of staff, utilizing funds effectively to purchase quality spare parts are also mandatory to have a GHG-free vehicle fleet. Meanwhile, some others believe that SLA should hire good vehicles as requirements arise.

The twenty-fourth question of this research is ***'What are the strategies of SLA to identify logistics vehicles that do not harm the environment by emitting excess greenhouse gases?'*** and the summary of answers is as follows.

Opinion/View/Idea	**Comments of the responders**									
	R1	**R2**	**R3**	**R$**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**
Conduct proper research involving high ranking officers of SLA and experts of the outside	√	√			√	√	√	√	√	√
Paste stickers for GHG controlled or free vehicles	√		√	√			√			
Conduct eco-tests	√	√	√	√	√	√	√	√	√	√
Induction of electric vehicles/ hybrid vehicles			√		√		√	√		
Establish proper maintenance	√	√	√	√	√	√	√	√	√	√
Conduct regular inspections	√	√	√	√	√	√	√	√	√	√
Conduct proper training to develop skills of human resources	√	√	√	√	√	√	√	√	√	√
Utilize funds meaningfully	√		√		√	√	√	√		
Effectively manage the movements of vehicles	√	√	√	√	√	√	√	√	√	√

Conduct awareness programs to staff including drivers	√	√	√	√	√	√	√	√	√	√
Use quality spare parts for repairs	√	√	√	√	√	√	√	√	√	√
Use railways as maximum as possible	√	√		√			√		√	√
Hire good vehicles on a requirement basis		√	√	√	√			√		

Table 4.25 – Excerpts of senior officials' answers
Source: Constructed by the researcher

As of above, many have stated that SLA needs to conduct proper research involving high-ranking officers of SLA and experts of the outside to maintain a proper vehicle fleet free from GHG. Conducting eco-tests, introducing electric vehicles/hybrid vehicles, establishing proper maintenance, conducting regular inspections, conducting proper training to develop skills of human resources, utilizing funds meaningfully, effectively managing the movements of vehicles, conducting awareness programs to staff including drivers, using of quality spare parts for repairs were suggested by many for better results. Using railways and hiring good vehicles on a requirement basis are also found as good strategies. A few have suggested pasting stickers for GHG-controlled or free vehicles for easy identification.

This concludes the analysis of 10 Officers representing different ranks of SLAOC and the Directorate of Supply and Transport of SLA.

Moreover, 5 Officials of the Ministry of Environment and the Central Environment Authority of Sri Lanka were consulted to obtain essential information for this study. Having conducted interviews virtually through zoom, the researcher discovered that reducing the carbon footprint release from the vehicles has become one of the priorities of the GoSL's sustainable development goals. Therefore, they believe that SLA has to convince the GoSL through a right justification based on statistical analysis to replace the aging vehicle fleet gradually in ten years to ensure GHG emission-free vehicles.

CHAPTER FIVE

FINDINGS AND DISCUSSIONS

5.1 Introduction

In this chapter, the researcher discusses the findings of this research giving more prominence to research questions, research objectives, and research hypotheses.

5.1.1 Testing of research questions

In this research, the researcher introduced three research questions and the first research question is ***'What are the reasons that lead to emitting extra greenhouse gases from logistics vehicles to the atmosphere?'*** and the identified reasons are as follows.

d. Most of the logistics vehicles of the SLA are old with a high rate of fuel consumption resulted in emitting excess GHG to the environment.

e. Not conducting vehicle maintenance accurately and on time.

f. High rate of fuel consumption.

g. Poor engine performances due to undoing proper repairs and pending overhaul actions.

h. Operate often in difficult terrains.

i. Overloading daily tasks.

j. Undoing servicing on time.

k. Undoing greenhouse gas emission tests.

l. Undoing regular inspections.

m. Not having a proper reporting procedure.

n. Lack of skills of the staff and drivers.

o. Not assigning permanent drivers for vehicles.

p. Lack of training opportunities for staff.

q. Using degraded spare parts.

The second research question is *'What is the capacity/possibility of SLA to introduce zero greenhouse gas emissions technology?'* and the summarised comments are as follows.

a. This is possible by introducing electric or hybrid vehicles to the fleet.

b. Projecting a statistical proposal to replace the aging vehicle fleet with new in a ten-year plan.

c. Conduct proper overhaul and repairs to the existing vehicles using quality spare parts.

d. Take measures to do away from the old vehicles based on greenhouse gas emission tests.

e. Not allowing vehicles with a higher rate of GHG emissions to run on the roads.

f. Enhancing the knowledge of staff and drivers through training and awareness programs on the proper vehicle maintenance and the impact of greenhouse gasses.

g. Initiate a step-by-step approach to get rid of aging vehicles.

h. Take an effort to acquire advanced greenhouse gas emissions technology to SLA.

i. Draw an overall plan and convince the GoSL to replace the existing vehicle fleet.

The third research question is ***'What is the possibility of the SLA in removing old vehicles by replacing them with new on yearly basis to reduce the current emissions of greenhouse gases from its logistics vehicles?'*** and the summarised comments are as follows.

a. Get approval from the GoSL to replace the existing vehicles with electric or hybrid vehicles to the fleet.

b. Projecting a statistical proposal to replace the aging vehicle fleet with new in a ten-year plan.

c. Draw an overall plan and convince the GoSL to replace the existing vehicle fleet.

d. Take measures to do away from the old vehicles based on greenhouse gas emission tests.

e. Initiate a step-by-step approach to get rid of aging vehicles.

f. Take an effort to acquire advanced greenhouse gas emissions technology to SLA and convince the GoSL.

5.2 Testing of research hypotheses

In this research, the researcher defined null and alternate hypotheses and they are as follows.

H_1 If SLA upgrades/replaces its vehicle fleet with a new vehicle fleet or a sufficiently maintained vehicle fleet, the emission of greenhouse gases to the atmosphere from logistics vehicles can be reduced.

$H0_1$ If SLA upgrades/replaces its vehicle fleet with a new vehicle fleet or sufficiently maintained vehicle fleet, the emission of greenhouse gasses from logistics vehicles cannot be reduced/avoided.

Based on the evidence excerpts, it was proven that if SLA upgrades/replaces its vehicle fleet with a new vehicle fleet or a sufficiently maintained vehicle fleet, the emission of greenhouse gases to the atmosphere from logistics vehicles can be reduced as the old fleet with poor maintenance is liable to this state.

5.3 Addressing research objectives

In this research, the researcher introduced four objectives. The first objective is ***'To propose a zero-greenhouse gas emissions technology for military vehicles of the SLA for the next five years.*** The proposed system is as follows.

<table>
<tr><th>1st year</th><th>2nd year</th><th>3rd year</th><th>4th year</th><th>5th year</th></tr>
<tr><td>Projecting a statistical proposal to replace the aging vehicles fleet with new vehicles in a ten-year plan</td><td>Submit an overall plan to convince the GoSL to replace the existing vehicle fleet</td><td colspan="3">Initiate a step-by-step approach to get rid of aging vehicles</td></tr>
<tr><td colspan="5">Procure electric or hybrid vehicles</td></tr>
<tr><td colspan="5">Conduct proper overhaul and repairs</td></tr>
<tr><td colspan="5">Regularly conduct greenhouse gas emission tests</td></tr>
<tr><td colspan="5">Curtail running vehicles with a higher rate of GHG emissions</td></tr>
<tr><td colspan="5">Enhancing the knowledge of staff and drivers through training and awareness programs on proper vehicle maintenance and the impact of greenhouse gasses</td></tr>
<tr><td colspan="5">Embrace advanced greenhouse gas emissions technology to SLA</td></tr>
</table>

Table 5.1 – Five-year plan
Source: Constructed by the researcher

The second objective is ***'To identify the means of reducing the current production of greenhouse gasses from military vehicles of the SLA'***. The proposed measures are as follows.

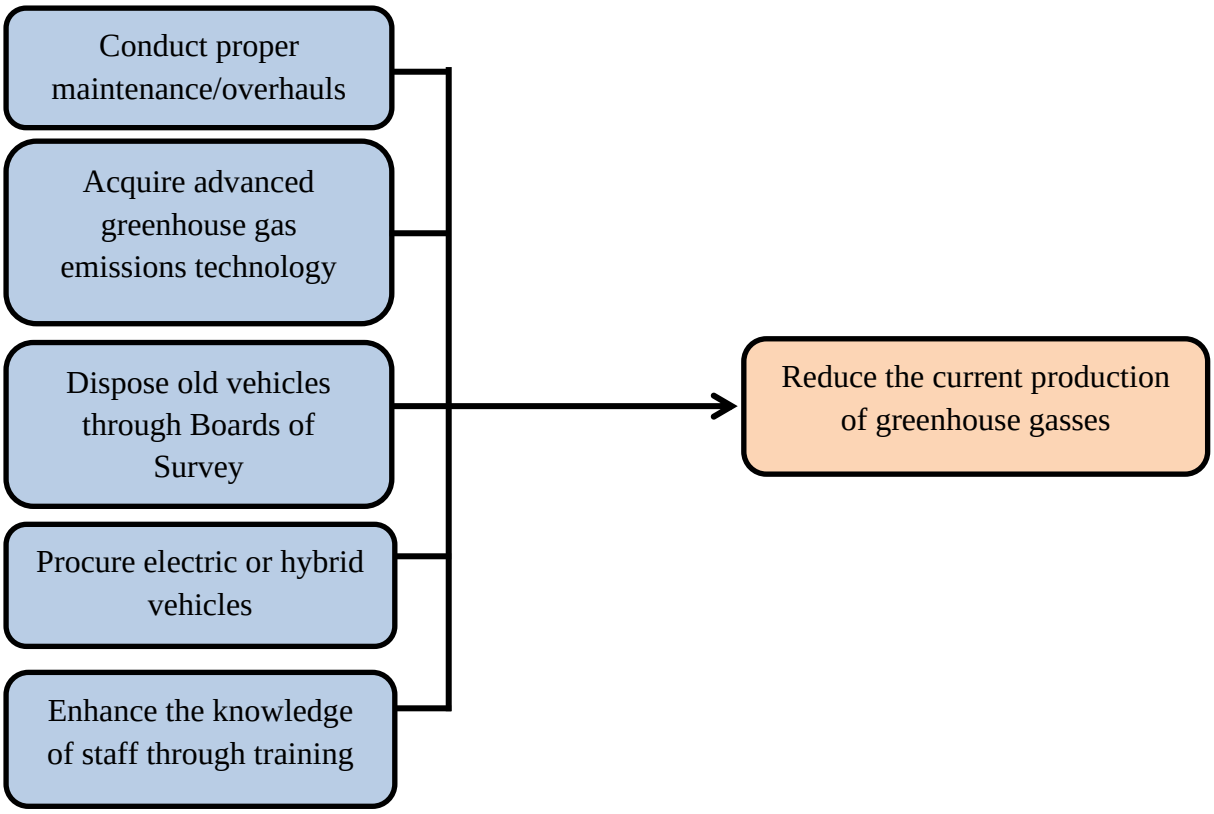

Figure 5.1 – Means of reducing the current production of greenhouse gasses
Source: Constructed by the researcher

The third specific objective is ***'To propose a method for the SLA to get rid of the old fleet of military vehicles that produce extra greenhouse gasses to the environment'***. The proposed methods are as follows.

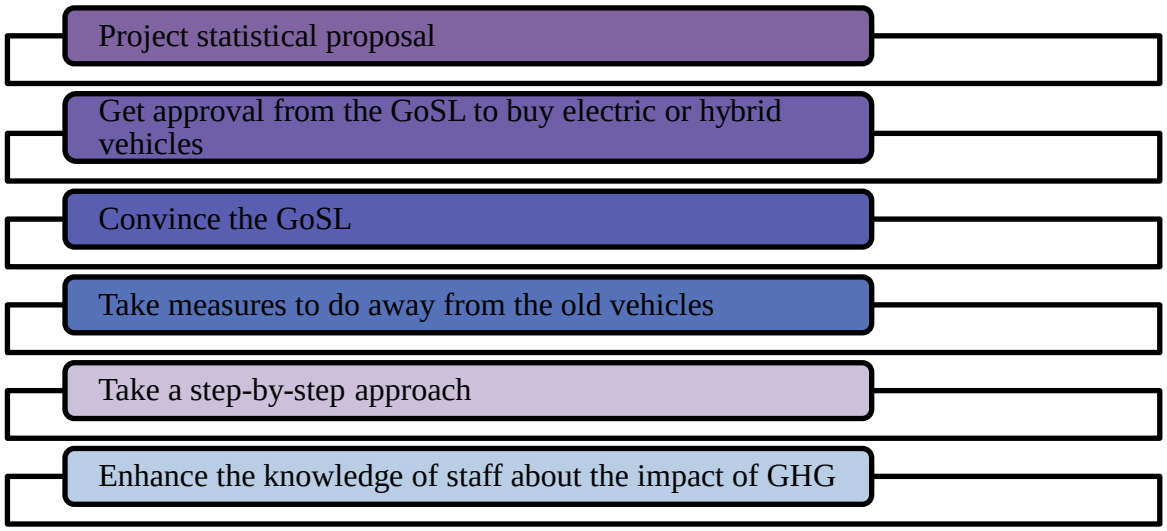

Figure 5.2 – Method of getting rid of the old fleet
Source: Constructed by the researcher

5.4 Conclusion

The above analysis established that SLA could be able to create a GHG-free logistics vehicles fleet by disposing of the existing vehicle fleet through a justifiable proposal. Moreover, the same can be achieved by procuring electric and hybrid vehicles in the future. This concludes the findings and discussion.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This research is undertaken to measure the carbon footprint of the logistics vehicle fleet of the SLA. Given that, the researcher conducted a comprehensive literature review; referring to various books, journals and paper articles, internet sources, and scholarly articles to discover the research gap which is an essential element to conduct research. Based on that, the researcher defined research objectives, research questions, and research hypotheses. The methodology is illustrated comprehensively with the adopted research methods and designs. Later a conceptual framework was formulated and the same was operationalized to formulate the questionnaire which was circulated amongst 10 selected senior officers in the SLAOC since it is of strategic importance.

In this research, the researcher used Microsoft Excel and SPSS software in coding and analysing the data. All the opinions, views, and comments were summarised to excerpt the essence of their ideas. The selected questions of this research were then tested and managed to identify the means of getting rid of the old fleet of vehicles to create a healthy vehicle fleet that emits no or reduced greenhouse gasses.

Having concluded the data presentation and analysis, the researcher identified key findings to resolve this issue. Procuring electric or hybrid vehicles was found as the ideal solution, however, if that is not feasible, SLA has to establish proper overhauling and repairing centres to ensure right maintenance. Moreover, it was revealed that conducting greenhouse gas emission tests is essential to identify vehicles that need speedy repairs. Additionally, it was revealed that enhancing the knowledge of staff and drivers through right training and awareness programs on proper vehicle maintenance and the impact of greenhouse gasses are essential to improve the standards of vehicle fleet. Obtaining advanced greenhouse gas emissions technology is also essential to the

SLA to do away with the old vehicle fleet. Convincing the GoSL through a detailed proposal prepared through a professional R & D Team facilitate SLA to approve the necessary funds from the GoSL.

Carefully filtered recommendations were documented for the authorities of SLA to initiate the creation of an environmentally friendly GHG-free vehicle fleet. Future researchable areas were also documented for interested parties to conduct further studies considering this as a base study.

6.2 Recommendations

The researcher would like to place the following recommendations on record for implementation.

a. Getting approval for a new fleet of vehicles to carry out logistics tasks of the SLA is difficult due to the bad economic situation in the country. Therefore, it is recommended for SLA to embrace an advanced and zero greenhouse gas emissions technology for military vehicles. Having introduced that, SLA has to make a sound proposal to the government that should be implemented gradually in five to ten years from now.

b. All future procurement should be based on quality and durable brands with warranty, so that even if the initial cost is high, that pays dividends in the long run.

c. Greenhouse policy has to be produced considering all the important elements and stern actions have to be taken against those who violate the same.

d. The current production of greenhouse gasses from military vehicles of the SLA has to be reduced by conducting professional engine overhauls and repairs.

e. No vehicles should be allowed to run without greenhouse gas emission test certificates.

f. A comprehensive report based on statistical data has to be produced involving high-ranking officers of SLA and the experts of the field to get rid of the old fleet of military vehicles that produce extra greenhouse gasses to the environment.

g. Right training has to be offered to the technicians and the drivers about the proper maintenance of vehicles and the means of identifying vehicles that emit excess greenhouse gasses.

h. The authorities of SLEME, SLAOC, SLASC have to take more responsibility in assuring proper maintenance of vehicles using quality spare parts.

i. The number of daily journeys is to be reduced by combining runs that travel in the same direction. For this carefully planned schedule is essential.

6.3 Future researchable areas

In this research, the researcher considers the vehicles only in SLAOC and the Directorate of Supply and Transport of the SLA. Therefore, one can explore the carbon footprints of all vehicles in the SLA to propose valuable recommendations to reduce the emission of greenhouse gasses.

Right repairs, maintenance, and overhauls are essential to ensure a healthy vehicle fleet in the SLA. However, daily complaints establish that the reason for the present state of vehicles is poor or substandard maintenance using inferior spare parts. Therefore, this area can be researched in depth.

Policy on vehicle disposal and acquisition can be produced through comprehensive research. For this, the researcher can get the assistance of the experts in the ministry of environment, ministry of transport, and other professionals in the field.

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