A STUDY ON SUSTAINABILITY OF PORT OPERATIONS: THE CASE OF PORT OF COLOMBO

A Research Report By:
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As a partial fulfillment of the requirement for the award of the degree

B.Sc. (Hons.) in Maritime Transportation Management and Logistics

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Year of submission: 2020

DECLARATION

I hereby confirm that this Dissertation was entirely carried out by me under the guidance of my supervisor and I am aware of the consequences of cheating and malpractices. I am willing to answer any query of any academic staff member in relation to my research at any time. I certify that this research has not been submitted in whole or in part to any other university or institution for another degree or Diploma.

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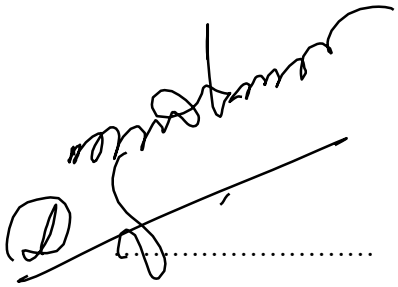

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ABSTRACT

The term “sustainable” as a broadly used phenomenon, consists of three dimensions: environmental, social and economic, which are known as triple bottom lines of the concept of sustainability. All United Nations (UN) Member States adopted the 2030 agenda for achieving Sustainable Development Goals (SDGs) which can be addressed by any industry. The preliminary intention of the International Maritime Organization related to sustainability is “The conservation and the sustainable use of oceans and their resources”. Seaports are complex transport nodes in the global transportation network. Further, seaports are disreputable as one of the most polluting industries due to their complex operations as an interface between sea and land. Lack of implementation of sustainability growth-led port policies is an identical problem in the maritime sector in many developing countries. This paper investigates the three dimensions of sustainability in relation to seaport operation selecting the Port of Colombo (PoC) as a case. The main research objective is to determine the extent to which the focused port is aligned with the most relevant 11 SDGs out of all 17 SDGs in UN 2030 agenda from 2015 to 2020. A questionnaire was developed and data were gathered from both operational & management level port employees (n=182). Hypothesis testing & paired sample t-test were performed. Analysis results indicated that PoC is only aligned with 9 SDGs out of the all core 11 SDGs related to port industry. All the 8 Core SDGs (Good health-well-being, Affordable-clean energy, Industry- innovation-infrastructure, Sustainable cities-communities, Responsible consumption-responsible production, Climate action, Life below water, Partnerships for the goals) have been developing during the period from 2015 to 2020. However, only one secondary SDG (Gender Equality – SDG 5) has developed well over other 4 Core SDGs. Clean water-sanitation & Decent work- economic growth have not been developing from 2015 to 2020 inside PoC. A conceptual model/framework connected with 4 SDGs (Life below water, Industry-innovation-infrastructure. Good health-well-being & Affordable-clean energy) which is specified for sustainability of PoC was derived using Exploratory Factor Analysis and Confirmatory Factor Analysis and Model Fit Analysis. The paper provides policy implications for sustainability policy design in port sector in Sri Lanka.

Keyword: Port Operations, Economic Sustainability, Social Sustainability, Environmental Sustainability, Sustainable Development Goals (SDGs)

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CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

UN's 2030 global agenda consists of 17 sustainable development goals (SDGs). This research was conceptualized on a structure of sustainability practices in port operations with reference to the 17 SDGs. Economic stability and corporate social responsibility are among the main drivers for sustainability hence, port functions or operations behave as an economic catalyst and international trade's midpoint (Cheon & Deakin, 2010; Kim & Chiang, 2014). Other driver is the continuation of environmental standards under all rules & regulations (Dinwoodie *et al*., 2012; Adams *et al*., 2010; Kim & Chiang, 2014). Releasing limber water, harmful emissions, waste disposal, noise production & pollution are related to one pillar named environmental sustainability. (Ozispa & Arabelen, 2018).

Sea port is an industrial & commercial tool equipped with infrastructure & technical facilities to shelter different types of ships. This case study is based on Port of Colombo which is famous as the main container port of Sri Lanka even it handles bulk cargo and other cargo types as well. A sea port is a node link between sea & land & it is a clear example for intermodality (Tarantola, 2005). Globalization, deregulation, logistics integration and containerization have reshaped the port and shipping industry (Notteboom, 2014). Sustainability concept sharpens the shape of it as a new trend.

Sustainability of port operations lay down with the triple bottom line. Balancing land related to the environmental aspect, balancing labor combined to social aspect & balancing technology according to economic aspect lead for the sustainability of port operations and for performance as a multifunctional business center which creates value creation and growth of merchant cities (Lun, 2011; Wang and Cheng,2010; Kim & Chiang, 2014). Simply, maritime activities including port operations should be aligned with triple bottom line satisfactorily.

Competitiveness & attractiveness to shipping lines directly relates to the operational sustainability of a port (Yeo *et al*., 2011; Cheon & Deakin, 2010) (Kim & Chiang,

2014).When concerning modern port competition, new opportunities to achieve competitive advantage and/or to sustain a competitive place are conclusive sequels for sustainable port development & operations (Adams *et al*., 2010) (Kim & Chiang, 2014). Implementation of suitable remedies to deduct transport externalities combined with ports is practiced by many global ports because, port operations are a considerable burden for nearby communities (Kotowska, 2016).

Sustainability in port operations aims the integration of sustainability into all port activities/functions. Earlier, it was a sideline management concern. But nowadays, it reflects as a core issue straightly related to efficiency and competitiveness. (Denktas & Karatas, 2012; Lun, 2011; Cheon & Deakin, 2010; Kim & Chiang, 2014). The companies in this industry take ownership of their responsibilities. The major responsibility is environmental awareness. By promoting the design and implementation of more sustainable solutions, they can have the advantages of competitive advantage & clear image on the public related to their broad support (Boerema, Biest & Meire, 2017).

An adverse effect can be happened in the environment due to the running process/operations of organizations (Canbulat, 2014).The trend of coursing coercion on the green, sustainable situation negatively by the trading system which increasingly demands more and more natural resources is as much visible in terminal ports (Canbulat, 2014). Contriving more sustainable maritime operations, decreasing potential risks & emboldening relevant authorities to adhere to sustainability agendas and manage development proposals proactively are the deeds supported by building an accessible generic framework (Dinwoodie *et al*, 2011).

The incline on the significance of sustainability issues has been increased throughout the decades & Ports' sustainability concept was not studied or researched for 10 years from the beginning of 1987 where the pure concept of sustainability was dawned (Ozispa & Arabelen, 2018). 2008 is a highlighting year which shows a start-up of the higher rising of several focused studies on sustainability issues of ports (Ozispa & Arabelen, 2018). South Asia which is the region of Port of Colombo has a rivalry based on the sustainability of port operations in each port (Kim & Chiang, 2014). This research has been carried out to evaluate the best practical sustainability framework specified for Port of Colombo & to

identify the gap between the existence of concerned SDGs in 2015 & the existence of the same concerned SDGs in 2020. The gap analysis was to identify a stagnation or development of the focused SDGs from 2015 to 2020.

Desired level of this research was the existence of all concerned SDGs inside Port of Colombo with an inclining trend from 2015 to 2020. But the actual level was existence of several SDGs and non-existence of other SDGs with declining or inclining pattern from 2015 to 2020.

1.2 Problem Statement

Nowadays each & every industry focuses sustainability. Thus, Ports also have been started to adhere with sustainability concepts. Sustainable Development Goals of UN 2030 agenda are being referred by any industry around the world. The word SDG is very famous with professionals who deal with sustainability aspects of any industry. Accomplishing SDGs and combining SDGs into organizational KPIs are modern trends in business world.

Ports are the main industrial & commercial tools for economic & social development of the countries (Hlali & Hammami, 2017). In other words, sea port is a multidimensional set-up connected through economical function, infrastructure system, geographical space, complex legal concept and trade. Hence, Port of Colombo also should be aligned with SDGs of UN 2030 agenda.

There is a developing unanimity to fulfill SDGs inside seaports for structuring sustainability based on the Triple Bottom Line (TBL). Port of Colombo's operations also have not been aligned to such specific sustainability framework including economic, social & environmental sustainability. Lack of implementation of sustainable growth-led port policies is an identical problem in this maritime field of Sri Lanka. Special concern should be aroused in Port of Colombo since it is the main seaport in Sri Lanka.

After the UN's adaptation of SDGs in 2015, Port of Colombo's adherence with the most specific SDGs has not been examined yet. Therefore, the main research problem is **"How far the focused port ("Port of Colombo") aligned with most relevant/specific SDGs of UN 2030 agenda from 2015 to 2020?"** or in other words, those selected most specific

SDGs related performance in between 2015 & 2020 should be compared to find out the development of SDGs at Port of Colombo.

Climate change causes the motivational power to adopt sustainable growth policies in maritime port operations. SDGs should be connected with KPIs of a seaport. Assorted & adoptable SDGs needs to be identified based on specific seaport operations which are exercised in Port of Colombo. Building an SDG-based measurable KPI system for Port of Colombo is a challenging task. Lack of critical evaluation of such specific SDGs for Port of Colombo is another problem. Therefore, formulating a sustainable practical framework for Port of Colombo was identified as the second research problem.

Further, Port of Colombo has two type of employees. They are management level employees & operational level employees. They may have same or different perceptions regarding the existence of each SDG inside Port of Colombo. Finding out availability or non-availability of such perceptional difference between management level workers & operational level workers regarding the current performance of each selected SDG of UN 2030 agenda inside Port of Colombo was aroused as another problem.

1.3 Justification for the Study

This research was conducted on the plan of action for people, planet & prosperity (3Ps) which is the 2030 agenda for sustainable development by the United Nations; “transforming our world”. The Agenda emphasizes the need to consider simultaneously the three dimensions of sustainable development: social, economic and environmental (which are aligned with 3Ps) (IMO). Therefore, all these three pillars which are laid on 17 SDGs under the agenda were considered on the port operations of Port of Colombo and were checked their application in the port using a Likert scale questionnaire.

Importance in making a paradigm shift towards considering sustainable climate adaptation; searching for peak optimization while considering the balance between PPP (above mentioned as 3Ps) indicators is the value of qualitative analysis of SDGs (Schipper, C.A., 2019). The main reasons for current advertency for research like this was Port of Colombo’s major role in Sri Lankan economy, a major role in international maritime

transportation, the pressure to alleviate climate change & negative impacts on society & environment (Bjerkan & Seter, 2019)

SDG based performance evaluation of Port of Colombo in between 2015 & 2020 will be important for port policy makers. A novel sustainable concept used in the research can be useful to make strategies & circumvent molestations. As an example, according to Schipper (2019), the SDG-GPP (Sustainable Development Goals-Green Port Policy) framework has been prepared including 24 SDG targets which are severely connected with global port issues. The SDG-GPP framework has used as a benchmark for this research study. Taking internal measures (like preparation of financial incentives & infrastructure facilities to deduct pollutants emissions by ships & hinterland transport trucks) & initiating actions for sustainable model shift (like railway & inland water-way access infrastructure development investments) lay a multi-faceted policy making approach for all the stakeholders of maritime port industry (Kotowska, 2016).

1.4 Research Questions

Based on the problem statement illustrated above in 1.2, the research questions are developed for the study as below.

i. "How far the focused port ("Port of Colombo") aligned with the most relevant 11 SDGs out of all 17 SDGs in the UN 2030 agenda from 2015 to 2020?"
ii. "How to formulate a practical framework relevant to sustainable operations of a container port like Port of Colombo?"
iii. "Is there a perceptional difference between Operational level & Management level employees (Port workers) about the availability/current performance of each selected SDG inside PoC?"
iv. "What are the sustainability challenges in Maritime Logistics & Shipping Industry?"
v. "How to mitigate the challenges with suitable strategies?"

1.5 Research Objectives

Regarding the research questions illustrated in 1.3, the research objectives set for the study as below.

i. To determine how far the focused port ("Port of Colombo") aligned with the most relevant 11 SDGs out of all 17 SDGs in UN 2030 agenda from 2015 to 2020 (Main objective)

ii. To formulate a framework relevant to sustainable operations of a container port like Port of Colombo

iii. To identify what type of perceptional difference is available between Operational level & Management level employees (Port workers) about the availability/current performance of each selected SDG inside PoC

iv. To identify the sustainability challenges in Maritime Logistics & Shipping Industry

v. To identify suitable strategies to mitigate the encountering challenges in developing SDGs inside PoC

1.6 Significance of the Study

The significance of the study can be divided into three perspectives such as theoretical significance, empirical significance and stakeholder significance. Theoretically, this research will support for academic studies in the field of maritime transportation management & Logistics. The concept of sustainability has not been researched sufficiently concerning maritime port operations. The researcher is able to build up intellectual capacity, conceptual knowledge, communication skills, social networking ability & research skills step by step.

Many types of research have been done to find out solutions, strategies or maneuvers & recommendations to reduce environmental pollution. It means more concern is on environmental sustainability. But empirically, port workers experience social & economic issues the same as environmental issues related to the sustainability aspect. With the experience, port operators have developed lots of tools & technologies for accomplishing

sustainable operations of maritime ports. According to Bjerkan & Seter (2019), sustainable methods (tools & technologies) for maritime port operations can be classified into four main sections. They are port management & planning methods, power and fuel-related methods, sea area based on special methods & land/shore area based special methods. Through conducting a questionnaire, most experienced port workers under both operational & management level could deliver their perspectives and ideas. Lack of empirical research is a drawback for implementing sustainable port operations since they are inadequate for port policy making. Finally, the research results can be used by port decision-makers to implement successful sustainable port operations inside Port of Colombo.

By absorbing new research results, stakeholders connected with Port of Colombo can act on the desired standard performance level of assorted 11 SDGs in the UN's 2030 agenda. The main three competitors inside Port of Colombo can refer & follow the research results and recommendations to be better sustainable port terminals.

1.7 Limitations of the Research

Currently, limited studies can be found in this South Asian region which focused on sustainability practices of port operations compared to other regions such as Europe, the USA & North-East Asia. Therefore, most of the referred articles for this research was found relevant to outer ports from South Asian Region. Having very less number of publications on port sustainability is another limitation for this study when collated with the studies on issues such as "green port" & "sustainable supply chain management" are the most often study areas in this field (Ozispa & Arabelen, 2018).

Time & accessibility were the constraints for taking the three container terminals inside Port of Colombo for the research study. Most of the Port workers were contacted via social media as respondents. Few port workers were interviewed to get the questionnaire to be filled. Totally 60 respondents were participated for first data sample which was taken to analyze the development of the selected SDGs. Next sample was with 122 respondents which were used to fulfill other research objectives. The results were varies based on individual perspective, experience & performance. Based on the data collection, quantitative analysis was done. The quantitative data collected are limited to the sample

size selected for the research. The data were affected by different levels of confidentiality & organizational behaviors. Even three terminals inside Port of Colombo has different infrastructures, different processes, different organizational structures & different organizational behaviors, all the respondents were considered as equal under the same unit as Port of Colombo.

1.8 Reflexivity Report

Independent & impartial research was undertaken & genuine data collection was exercised. More than 50 topic related articles were referred to build up the concept of sustainability towards port operations and to gain knowledge about global best sustainable port practices. The research confirms the literature review, data collection & data analysis were done with utmost accuracy, quality & integrity. The researcher's effort is to provide true & trustworthy research findings for Port of Colombo. All the stakeholders including port operators, policy makers, operational level employees & management-level employees can know the status of Port of Colombo in respect of selected 11 SDGs out of all 17 SDGs in UN's 2030 agenda.

1.9 Chapter Outline

This research is comprised & compiles with five chapters as below.

Chapter One depicts pure introduction about the research area & the specific problem which is addressed under several sub topics; Background, Problem Statement, Justification, Research Questions, Research Objectives, Significance, Limitations & Reflexibility report.

Chapter Two reviews the literature & evaluates the factors affecting the sustainability of port operations. This chapter gives a general overview of SDGs, maritime industry alignment with SDGs & Port sector alignment with SDGs & moreover critical evaluation, analysis of the investigated literature & the conclusion of the literature review based on research objectives.

Chapter Three cogitates the used research methodology used in passed literature when studying the problem. Under this chapter, it comprises research design/conceptual framework, methodological process, formulation of empirical model, research hypothesis,

operationalization, population & sampling method, data collection method, data analysis method, & finally the chapter summary presentation.

Chapter Four presents the analysis of the collected data as per the main research objective. It includes demographic information, descriptive analysis, inferential analysis, correlation analysis, and qualitative analysis of data and the tools used to the process, which includes sample adequacy, reliability, model fit, CFA (Confirmatory Factor Analysis), EFA (Exploratory Factor Analysis), Paired sample t-tests, independent sample t-tests, Microsoft Excel tabulation techniques, data interpretation and presentation of data with explanations, charts and figures. Under this chapter both the quantitative and qualitative analyses performed with the use of primary data.

Chapter Five discusses the comparison results in between 2015 & 2020, EFA results concerning past literature findings of developed & developing ports and shed light on selected SDGs to confirm Port of Colombo's operational performance are aligned with them. Further it presents a conclusion, recommendation, further research ideas and opportunities and ethical statement of the research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Sustainable Development Goals (SDGs) are comprehensive, far-reaching & people-centered set of universal and transformative goals (United Nations' the 2030 Agenda for Sustainable Development). These seventeen aspirational "Global Goals" are consisted with 169 targets and 244 indicators. It was adopted by the 194 Member States of the United Nations (UN) General Assembly in September 2015. The main research objective was to find out the status of Port of Colombo with regard to the availability and alignment with these seventeen goals.

The "Sustainable Development Goals" or "Global Goals", are kind of expanded invention or a version of the Millennium Development Goals (MDGs). MDGs are eight targets that the world committed to accomplish by 2015. The MDGs, adopted in 2000, targeting to diminish severe global issues such as slashing poverty, hunger, disease, gender inequality, and access to water and sanitation (United Nations Development Programme, 2016).

All the SDGs may not have a strong relevance with any business activity. But trying to consider all the SDGs for any social, environmental or economic activity/process/business or organization should be done. This research's main objective highlights the relevance with sea port operations. Port of Colombo was selected as it is the one and only main container port of Sri Lanka. A case study approach was followed by selecting one port of Sri Lanka via benchmarking similar type of researches done in foreign countries.

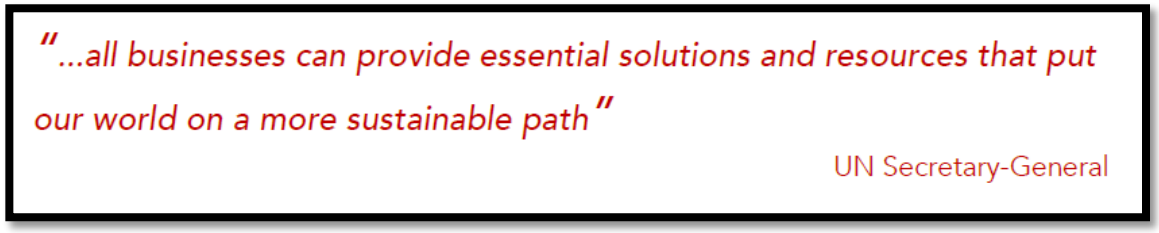

Figure 1: Declaration of UN Secretary General about consideration of all SDGs

Source: United Nations SDGs & Sea Ports-Assessing Relevance & Finding Opportunities [Brochure]. (2017). retrieved from: http://www.sprottplanning.com/pdfs/2017-2%20SDG%20brochure%20outline.pdf

Figure 2: A diagram listing the 17 Sustainable Development Goals

Source: United Nations SDGs & Sea Ports-Assessing Relevance & Finding Opportunities [Brochure]. (2017). Retrieved from:http://www.sprottplanning.com/pdfs/2017-2%20SDG%20brochure%20outline.pdf

First SDG is to end extreme poverty in all its forms everywhere by 2030 (United Nations 2030 agenda for Sustainable development). It can be done through interrelated strategies like the promotion of social protection systems, decent employment and building the resilience of the poor. (United Nations' the Sustainable Development Goals Report, 2017). Second SDG is to end hunger, achieve food security and improved nutrition and promote sustainable agriculture (Department of Census and Statistics, 2017). It is connected with agriculture & health sectors. Ending hunger means establishing food security. Increasing food production, well-functioning markets, and increased incomes for smallholder farmers, similar accessibility for technology & land & additional investments caused a vibrant and productive agricultural sector (United Nations' the Sustainable Development

Goals Report, 2017). It builds up a prominent food security which serves health sector extremely.

Third SDG ensures healthy lives and promote well-being for all at all ages. Reducing the global maternal mortality ratio, ending preventable deaths of newborns and children under 5 years of age, ending the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases, reducing by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being are few targets under third SDG (United Nations 2030 agenda for Sustainable development).

Fourth SDG ensures inclusive and equitable quality education and promote lifelong learning opportunities for all. Poverty, armed conflict and other emergencies keep more kids around the world out of school & achieving the goal of universal primary and secondary education, affordable vocational training, access to higher education and etc. are the musts to be done in this regard (UNDP's sustainable Development Goals).

Fifth SDG is to achieve gender equality and empower all women and girls. There are still gross inequalities in work and wages, lots of unpaid "women's work" such as child care and domestic work, and discrimination in public decision-making (UNDP's sustainable Development Goals). Achieving gender equality and the empowerment of women and girls will require more vigorous efforts, including legal frameworks, to counter deeply rooted gender-based discrimination often resulting from patriarchal attitudes and related social norms (United Nations' the Sustainable Development Goals Report, 2017).

Sixth SDG ensures availability and sustainable management of water and sanitation for all. Sustainable management of water resources and access to safe water and sanitation are essential for unlocking economic growth and productivity, and providing significant leverage for existing investments in health and education (UNEP).

Seventh SDG ensure access to affordable, reliable, sustainable, and modern energy for all. Energy lies at the heart of both the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change (HLPF, 2018). Becoming more energy-efficient via investing in clean energy sources such as solar and wind is the path to enable this seventh SDG.

Eighth SDG Promotes sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all. It deals with issues at the core of the ILO's mandate & covers a variety of topics, including those for which there are tier I and tier II indicators, such as labour productivity, informal employment, earnings (including the gender pay gap), unemployment, youth not in education, employment or training, child labour and occupational injuries (ILO, 2018).

Ninth SDG is to Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. Inclusive and sustainable industrialization, together with innovation and infrastructure, can unleash dynamic and competitive economic forces that generate employment and income (United Nations' the Sustainable Development Goals Report, 2019).

Tenth SDG reduces inequality within and among countries. It ensures safe, orderly and regular migration, and strengthening the voices of developing countries in international economic and financial decision-making. (United Nations' the Sustainable Development Goals Report, 2019). Decreasing inequalities based on income, age, sex, disability, race, ethnicity, origin, religion or economic or other status within a country should be practiced in any field like Port of operations. (United Nations' the Sustainable Development Goals Report, 2019).

Eleventh SDG makes cities and human settlements inclusive, safe, resilient and sustainable. While cities are incubators of innovation and help foster increased employment and economic growth, rapid urbanization has brought with it enormous challenges, including inadequate housing, increased air pollution, and lack of access to basic services and infrastructure (United Nations' the Sustainable Development Goals Report, 2017).

Twelfth SDG Ensures sustainable consumption and production patterns. By endorsing a stand-alone goal on cities which is known as the "urban SDG", the first-ever international agreement on urban-specific development acknowledges sustainable urban development as a fundamental precondition for sustainable development (UN ECOSOC, 2016).

Thirteenth SDG Takes urgent action to combat climate change and its impacts. Climate change is the defining issue of our time and the greatest challenge to sustainable development & limiting global warming to 1.5°C is necessary to avoid catastrophic consequences and irreversible changes (United Nations' the Sustainable Development Goals Report, 2019).

Fourteenth SDG Conserve and sustainably use the oceans, seas and marine resource for sustainable development. More than 3 billion people depend on marine and coastal diversity for their livelihoods and Oceans absorb about 30 percent of the carbon dioxide that humans produce. But overexploited fish stocks (a third of the world's fish stocks), producing more carbon dioxide than ever before, trashing 13,000 pieces of plastic litter on every square kilometer of ocean should be controlled and managed to achieve this SDG (UNDP's sustainable Development Goals).

Fifteenth SDG is to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. This SDG specifies to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation & biodiversity loss (Levin, S., 2018).

Sixteenth SDG promotes peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels. People need to be free of fear from all forms of violence and feel safe as they go about their lives whatever their ethnicity, faith or sexual orientation & governments, civil society and communities work together to implement solutions to reduce violence, deliver justice, combat corruption and ensure inclusive participation at all times (UN, 2017).

Seventeenth SDG strengthens the means of implementation and revitalize the Global Partnership for Sustainable Development. The world is more interconnected today than ever before, thanks to the internet, travel and global institutions (UNDP's sustainable Development Goals). This is the base of acquiring this SDG. Attaining the Goals will require coherent policies, an enabling environment for sustainable development at all

levels and by all actors, and a reinvigorated Global Partnership for Sustainable Development (United Nations' the Sustainable Development Goals Report, 2017).

2.2 Sustainability concept through Triple Bottom Line

Seeking to meet the needs of the present except compromising the achievability of future generation's needs is the goal of the concept of sustainability according to the Brundtlant Conference Report for the World Commission on Environment & Development in 1987. In 1994, the term 'triple bottom line' [TBL] was suggested by John Elkington (Henriques & Richardson, 2004). This TBL concept creates the path to any process, organization or operation (Ex. Port operations) to not to concern profit as their sole measure of success but also environmental and social outcomes. According to long-term use of port industry's constructions, technology & productivity are being critical for making the possibility to reduce the extent of terminal expansion. Based on the present technological development, port developers initially do port planning. On the other hand, port planners & operators must strive to the highest degree in order to optimize port space & ameliorate productivity. This will circumvent redundant terminal or berth expansion. Optimizing diffusions, upgrading information systems, occupying latest technological machineries & equipment, congruous cargo stacking & rationalizing resources & terminal design can be the recommended measures for such assaying (Yap & Lam, 2013). This is already applied in the selected terminal, the first private public partnership port terminal in Port of Colombo.

Canbulat (2014, p.40) explains that literature & Turkish experts about environmental issues of container ports give the priority for "air pollution & air quality" within the most important first ten criteria for green container terminals & with the decrease of air pollution, working conditions can be increased hence no one likes to work in a polluted environment. The vastly conversed environmental sustainability issues are generating gas emissions within ports or at sea or in emission control areas (ECAs) by ships, port equipment and container trucks (Lee, Kwon & Ruan, 2019).

The economies of scale resulted from much larger capacity of maritime transport than other modes of transport causes a lower social harmfulness of maritime transport (Kotowska, 2016). Sustainability does not connect only with environmental policy but

also it connects with the improvement of the welfare of human beings around a port (Lu, Shang & Lin, 2016). According to economic point of view, the green collaborative activities provide advantages for supply chain members (De Giovanni & Zaccour, 2014). This can be taken in relations with port operations in a terminal as well. Organizations can achieve cost savings and efficiency via integrating environmental responsibility into their economic strategies. Cost can be saved through resource reduction. The increment of revenue earned from stakeholder relations & brand image leads to efficiency (Hart, 1995; Hoffman & Ventresca, 1999). Thus, depicts that financial, commercial & marketing & procurement departments of a terminal also should be integrated with port operations in having successful integration regarding economic sustainability. As per Lu, Shang Lin (2016) economic sustainability issues consist of assessment items such as the benefits of port operators, economic activity development, fair competition, infrastructure construction, employment & local development, leisure & tourism and investment. Jedliński (2012) mentioned two factor types affecting for sustainable economic growth; endogenous factors such as an increase in labor efficiency, employees' knowledge & experience & investment layouts and exogenous factors such as resource segregation changes in economy, legal regulation changes, cultural & social changes, access to natural resources.

The third dimension, "social sustainability" is connected with population, port accessibility, security & safety, neighboring interaction, communication, increasing awareness & participation of the public & engagement of stakeholders in developing port sustainability because they are the most relevant assessment items (Lu, Shang & Lin, 2016). Provision of greater amount of direct employment, indirect employment and induced employment opportunities generate appreciable social benefits which cause economic growth as well (Kotowska, 2016). In addition, Shiau and Chuang (2015) has been proposed 34-expert based port sustainability indicators based on social construction of technology extracted by local legislators & residents.

The highest ranked social issue is related to employee job security and job safety & followed by others which are deeming environmental protection when doing port operations, providing facilities to economic activities, preventing port traffic accidents & ensuring cargo handled safely & effectively (Lu, Shang & Lin, 2016). Besides, the least

ranked sustainability factors are mitigating light influence on neighboring residents, deeming the arrangement of vehicles under construction of port transportation system, avoiding using unpolluted land in port area, hiring minority groups & consulting interests groups when creating port projects.

Lu, Shang & Lin (2016) identifies four sustainability assessment factors; economic issue, environmental practices, social concern & environmental material which are in a descending order relevant to the container port sustainability assessment context in Taiwan.

2.3 SDGs in Maritime Industry Alignments

A main cause for the imbalance of the TBL is global civilization progress (Kotowska, 2016). It has created lots of unsustainable issue globally. Fossil fuel combustion from various equipment and vehicles causes transport externalities. Transport externalities mean the negative social & environmental impacts generated from transport including maritime transport activities. A negative environmental impact (transport externality) is global warming due to emission of external amounts of greenhouse gases (mainly CO_2) to environment. Another transport externality is emission of the gasses (nitrogen oxides & Sulphur oxides) which cause acid rains, haze in air, eutrophication in water (as environmental effects), health issues for human (social effect) & other animals.

Shipping is the most environmentally sound mode of transport, and shipping has the lowest carbon footprint per unit of cargo transported. Therefore, it is essential component of sustainable economic growth.

When evaluating implemented port plans with SDGs, it depicts varying degrees of sustainable ambition scenarios to contribute to an adaptive and resilient port, however, highly sustainable exceptions are existing (Schipper, 2019). Further, Schipper (2019) states that SDG assessments can offer a proven and practical approach for transitioning ports towards sustainability master planning, can use as clear quantitative KPIs by many ports and coastal areas in the world, can construct clear sustainability goals and objectives with stakeholders, can ensure that all potentially effective measures towards sustainability transitions in ports are included, can be effective and successful if different varieties of

validated data are made publicly available, can link sustainability achievements to UN-Sustainable Development Goals & can be applied to incorporate sustainable goals in port design processes.

As described in problem statement of this research, constructing an SDG-based measurable KPI system for Port of Colombo is a challenging task. But Hakam (2015) has proposed a conceptual intelligent sustainability framework for Nordic container ports. As per that research, different ports have different characteristics which are specific based on their sizes, geographical properties of the region & the market logistical structure. Therefore, Nordic container ports may have different characteristics from Colombo container port. But the proposed framework can be benchmarked for PoC's sustainability performance. Below figure depicts that holistic framework proposed by Moulay Hicham Hakam which will monitor port sustainability performance based on TBL separately over a predefined time horizon.

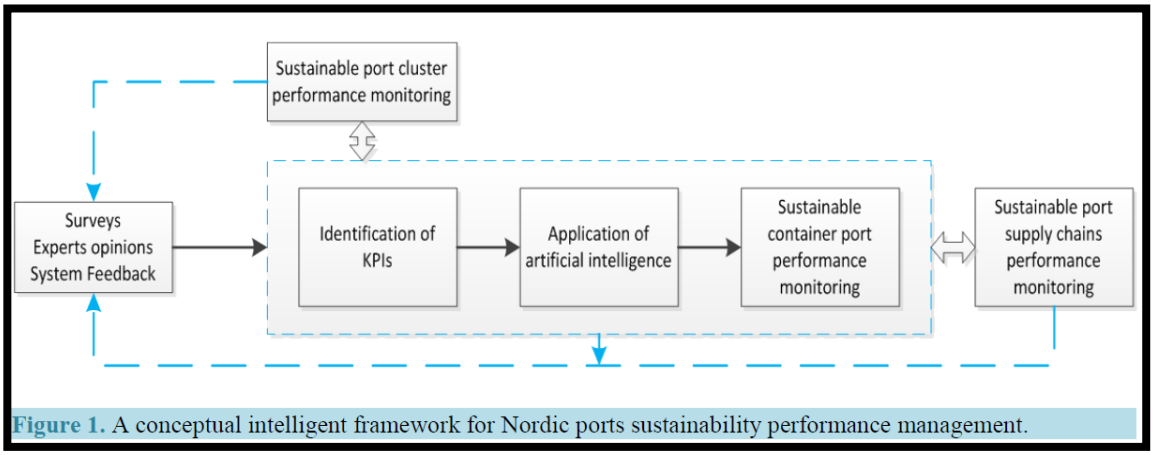

Figure 3: Proposed sustainability framework by Hakam (2015) for Nordic Container ports

Source: Hakam, M.H. (2015). Nordic Container Port Sustainability Performance—A Conceptual Intelligent Framework. Journal of Service Science and Management. 08(01), 14–23. 10.4236/jssm.2015.8100

Each port will prioritize each SDG differently based on environmental, social and economic realities. Potential port authority actions for each SDG, measurement performance indicators, and guiding tools and methodologies for use in practice were defined under the World Ports Sustainability Program (WPSP) and which of the SDGs to

apply to the five WPSP themes and identify indicators to measure the sustainability performance of port authorities in these areas were determined by IAPH, in cooperation with the UN Conference on Trade and Development (UNCTAD), the Antwerp Management School and the University of Antwerp. The WPSP's themes are climate and energy; community outreach and port city dialogue; resilient infrastructure; governance and ethics; and safety and security (Mead, 2019).

Recognizing enabling factors, such as a dedicated legal framework or sustainable funding mechanisms, and the use of monitoring evidence to facilitate adaptation of an approach can enable area-based management approaches make valuable contributions towards the delivery of SDG Targets (Fletcher, Scrimgeour, Friedrich, Fletcher & Griffin, 2018).

Port operations are noticeable affliction for cities like Colombo. Kotowska (2016) presents a multi-faceted approach for port authorities & other port operators especially for policy making aspects. This approach implements variety of solutions to omit transport externalities. One face of this approach is exercising internal measures like introducing financial incentives and infrastructural changes for controlling purposes like reduce pollution. Another face of this approach proposing new initiatives based on modal shift, and other sustainable concepts.

2.4 Introduction of Core SDGs & Secondary SDGs

A classification of SDGs of a leading Australian web-based practice serving private & public sector clients across a range of markets within Australia and abroad called Sprott Planning (http://www.sprottplanning.com/about-us.html) was used in this research. It/the categorization has been implemented based on in-depth examination of the SDGs using the site's detailed operational & corporate experience within the maritime sector.

They have categorized SDGs as "Core", "Secondary" and "Case-Specific". Core SDGs consist with a direct relevance for ports. It means they are common to all port communities & serve as a means of comparison among ports throughout the world. Therefore, main focus to be upon Core SDGs; SDG 3 (Good Health & Well-being), SDG 7 (Affordable & Clean Energy), SDG 9 (Industry, Innovation & Infrastructure), SDG 11 (Sustainable Cities & Communities), SDG 12 (Responsible Consumption & Production), SDG 13

(Climate Action), SDG 14 (Life below Water) & SDG 17 (Partnerships for the Goals). Number of core SDGs are eight.

Secondary SDGs also have some sort of in-direct relevance with seaports. They are the SDGs considered for compliance beyond social, economic & environmental responsibility. Only, 3 SDGs affects for seaport operations; SDG 5 (Gender Equality), SDG 6 (Clean Water & Sanitation) & SDG 8 (Decent Work & Economic Growth).

Case-specific SDGs own a case/port specific relevance for seaports which differentiate from port to port globally, depending on port context, port setting, and ownership status, country's development status & support programs. Sprott Planning.com has identified 6 case-specific SDGs for seaport operations. They are SDG 1 (No Poverty), SDG 2 (No Hunger), SDG 4 (Quality Education), SDG 10 (Reduced Inequalities), SDG 15 (Life on Land) & SDG 16 (Peace, Justice & Strong Institutions).

2.5 Significance/Justification of the Study

This research was conducted on the plan of action for people, planet & prosperity (3Ps) which is the 2030 agenda for sustainable development by United Nations; "transforming our world". The Agenda emphasizes the need to consider simultaneously the three dimensions of sustainable development: social, economic, and environmental (which are aligned with 3Ps) (IMO). Therefore, all these three pillars which is laid on 17 SDGs under the agenda were considered on the port operations of Port of Colombo and were checked their availability via doing a Likert scale questionnaire (Appendix 01 & Appendix 02).

Importance in making a paradigm shift towards considering sustainable climate adaptation; searching for peak optimization while considering the balance between PPP (above mentioned as 3Ps) indicators is the value of qualitative analysis of SDGs (Schipper, , 2019). The main benefits of this research are that port authorities & port operators can further work on the identified unsustainable areas to make them aligned with the expected level of the SDGs, also finding the most practiced SDGs inside Port of Colombo in order to highlight the reputation of this globally attractive port & significance or contribution of port operations' sustainability towards world sustainability as a whole.

2.6 Objectives based Literature Review

Schipper (2019) connects the Sustainable development goals & their corresponding targets to key port performance indicators for several representative port master plans. Nyenno & Nitsenko (2017) proposes a monitoring tool for a business model of a sea commercial port as a way to reach sustainable development goals. It aims to assess performance and meet SDGs including all indicators. Via accepting & embracing a pro-active approach with an alignment between economic activities & environmental protection which was achieved complementarily through the Building- or Working with Nature philosophy, can help to make sustainable port development viable and effective. It is discussed with a series of key components and steps that can be followed to reach sustainable development (construction and operation) including a series of examples by the research done by Rijks, Vizcaíno, Vellinga & Lescinski (2014). Like above research articles, this research objectives to examine the existence of SDGs inside Port of Colombo. Determining how far Port of Colombo aligned with the selected 11 SDGs from 2015 to 2020 is the main research objective.

Hinkka *et al.* (2018) analysed the indicators for terminal planning & compare them with existing KPIs used for measuring the performance of ports & terminals. Perera & Abeysekara (2016) developed a model providing a comprehensive tool for environmental performance management. Lack of specific sustainable framework for port operations at Port of Colombo was aroused as a research question. Thus, this research also targeted to formulate such framework built with mostly existing SDGs at this port. This objective was supported by many foreign research articles.

Port management can be categorized based on different perspectives; strategic, economic & operational and further, due to the internal dynamics of seaport systems, these management decisions are derived through an environment of uncertainty, variability & limited resources (Arisha & Mahfouz, 2009). Port of Colombo's employees can classified as management level & operational level. These two types of employees may have or may not have different perspectives about the sustainability of port operations. Shemon et al. (2019) explains & analyses the shipping industry in Bangladesh and highlighting some competitiveness, which the firms in the industry may acquire by managing skilled and

competent employees. This paper also highlights management & operational or competent levels of employees by taking Bangladesh shipping industry as an example. The efficient performance of sea ports is determined to a large extent by the presence of enough and qualified personnel, as well as by the favorable conditions of the working environment (Koralowa, 2016). Favorable conditions in the sense; sustainability aspects are very closely concerned by each and every employee of a port. Likewise, Port of Colombo's employees' concern of sustainability of port operations was analyzed as another objective of this research.

As per Lee *et at.(2019)* , for the shipping and port sector, these issues are related to green ports/shipping, carbon emission/climate change and region-specific environmental regulation/management & for the maritime logistics sector, sustainability issues are generally related to achieving optimal logistics systems, sustainable supply chain design, and service quality management. As a case of study, Awad-Núñe et al. (2016) has been evaluated the sustainability of all of the 10 existing dry ports in Spain . In that research, set of logistics platforms have been found that the most important variables for achieving sustainability are those related to environmental protection, so the sustainability of the locations requires a great respect for the natural environment and the urban environment in which they are framed. Various sustainability issues & mitigation strategies, techchiques & methods were searched via extensive literature. Finding the sustainability challenges & related mitigation strategies was another objective of this research.

2.7 Chapter Summary

This chapter describes what the SDGs & Triple Bottom Line Concept are. Then, it builds the relationship of SDGs and maritime industry. Port sector is a part of maritime industry. Explanation of Core SDGs & Secondary SDGs which are identified as the most influential SDGs towards port operations are discussed properly. An Australian website called "sprottplanning.com" was benchmarked to identify these Core SDGs and Secondary SDGs. Later, the significance/justification of the literature is given in this chapter. Finally, the objective based literature review is presented.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

Chapter three comprises with conceptual framework, formulation of empirical model, operationalization, sampling, data collection method and finally the chapter summary.

This research was based on a clear assessment of *United Nations SDGs & Sea Ports- Assessing Relevance & Finding Opportunities* [Brochure] (2017) which is a leading Australian based practice, serving private & public sector clients across a range of markets within Australia and abroad since it is particularly focused on the seaport industry and other major infrastructure activities. According to the analysis, the all 17 SDGs had been segregated into Core, Secondary & Case-Specific SDGs. Core SDGs have a direct relevance for ports and likely to be common with all port communities around the globe and serve as a means of comparison among ports throughout the world & they are 3rd, 7th, 9th, 11th, 12th, 13th, 14th & 17th SDGs. Secondary SDGs has been considered for compliance beyond social, economic and environmental responsibility & they are 5th, 6th & 8th SDGs. Case-Specific SDGs are depending on port context, setting, ownership & support programs & they are 1st, 2nd, 4th, 10th, 15th & 16th SDGs.

3.2 Basic Conceptual Framework

Figure 3.1 presents the conceptual framework of this research.

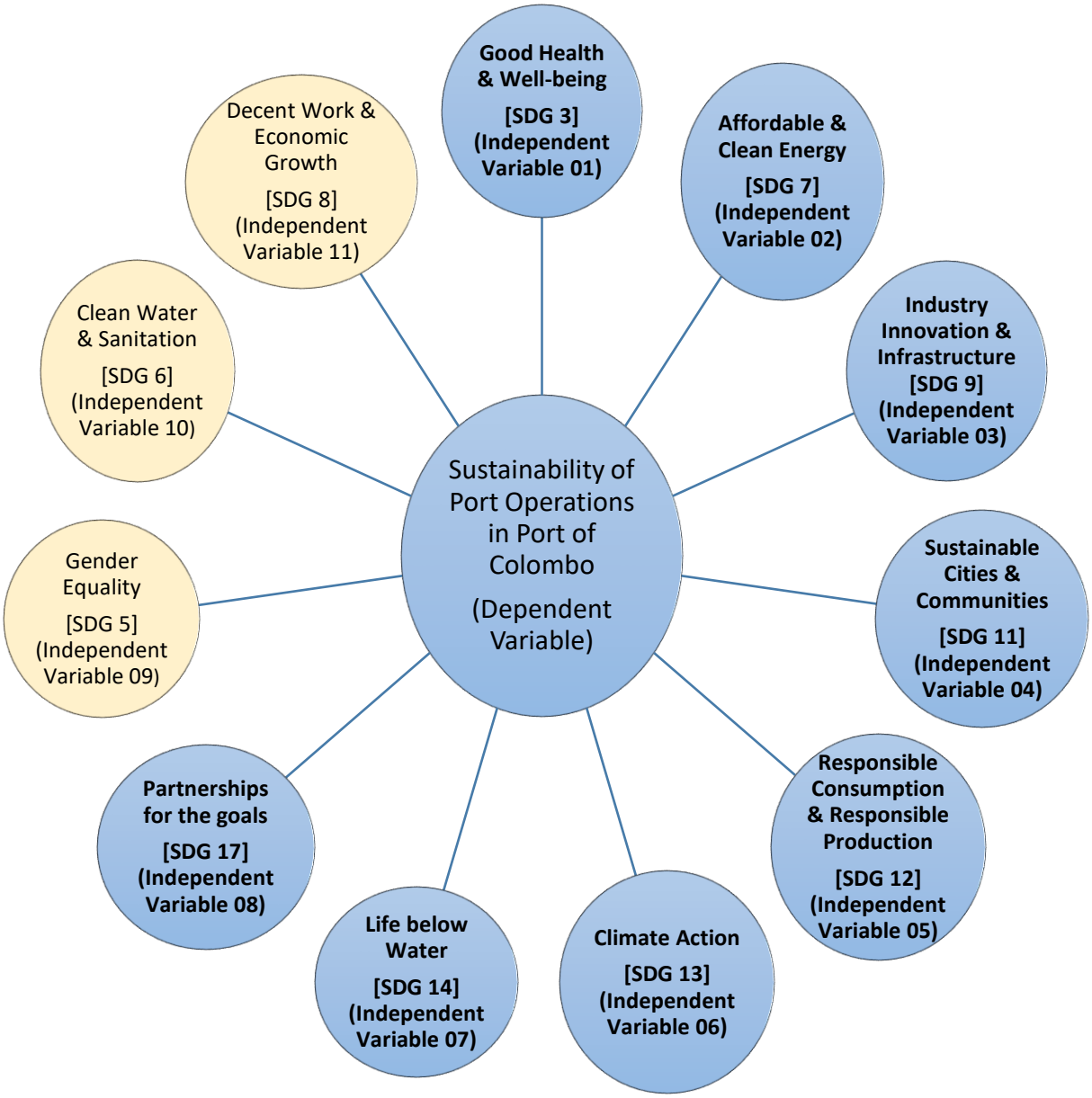

Figure 4-Conceptual Framework

Representation between the independent variables and the main dependent variable is presented in the conceptual framework. 11 major independent variables are shown in each outer circle above and the main dependent variable is included in the middle circle. The 11 major independent variables are the accumulation of 8 core SDGs & 3 Secondary SDGs (Sprott Planning & Environment, 2017). Each major independent variable again is considered as a dependent variable (SDG) which is affected by three other independent variables (SDG indicators) set or one independent variable (SDG indicator).

3.3 Operationalization

3 levels of variables were used in the research.

Main dependent variable = Sustainability of Port operations; LEVEL 1

Major independent variables = Sustainability Development Goals/ SDG; LEVEL 2

Other independent variables = Indicators of each relevant SDG; LEVEL 3

LEVEL 3 variables were collected as required primary data which is shown in Table 1 to Table 11. Therefore, both operational level & management level employees inside Port of Colombo (Sample I) were targeted to gather primary data with relation to the current (2020) & earlier (2015) performance of the selected SDGs inside Port of Colombo. In developing the below Table 1, studied information from UN's 2030 agenda's 17 SDGs & SDG targets and Sprott Planning (2017) described in chapter two were used together with the researcher-developed conceptual framework shown in Figure 1.

But another sample (Sample II) was taken to collect data via another Likert scale questionnaire. That Likert scale questionnaire was questioned gender, age groups, working experience, job positions & relevant departments, academic qualifications, current performance of each SDG & attitude towards few changes/sustainable solutions to be implemented in PoC.

Current Performance of each SDG was measured with 5 points of scale; No.1 depicted "Not in Practice", No.2 depicted "Very Less in practice", No.3 depicted "Not aware", No.4 depicted "More in Practice' & No.5 Depicted "Mostly in Practice". Like this main 8 questions was asked with same 5 point- scale and 3 dependent variables were used to

measure one independent variable (Each Core SDG). Other supplementary questions were used with the same scale to measure Secondary SDGs.

Table 1-Operationalization of SDG 3

Level 2 Variables (as independent)	**Level 3 Variables (as dependent)**	**Measurement**
SDG 3; Good Health & Well-being	SDG3.1; Port terminal provides prompt medical care services under occupational health	5 point Likert Scale
	SDG3.2; Port terminal does health monitoring (or Check-Ups) of employees	5 point Likert Scale
	SDG3.3; Port terminal considers mental health of all employees	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 2-Operationalization of SDG 7

Level 2 Variables (as independent)	**Level 3 Variables (as dependent)**	**Measurement**
SDG 7; Affordable & Clean Energy	SDG7.1; Port terminal has an onshore power supply (OPS) which allows ships to effectively "plug in" to a land-based electrical grid while at port docks	5 point Likert Scale
	SDG7.2; Port terminal uses clean, affordable, reliable, renewable & modernized energy sources like Solar energy/ Wind energy/ Tidal & Wave energy	5 point Likert Scale
	SDG7.3; Port terminal conducts awareness sessions to employees about sustainable energy	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 3-Operationalization of SDG 9

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 9; Industry Innovation & Infrastructure	SDG9.1; Port terminal tries to apply artificial intelligence to do port operations	5 point Likert Scale
	SDG9.2; Port terminal tries to mitigate the traffic congestion inside the port via new technological developments	5 point Likert Scale
	SDG9.3; Port terminal supports technology development, research and innovation	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 4-Operationalization of SDG 11

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 11; Sustainable Cities & Communities	SDG11.1; Port terminal's gas emissions is not causing law air quality & it never affects the nearby citizens/communities livelihood	5 point Likert Scale
	SDG11.2; Port terminal never receives environmental complaints from local community	5 point Likert Scale
	SDG11.3; Port terminal supports local communities' diversity & minorities via good CSR (Corporate Social Responsibility) Practices	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 5-Operationalization of SDG 12

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 12; Responsible Consumption & Responsible Production	SDG12.1; Port terminal has achieved ISO 140001- (Promote continual improvements by encouraging ports to adopt and implement EMS; assists systematic development of formalized management process, and evaluate effectiveness of activities, operations, products And services)	5 point Likert Scale
	SDG12.2; Port terminal consists energy saving device usage	5 point Likert Scale
	SDG12.3; Port terminal focuses on Recyclable Resource usage as a major objective of their consumption policies	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 6-Operationalization of SDG 13

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 13; Climate Action	SDG13.1; Port terminal reduces the carbon dioxide emissions on yearly basis	5 point Likert Scale
	SDG13.2; Port terminal identifies climate change risks & takes necessary actions to mitigate climate change	5 point Likert Scale
	SDG13.3; Port terminal is proactive to not to contaminate basin's seawater area	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 7-Operationalization of SDG 14

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 14 Life below Water	SDG14.1; Port terminal maintains a clean basin water area with zero oil spillage	5 point Likert Scale
	SDG14.2; Port terminal identifies the need for marine conservation & taking necessary actions against marine pollution	5 point Likert Scale
	SDG14.3; Port terminal improves ocean health and contribution of marine biodiversity	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 8-Operationalization of SDG 17

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 17; Partnerships for the goals	SDG17.1; Port terminal signs partnership agreements with employee committees for successful & effective port operations	5 point Likert Scale
	SDG17.2; Port terminal accepts the connectivity of all stakeholders via the new developments of ASYCUDA system (Automated System for Customs Data – for Sea Cargo)	5 point Likert Scale
	SDG17.3; Port terminal is positive to support national plans to implement all the sustainable development goals	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 9-Operationalization of SDG 5

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 5; Gender Equality	SDG5.1; Maintains gender balance within the entire work force	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 10-Operationalization of SDG 6

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 6; Clean Water & Sanitation	SDG6.1; Practicing a Water Quality contingency plan (to provide safe and affordable drinking water for all)(	5 point Likert Scale
	SDG6.2; Provision of port waste reception services for ships	5 point Likert Scale
	SDG6.3; Adequate and equitable sanitation and hygiene for all and maintaining related issues of defecation, paying special attention to the needs of Women	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

Table 11-Operationalization of SDG 8

Level 2 Variables (as independent)	Level 3 Variables (as dependent)	Measurement
SDG 8; Decent Work & Economic Growth	SDG8.1; Maintains gender balance within the entire work force	5 point Likert Scale

Source: Questionnaires (Appendix 1 & Appendix 2)

As above, selected Core SDGs from explored literature were segregated into 3 sub-divisional indicators & sum of respondent answers which were particular to the three indicators of a SDG was calculated via using Excel. Same as before, two of selected Secondary SDGs were represented by only one indicator differing from three-indicators-

representation which was done for Core SDGs. But only one Secondary SDG (Clean Water & Sanitation) was represented by the same three-indicators-representation.

3.4 Sample Profile

The population under this research was all port workers of Sri Lanka. As per Economic and Social Statistics of Sri Lanka 2020 published by Central bank, 8975 employees worked at Port of Colombo 2019-2020 provisionally (Central Bank of Sri Lanka, 2020). Therefore, the sampling frame is nearly 9000 including both operational and management level employees inside Port of Colombo. They work at the three terminals of Port of Colombo.

No specification was considered as terminal wise. It means, all operational level & management level employees of each terminal were considered as participated & were not specified based on three terminals of Port of Colombo. Targeted data samples were collected randomly from the sampling frame. Since an unbiased good sample is the one that is the representative of the entire population and is the one which gives an equal chance of being chosen for each person/respondent, the researcher has followed simple random sampling (SRS) of probability sampling methods for quantitative analysis in this research as the sampling technique.

Mainly, two data samples were collected based on research objectives. Sample I was with 60 respondents as the first sample size & Sample II was with 122 respondents as the second sample size. Unit of the study or element is the subject on which the information is obtained. Sustainability is the sample element taken to analyze the status of the port operations of Port of Colombo.

3.5 Data Collection Method & Tools

This research is a mixed approach of both qualitative & quantitative aspects. The selected primary data collection tools for this study were two structured questionnaires (Appendix 01 & Appendix 02). These questionnaires were included Likert scale questions which are widely used to measure attitudes & opinions to the great degree of demands than simple “yes or no” questions. Further, the survey questions in both questionnaires offered a range of answer options from one extreme attitude to another like “Not in Practice” to “Mostly

in Practice". This Likert scale questioning type was chosen because they are the most reliable measure of opinions, perceptions & behaviors to check performance of each selected SDG at PoC.

Method of administrating the structured questionnaire was mainly through online & face to face interviews. Structured Questionnaire was formulated as a "Google Form" & also distributed as a hard copy as well. Relevant secondary data were collected by means of extensive literature study that included in textbooks, journal articles, reports & statistics and internet-based web searches & research databases. All the responses were observed, checked, organized, coded, and transferred to a data analyzing software namely Microsoft Excel. Later, the data was fed into SPSS software.

3.6 Data Analysis Method and Presentation

The collected data was analyzed systematically by using SPSS (Statistical Package for the Social Science - (Version 13.0 & Version 23) which provide charts and tables. Different statistical analysis techniques including mean, median, mode, range, standard deviation, coefficient of variance, frequency distributions, skewness measures, correlation measures and regression analysis were used to interpret results. Sample adequacy was measured using Kaiser-Meyer-Olkin Measure of Sampling Adequacy Test. Reliability of the data set was checked using Cronbach's Alpha test which is the in-built feature of SPSS.

EFA was initially employed to recognize the underlying factors from a set of observed variables (survey questions) without applying a preordained framework or structure on the recompense (Child, 2006). Secondly, CFA was used to check the validity of the latent constructs gained in EFA and their relationships (Bandara *et al.*, 2016). There were three main reasons for selecting EFA & CFA for the factor analysis of this research; first reason was EFA & CFA are famous for analyzing Likert scale data, second reason was identifying the key underlying factors from a number of survey questions/variables should be done definitely by EFA because of the exploratory nature of this qualitative research, third reason was the execution of CFA is essential to get an insight into the relationship between the key factors in sustainability because EFA is not able to test hypotheses concerning the relationships between the underlying factor/variables.

Cudeck (2000) mentioned that EFA determines a number of unobserved influences underlying a domain of variables being investigated & EFA admeasures the extent of each variable associated with factors. Further, EFA provides details about the nature of the variables from observing which factors contribute to the performance of which variable. For this research, the varimax rotation method was exercised under EFA because it supports to gain a simple structure for data than other rotation methods (Bryant and Yarnold, 1995).

Analyzing the relationship between the latent variables identified by EFA is a task done by CFA. The simultaneous regression equations are an alternation to CFA (Bandara *et al*, 2013). It could analyze the effect of various factors on port sustainability using secondary data. However, that alternative method could not be used in this research case due to the latent variables. Descriptive analysis (both tabular & graphical) data presentation techniques were created to showcase the research findings and other details.

3.7 Chapter Summary

Focusing on research methodologies & related techniques, the conceptual framework was designed based on an extensive literature survey and the empirical model was formulated. From the Conceptual framework, developed the operationalization of the variables with literature support. And this study is done according to the mixed approach using quantitative research approach with the support of the qualitative research approach.

CHAPTER FOUR: DATA ANALYSIS

4.1 Introduction

In this chapter, the researcher aims to showcase the primary data analysis of the research. Two data samples were used based on different objectives. Developments of considered SDGs were analyzed using first data sample taken from 60 respondents. A paired sample t-test was conducted to achieve the main research objective. The second data sample taken from 122 respondents was used in Confirmatory Factor Analysis & Exploratory Factor Analysis to formulate the specified conceptual framework of sustainable port operations for Port of Colombo. Two Likert scale questionnaires were utilized to gather the respective two samples. The both sample characteristics are clearly in line with the population parameters because both the samples were statistically checked in respect of the sample adequacy, the sample reliability, the goodness of the fitness of the data set, the significance of the data set and the sample validity.

4.2 Sample I – Characteristics

4.2.1 KMO measure of Sample Adequacy

The Sample Adequacy was tested using KMO Test. As Table 2; the Kaiser-Meyer-Olkin Measure of Sampling Adequacy ratio was 0.761 at 0.00 significant level and therefore the sample is well adequate.

Table 11-Sample I Adequacy & Sphericity

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.761
Bartlett's Test of Sphericity	Approx. Chi-Square	1028.627
	df	231
	Sig.	.000

Source –SPSS analysis results of Sample I

4.2.2 Sample Reliability Test

After testing sample adequacy, the sample was then checked for its reliability. The Sample reliability was tested using Cronbach's alpha value and the value obtained was 0.912 for the 22 variables considered as in Table 12. Therefore, it was revealed that the reliability of the sample which is the measure of how well the sample data set can generalize and predict the population information was very well adequate.

Table 12-Sample I Reliability Statistics

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.912	.919	22

Source –SPSS analysis results of Sample I

4.3 Univariate Analysis (Sample I)

4.3.1 Paired Sample t-test

To detect whether there is a difference in each SDG's overall performance between 2015 & 2020, this paired sample T-test was conducted. Main research problem: "How far the focused port called Port of Colombo aligned with the most relevant/specific SDGs of the UN 2030 agenda for port operations from 2015 to 2020?"; To address this problem, each selected SDG's performance was analyzed via a paired sample t-test to find, is there a significant statistical change in each SDGs performance in between 2015 & 2020. Likewise all Core SDGs & Secondary SDGs were analyzed.

Null hypothesis: There is no significant statistical change in each SDG's performance between 2015 & 2020. Independent variable is time; 2015 & 2020. Dependent variables are each selected SDG's performance in 2015 & in 2020. Since only one group of participants (sample = 60) were taken, a paired sample T-test was successfully used in the research. The Table 1 in Appendix 08 was analyzed to interpret if there was a statistical change in each Core SDG's & each Secondary SDG's from 2015 to 2020.

When focusing on paired differences in Table 1 in Appendix 08, SDG3 (Good Health & Well-being) has remarked a significant difference (because probability value/ Sig. (2-tailed) = 0.002 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (1.4500 is a positive value), a conclusion could be made that the difference in SDG3 is an increment/development from 2015 to 2020. The mean increase was 1.45 with the 95% Confidence Interval for the difference between the means of 0.56 to 2.34.

SDG7 (Affordable & Clean Energy) also has changed significantly and statistically from 2015 to 2020 (because probability value/ Sig. (2-tailed) = 0.000 < 0.05). Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (1.7500 is a positive value), a conclusion could be made that the difference in SDG7 is an increment/development from 2015 to 2020. The mean increase was 1.75 with the 95% Confidence Interval for the difference between the means of 0.93 to 2.57.

SDG9 (Industry Innovation & Infrastructure) has shown a statistically significant difference (because probability value/ Sig. (2-tailed) = 0.011 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (1.2333 is a positive value), a conclusion could be made that the difference in SDG9 is an increment/development from 2015 to 2020. The mean increase was 1.23 with the 95% Confidence Interval for the difference between the means of 0.30 to 2.17.

SDG11 (Sustainable Cities & Communities) also has behaved by remarking a statistically significant change (because probability value/ Sig. (2-tailed) = 0.000 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (1.7833 is a positive value), a conclusion could be made that the difference in SDG11 is an increment/development from 2015 to 2020. The mean increase was 1.78 with the 95% Confidence Interval for the difference between the means of 1.03 to 2.53.

SDG12 (Responsible Consumption & Responsible Production) was also similarly behaved as previous SDGs via highlighting a statistically significant change (because probability value/ Sig. (2-tailed) = 0.000 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (2.7667 is a

positive value), a conclusion could be made that the difference in SDG12 is an increment/development from 2015 to 2020. The mean increase was 2.77 with the 95% Confidence Interval for the difference between the means of 1.85 to 3.69.

SDG13 (Climate Action) also has behaved by remarking a statistically significant change (because probability value/ Sig. (2-tailed) = 0.011 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (1.2667 is a positive value), a conclusion could be made that the difference in SDG13 is an increment/development from 2015 to 2020. The mean increase was 1.27 with the 95% Confidence Interval for the difference between the means of 0.30 to 2.24.

SDG14 (Life below Water) remarked a statistically significant change (because probability value/ Sig. (2-tailed) = 0.004 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (1.4000 is a positive value), a conclusion could be made that the difference in SDG14 is an increment/development from 2015 to 2020. The mean increase was 1.40 with the 95% Confidence Interval for the difference between the means of 0.46 to 2.35.

SDG17 (Partnerships for the goals) as the final Core SDG occurred a statistically significant change (because probability value/ Sig. (2-tailed) = 0.000 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (2.3167 is a positive value), a conclusion could be made that the difference in SDG17 is an increment/development from 2015 to 2020. The mean increase was 2.32 with the 95% Confidence Interval for the difference between the means of 1.55 to 3.09.

Moving on to first secondary SDG, SDG5 (Gender Equality) has also performed a statistically significant change (because probability value/ Sig. (2-tailed) = 0.002 < 0.05) from 2015 to 2020. Therefore, the researcher rejected the null hypothesis. By looking at the mean difference (0.5500 is a positive value), a conclusion could be made that the difference in SDG5 is an increment/development from 2015 to 2020. The mean increase was 0.55 with the 95% Confidence Interval for the difference between the means of 0.22 to 0.88.

As the next considering secondary SDG, SDG6 (Clean Water & Sanitation) has not performed the same behavior as previous SDGs. It didn't showcase statistically significant change (because probability value/ Sig. (2-tailed) = 0.235> 0.05) from 2015 to 2020. But SDG6 has developed (0.600 is a positive value) somehow even that is not a very significant change. SDG 8 (Decent Work & Economic Growth) never performed a statistically significant change same as SDG6 (because probability value/ Sig. (2-tailed) = 0.301> 0.05). But SDG8 has developed (0.1667 is a positive value) somehow even that is not a very significant change.

When comparing t values below, the highest t value is 6.032 & it means the highest developed SDG inside PoC from 2015 to 2020 is SDG 12 (Responsible Consumption & Production). The second highest developed SDG (t value = 6.016) inside PoC from 2015 to 2020 is SDG17 ((Partnerships for the goals). The third highest developed SDG (t value = 4.763) inside PoC from 2015 to 2020 is SDG11 (Sustainable Cities & Communities).

From remaining significantly developed SDGs, the descending order of performance development inside Port of Colombo is SDG7, SDG5, SDG3, SDG14, and SDG9 & SDG13. Amazingly, only one secondary SDG has developed much more comparatively than few core SDGs. It is SDG 5 (Gender Equality). Each selected SDG's performance inside PoC from 2015 to 2020 was generally analyzed before & then the sub-indicators of a SDG were tested via separate paired-sample T-tests. It helped to find out which indicator/s contributed more to the development of a particular SDG.

4.3.1.1 SDG3 - Good Health & Well-being

When considering SDG3 (Good Health & Well-being), it was segregated into three sustainability indicators & as a whole, SDG3 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 6th SDG which developed based on the port operations of Port of Colombo. For its development only two indicators have contributed (because those two indicators' Sig. (2-tailed) < 0.05). The evidence is given in Table 2 (Appendix 08). The contributed two indicators are the provision of prompt medical care services under occupational health & health monitoring (or Check-Ups) of employees. From these two, the mostly contributed indicator for SDG3

is the provision of health monitoring (or Check-Ups) because its t value is the highest (4.178 > 3.253). But the last indicator (consideration of mental health of all employees) has not statistically & significantly developed (because probability value/ Sig. (2-tailed) = 0.424> 0.05). Therefore, it has not contributed to the performance of SDG3 inside PoC.

4.3.1.2 SDG7 - Affordable & Clean Energy

When considering SDG7 (Affordable & Clean Energy), it was segregated into three sustainability indicators & as a whole, SDG7 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 4th SDG which developed based on the port operations of Port of Colombo. For its development only two indicators have contributed (because those two indicators' Sig. (2-tailed) < 0.05). The evidence is given below in Table 3 (Appendix 08). The contributed two indicators are the usage of clean, affordable, reliable, renewable & modernized energy sources like solar energy/ Wind energy/ Tidal & Wave energy & conduction of awareness sessions to employees about sustainable energy. From these two, the mostly contributed indicator for SDG3 is the conduction of awareness sessions to employees about sustainable energy because its t value is the highest (5.669 > 2.010). But the first indicator (provision of onshore power supply (OPS) which allows ships to effectively "plug in" to a land-based electrical grid while at port docks) has not statistically & significantly developed (because of probability value/ Sig. (2-tailed) = 0.156> 0.05). Therefore, it has not contributed to the performance of SDG7 inside PoC.

4.3.1.3 SDG9 - Industry Innovation & Infrastructure

When considering SDG9 (Industry Innovation & Infrastructure), it was segregated into three sustainability indicators & as a whole, SDG9 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 8th SDG which developed based on the port operations of Port of Colombo. For its development only two indicators have contributed (because of those two indicators' Sig. (2-tailed) < 0.05). The evidence is given below in Table 4 (Appendix 08). The contributed two indicators are the application of artificial intelligence to do port operations & mitigation of the traffic

congestion inside the port via new technological developments. From these two, the mostly contributed indicator for SDG9 is the mitigation of the traffic congestion inside the port via new technological developments because its t value is the highest (2.525 > 2.498). But the last indicator (support for technology development, research and innovation) has not statistically & significantly developed (because probability value/ Sig. (2-tailed) = 0.071> 0.05). Therefore, it has not contributed to the performance of SDG9 inside PoC.

4.3.1.4 SDG11- Sustainable Cities & Communities

When considering SDG11 (Sustainable Cities & Communities), it was segregated into three sustainability indicators & as a whole, SDG11 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 3rd SDG which developed based on the port operations of Port of Colombo. For its development, all the three indicators have contributed (because of all indicators' Sig. (2-tailed) < 0.05). The evidence is given below in Table 5 (Appendix 08). Based on the t values, the contribution order is descending like this; the highest contribution from support for local communities' diversity & minorities via good CSR (Corporate Social Responsibility) Practices, the medium contribution from the absence of environmental complaints from local community & low contribution from no practice of gas emission which causes law air quality & it never affects the nearby citizens/communities livelihood (t values; 4.309 > 4.047 > 2.472).

4.3.1.5 SDG12 - Responsible Consumption & Responsible Production

When considering SDG12 (Responsible Consumption & Responsible Production), it was segregated into three sustainability indicators & as a whole, SDG12 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 1st SDG which developed based on the port operations of Port of Colombo. For its development, all the three indicators have contributed (because of all indicators' Sig. (2-tailed) < 0.05). The evidence is given below in Table 6 (Appendix 08). Based on the t values, the contribution order is descending like this; the first contribution from the achievement of ISO 140001- (Promote continual improvements by encouraging ports to

adopt and implement EMS; assists systematic development of formalized management process, and evaluate the effectiveness of activities, operations, products and services),the medium contribution from the usage of Recyclable Resource as a major objective of their consumption policies & low contribution on the usage of the energy- saving devices (t values; 7.209 > 4.352 > 3.331).

4.3.1.6 SDG13- Climate Action

When considering SDG13 (Climate Action), it was segregated into three sustainability indicators & as a whole, SDG13 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 9th SDG which developed based on the port operations of Port of Colombo. For its development only two indicators have contributed (because of those two indicators' Sig. (2-tailed) < 0.05). The evidence is given below in Table 7 (Appendix 08). The contributed two indicators are the reduction of carbon dioxide emissions every year & identification of climate change risks & taking necessary actions to mitigate climate change. From these two, the mostly contributed indicator for SDG13 is the identification of climate change risks & taking necessary actions to mitigate climate change because its t value is the highest (2.764 > 2.424). But the last indicator, being proactive to not to contaminate basin's seawater area has not statistically & significantly developed (because of probability value/ Sig. (2-tailed) = 0.078> 0.05). Therefore, it has not contributed to the performance of SDG13 inside PoC.

4.3.1.7 SDG14- Life below Water

When considering SDG14 (Life below Water), it was segregated into three sustainability indicators & as a whole, SDG14 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 7th SDG which developed based on the port operations of Port of Colombo. For its development only two indicators have contributed (because of those two indicators' Sig. (2-tailed) < 0.05). The evidence is given below in Table 8 (Appendix 08). The contributed two indicators are the identification of the need for marine conservation & taking necessary actions against marine pollution & improvement of ocean health and the contribution of marine biodiversity. From these two, the mostly contributed indicator for SDG14 is the identification of the need for marine

conservation & taking necessary actions against marine pollution because its t value is the highest (3.590 > 3.433). But the first indicator, maintaining a clean basin water area with zero oil spillage has not statistically & significantly developed (because of probability value/ Sig. (2-tailed) = 0.506> 0.05). Therefore, it has not contributed to the performance of SDG14 inside PoC.

4.3.1.8 SDG 17- Partnerships for the goals

When considering SDG17 (Partnerships for the goals), it was segregated into three sustainability indicators & as a whole, SDG14 has been significantly & statistically developed during 5 years' time period (2015 – 2020). It could be ranked as 2nd SDG which developed based on the port operations of Port of Colombo. For its development, all the three indicators have contributed (because all indicators' Sig. (2-tailed) < 0.05). The evidence is given below in Table 9 in Appendix 08. Based on the t values, the contribution order is descending like this; the first contribution from being positive to support national plans to implement all the sustainable development goals, the medium contribution from acceptance of the connectivity of all stakeholders via the new developments of ASYCUDA system (Automated System for Customs Data – for Sea Cargo) & low contribution on signing up partnership agreements with employee committees for successful & effective port operations. (t values; 5.455 > 5.343 > 2.187).

4.3.1.9 SDG5- Gender Equality

When considering SDG5 (Gender Equality), it was only represented by only one indicator, SDG5 has been significantly & statistically developed during 5 years' time period (2015 – 2020). Therefore, separate paired sample T-test was not done on this SDG5.When considering SDG6 (Clean Water & Sanitation), it was segregated into three sustainability indicators & as a whole, SDG6 has not been significantly & statistically developed during 5 years' time period (2015 – 2020). Therefore, no use of doing a separate paired sample T-test. SDG 8 (Decent Work & Economic Growth) also was represented by one indicator & SDG8 has not been significantly & statistically developed during 5 years' time period

(2015 – 2020). Therefore, separate paired sample T-test was not done on this SDG8 as well.

4.4 Sample II – Characteristics

This sample II also was statistically checked in respect of sample adequacy, sample reliability, the goodness of the fitness of the data set, the significance of the data set and sample validity.

4.4.1 KMO measure of Sample Adequacy

The Sample Adequacy was tested using KMO Test. As Table 3; the Kaiser-Meyer-Olkin Measure of Sampling Adequacy ratio was 0.881 at 0.00 significant level and therefore the sample was well adequate.

Table 13-Sample II Adequacy & Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.881
Bartlett's Test of Sphericity	Approx. Chi-Square	505.086
	df	55
	Sig.	.000

Source –SPSS analysis results of Sample II

4.4.2 Sample Reliability Test

After testing sample adequacy, the sample was then checked for its reliability. The Sample reliability was tested using Cronbach's alpha value and the value obtained was 0.879 for the 11 variables considered as in Table 14. Therefore, it was revealed that the reliability of the sample which is the measure of how well the sample data set can generalize and predict the population information was very well adequate.

Table 14-Sample II Reliability Statistics

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.879	.882	11

Source –SPSS analysis results of Sample II

4.5 Univariate Analysis (Sample II)

4.5.1 Independent Sample T-test based on Perceptions

Sample II was with 122 respondents & they have been clustered into 141 job positions under questionnaire. For convenience, the 141 job positions were divided into two groups: Operational level & Management level. This independent sample T-test was done to analyze whether there is a perceptional difference between Operational level & Management level employees (Port workers) about the availability/current performance of each selected SDG inside PoC. Null hypothesis: there is no statistically significant perceptional difference between Operational level & Management level employees (Port workers) about any selected SDG's availability inside PoC.

According to the analysis (Group Statistics Table 1 in Appendix 10) related to Core SDGs, there were 92 operational level (including engineering job positions as well) port workers & 30 management level port workers. The mean for management-level employees is always slightly higher than the mean for operational level employees. The standard deviations for both groups (operational & management) are about the same. Before concluding the main results, the results of Levene's Test for Equality of Variances which tests the homogeneity of variance assumption was thoroughly observed.

Under the Levene's Test, the null hypothesis was that the variances of the two groups are approximately equal (it means the distribution of the perceptions of operational level workers about the availability of each Core SDG is similar in shape to the distribution of the perceptions of management-level workers about the availability of each Core SDG). The alternative hypothesis is that the two distributions are significantly different in shape.

Based on that, all the significant values (per each Core SDG) are much higher than the researcher's level of significance (0.05) & therefore, the null hypothesis was accepted. Therefore, the researcher assumed that the variances are approximately equal. Another way to prove to accept equal variances (or null hypothesis) is in the Group Statistics Table 1 (Appendix 10), that the standard deviations (square root of the variance) for both groups were also very similar for each Core SDG. Therefore, the first line in the table 2 (Appendix 10) (under "Equal variances assumed") for each SDG was only considered for interpreting the main results.

When concluding the main results based on perceptions of both two groups, t-values, degrees of freedom & significance value were focused. All the significant values under each Core SDG (as shown in the Table 2 - Appendix 10) were analyzed with the researcher's level of significance (0.05). The Sig. (2-tailed) values of SDG3, SDG7, SDG9, SDG11, and SDG12 & SDG13 are less than 0.05 & therefore the perceptional attitudes between operational level & management level workers towards the availability/performance about those SDGs are statistically & significantly different. But about SDG14 & SDG17, both two groups do not hold a statistically significant difference in their perceptions/attitudes because of their respective Sig. (2-tailed) values are higher than 0.05. Therefore, only for SDG14 & SDG17 out of all Core SGDs, the null hypothesis can be accepted.

The same analysis related to secondary SDGs was also conducted but sample size 118 due to few missing responses for the questionnaire. Here also, Under the Levene's Test, equal variances were assumed. Then, Sig. (2-tailed) values of SDG5, SDG6 & SDG8 were observed. Perceptional difference was found only for SDG6 (because Sig. (2-tailed) = $0.021 < 0.05$). But operational & management level workers have the same perceptional attitude towards SDG5 & SDG8 because of the relevant Sig. (2-tailed) were much higher than 0.05 (the level of significance). The results are shown in table 3 & table 4 in Appendix 10.

4.5.2 Analysis of Proposed Solutions/Changes for PoC

112 respondents were given their attitudes (likeness/Unlikeness) towards 5 proposed solutions/changes to be implemented in Port of Colombo. Excel was used to analyze this. Then, proper tabulation was done in Excel to summarize the responses given by the port workers (Sample II).

Table 15-Excel Report Table to analyze preference for given Solutions

SOLUTIONS	Very Unlike (%)	Unlike (%)	Neutral (%)	Like (%)	Very Like (%)	Total	Total No of Participants
SOLUTION1	1%	4%	11%	38%	46%	**100%**	**112**
SOLUTION2	0%	3%	4%	26%	68%	**100%**	**112**
SOLUTION3	0%	4%	3%	30%	63%	**100%**	**112**
SOLUTION4	0%	2%	3%	29%	66%	**100%**	**112**
SOLUTION5	0%	9%	11%	31%	49%	**100%**	**112**

Source – Survey Data of Questionnaire 1

SOLUTION 1 is Drone Technology (to assess container damages, vessel damages & yard control etc.) should be implemented in the port. SOLUTION 2 is New Vehicle Routing System (to reduce traffic congestion) should be implemented in port. SOLUTION 3 is Developing a multi model split (Rail-Road-Sea-Inland Waterways connectivity) should be done in port. SOLUTION 4 is Green building certification like LEED Plus (which assesses building design and construction in terms of energy efficiency, water usage, air quality, and choice of building materials as well as environmental factors such as access to public transportation and responsible land use) should be practiced in ports. SOLUTION 5 is full automation should be implemented at least in a part of port. Majority of respondents have given their preference (demonstrated by like or Very Like responses) for all the solutions. Highest preference owned solution was Solution No.2. Second most preferred solution was Solution No.4. Third rank in respect of preference of port workers was achieved by Solution No.3.

4.6 Bivariate Analysis (Sample II)

Each SDG's three indicators were analyzed with this bivariate analysis. The resulted tables are attached to Appendix 11.

4.7 Multivariate Analysis (Sample II)

4.7.1 Exploratory and Confirmatory Factor Analysis

4.7.1.2 *EFA Results*

The study relies on the data collected from a survey conducted with port workers of PoC carried out in January 2020 to March 2020.The questionnaire was designed based on the literature on 11 SDGs out of all 17 SDGs of the UN 2030 agenda. To identify and analyze what sustainability aspects (indicators/factors) under the selected 11 SDGS are aligned with sustainability in port operations of PoC or to formulate a specific sustainability framework for PoC, this study applied both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) in evaluating the factors influential to sustainable port operations specialized for PoC.

This analysis helps to find the level of Sri Lankan port sector practices which focus to achieve the Core & Secondary SDGs (Totally 11). This section presents the results of EFA and CFA based on questions Q7 to Q15 (see Appendix 02) covering 29 unique variables under the selected 11 SDGs. First EFA based Principle Component Analysis (PCA) was executed to identify the underlying latent construct for the 29 variables and second CFA was conducted to test the stability of the latent construct & analyze the latent sustainability indicators or factors underlying port operations of PoC.

Table 6 reports the results of EFA concerning the variables which were previously referred as SDG indicators affecting the port operations' sustainability. As shown in Table 6, the first five factors have the initial eigenvalues of 4.863, 1.704, 1.451, 1.184 and 1.081, which are larger than 1; and they explain 79.106% of the total variance of the variables. Therefore, according to the Kaiser criterion, these factors can be retained for further analysis.

Table 16-Total Variance Explained in PCA for 29 SDG indicators

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.863	37.411	37.411	4.863	37.411	**37.411**
2	1.704	13.110	50.521	1.704	13.110	**50.521**
3	1.451	11.162	61.683	1.451	11.162	**61.683**
4	1.184	9.110	70.793	1.184	9.110	**70.793**
5	1.081	8.313	79.106	1.081	8.313	**79.106**
6	.514	3.956	83.062			
7	.461	3.550	86.612			
8	.437	3.359	89.971			
9	.323	2.486	92.457			
10	.294	2.264	94.721			
11	.262	2.016	96.737			
12	.249	1.915	98.652			
13	.175	1.348	100.000			

Source – SPSS analysis results particular to EFA analysis

Further the following table is taken from Extraction Method under Principal Component Analysis. Rotation Method is Varimax with Kaiser Normalization. Rotation Converged in 7 iterations.

Table 17-Rotated-rescaled Component Matrix of these underlying factors in PCA output taken from SPSS

	Component				
	Life below	Industry Innovation & Infrastructure	Good Health & Well-being	Affordable & Clean Energy	Clean water & Sanitation
Identifies the need for marine conservation & taking necessary actions against marine pollution.	.869				
Maintains a clean basin water area with zero oil spillage.	.832				
Improves ocean health and contribution of marine biodiversity.	.811				
Mitigate the traffic congestion inside the port via new technological developments.		.838			
Technology development, research and innovation.		.775			
Artificial intelligence to do port operations.		.653			
Prompt medical care services under occupational health.			.894		
Health monitoring (or Check-Ups) of employees.			.858		
Clean, affordable, reliable, renewable & modernized energy sources like Solar energy/ Wind energy/ Tidal & Wave energy.				.863	
Awareness sessions to employees about sustainable energy.				.748	
Onshore power supply (OPS) which allows ships to effectively "plug in" to a land-based electrical grid while at port docks.				.619	
Provision of port waste reception services for ships					.888
Adequate and equitable sanitation and hygiene for all and maintaining related issues of defecation, paying special attention to the needs of Women			.		.558

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 7 iterations.

Source –SPSS analysis results particular to EFA analysis

The result of EFA suggests that Colombo port followed specific sustainability indicators which is particular and relevant to SL context. A number of factors/indicators may influence its sustainability of port operations and hence those indicators should be included into the proposing sustainability framework of Port of Colombo. These include 5 components. The component 1 includes three variables and they are the SDG indicators named SDG14.2, SDG14.1 & SDG14.3 in order. Therefore, the component 1 can be named as **Life below Water** which is SDG 14. Next three variables in the rotated component matrix construct the component 2 collectively. They are SDG9.2, SDG9.3 & SDG9.1 in order. Based on that, the component 2 can be demonstrated as **Industry Innovation & Infrastructure** which is SDG 9. Third component is only built from 2 variables. They are SDG3.1 & SDG3.2 in order. Therefore, the component 3 can be represented by **Good Health & Well-being** (SDG3). 4th component is created by three variables & they are SDG7.2, SDG7.3 & SDG7.1 in order. Because of that, the component 4 can be named as **Affordable & Clean Energy** which is SDG 7 under Core SDGs. Finally, another two factors/variables construct final component. They are, SDG6.3 & SDG6.2. Therefore, the fifth component can be declared as **clean water & Sanitation** (SDG6).

4.7.1.3 *CFA Results* – Model 1

Figure 16 presents the result of CFA that all the possible relationships between the underlying factors of port sustainability practices/indicators with the standard estimates of the regression coefficients respectively.

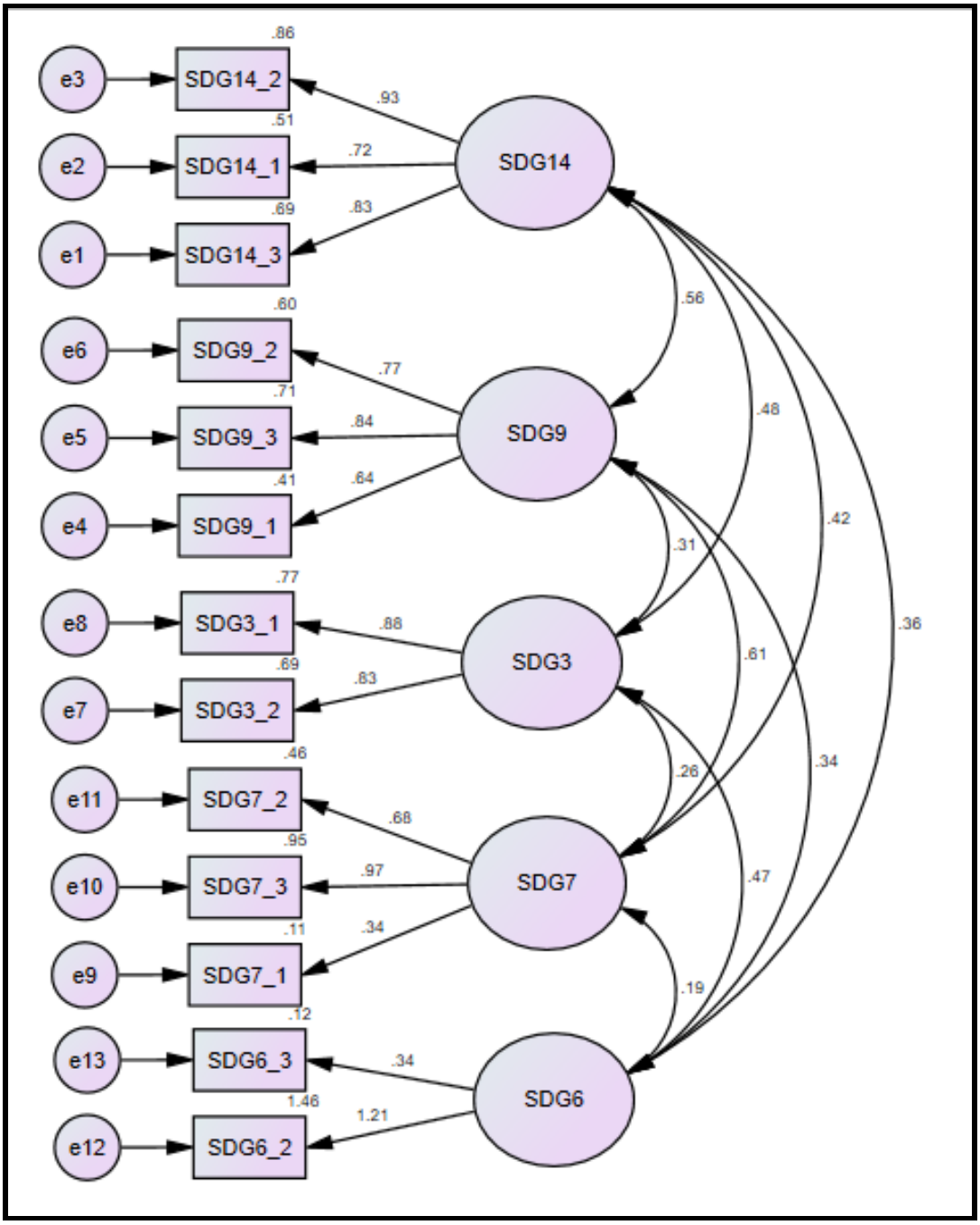

Figure 5-Initial drawing in SPSS-AMOS

The output of the first run in SPSS AMOS is attached in Appendix 03.

Figure 17 (in Appendix 03) showcases the Chi-square statistic CMIN/DF value of the Default model as 1.731 which should be less than 5 or 3 for a better fit. Here this CMIN/DF is acceptable. Other model fit values are not acceptable (Appendix 03).

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	49	95.220	55	.001	1.731
Saturated model	104	.000	0		
Independence model	13	740.247	91	.000	8.135

Figure 6-CMIN output table for AMOS first run

In other words, the first drawn model's RMSEA & PCLOSE value are not acceptable for a better fit. Figure 18 demonstrates it well. Here, the root means square error of approximation (RMSEA) is 0.078. RMSEA should be less than 0.05. Therefore, RMSEA for the first drawn model is not acceptable. Here PCLOSE is 0.047 and PCLOSE should be greater than 0.05. Finally, PCLOSE value is also not acceptable. A modification of the model is necessary. Variables with low loadings are first excluded and based on the values of standardized residual covariances, and variables with higher residual covariances (which are above 0.4) are excluded in repeated trials.

Table 18: Regression Weights for the first run in AMOS

			Estimate	S.E.	C.R.	P	Label
SDG14_3	<---	SDG14	1.000				
SDG14_1	<---	SDG14	.934	.107	8.711	***	par_1
SDG14_2	<---	SDG14	1.141	.101	11.301	***	par_2
SDG9_1	<---	SDG9	1.000				
SDG9_3	<---	SDG9	1.360	.197	6.913	***	par_3
SDG9_2	<---	SDG9	1.249	.187	6.663	***	par_4
SDG3_2	<---	SDG3	1.000				
SDG3_1	<---	SDG3	.962	.123	7.805	***	par_5
SDG7_1	<---	SDG7	1.000				
SDG7_3	<---	SDG7	2.938	.843	3.487	***	par_6
SDG7_2	<---	SDG7	1.903	.533	3.567	***	par_7
SDG6_2	<---	SDG6	1.000				
SDG6_3	<---	SDG6	.292	.152	1.922	.055	par_8

Source-Results of CFA done with AMOS software

*** 0.001 = significant at 1% significance level

Estimates (Group number 1 - Default model)
Scalar Estimates (Group number 1 - Default model)
Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

The regression weights reported in Table 17 strongly indicate that most of the variables are significant at 1% except only one value (0.055) in the bottom.

Figure 7-RMSEA output table for AMOS first run

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.078	.051	.104	.047
Independence model	.243	.227	.259	.000

According to Figure 16, the CFA results indicate strongly significant relationships between most of the variables, but SDG 6 does not satisfactorily behave. As the CFA result could not find significant relationship between SDG6 and others mostly, therefore it was excluded from the analysis. It seems, the first model need modifications. By dropping the variables with small coefficients in the first drawing and by re-running, it can be done. Therefore, removing of the unnecessary variables was done one by one. Finally, the model was improved after the re-running. By checking CMIN, RMSEA and PCLOSE, the model was finally destined to an expected range of the values.

4.7.1.4 *CFA Results* – Model 2

According to previous Figure 16, the relationships between variables as indicated by their correlation show the lowest correlations with SDG 6 mostly. Therefore, entire SDG 6 was removed via deleting the respective two variables/factors (SDG6.3 & SDG6.2). This removal was done by looking at regression weights. Since SDG6 is the only remaining secondary SDG in the model, its existence with Core SDGs is not matching. The removal of SDG6 is acceptable in that view as well. The output of the second run in SPSS AMOS is attached in Appendix 04. Then, model was improved a little bit than before. CMIN/DF value was 1.674, RMSEA value was 0.075 & PCLOSE value was 0.106. But in this second run of AMOS also, all the values were satisfied with the expected range.

4.7.1.5 *CFA Results* – Model 3

For further improvement of the model, next variable was SDG7.3 to be removed. It was done as the third run. The output of the third run in SPSS AMOS is attached in Appendix 05. Finally, CMIN/DF, RMSEA & PCLOSE value gained values in the expected level & all were acceptable. Figure 8 shows it clearly. CMIN/DF value has further reduced than before. It is 1.064 & of course it should be less than 3. RMSEA is 0.023 & of course its acceptable level was less than 0.05. PCLOSE is 0.752 & of course, it should be greater than 0.05. Table 19 shows all the variables in this final AMOS model are significant. When comparing with the secondly improved AMOS model, both CMIN/DF and RMSEA have improved significantly with their values from 1.674 to 1.064 and from 0.075 to 0.023 respectively and PCLOSE related to RMSEA has been improved from 0.106 to 0.752.

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	36	30.860	29	.372	1.064
Saturated model	65	.000	0		
Independence model	20	593.281	45	.000	13.184

Figure 8-CMIN output table for AMOS Last Successful Run-Third Run

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.023	.000	.074	.752
Independence model	.317	.295	.340	.000

Figure 9-RMSEA output table for AMOS Last Successful Run-Third Run

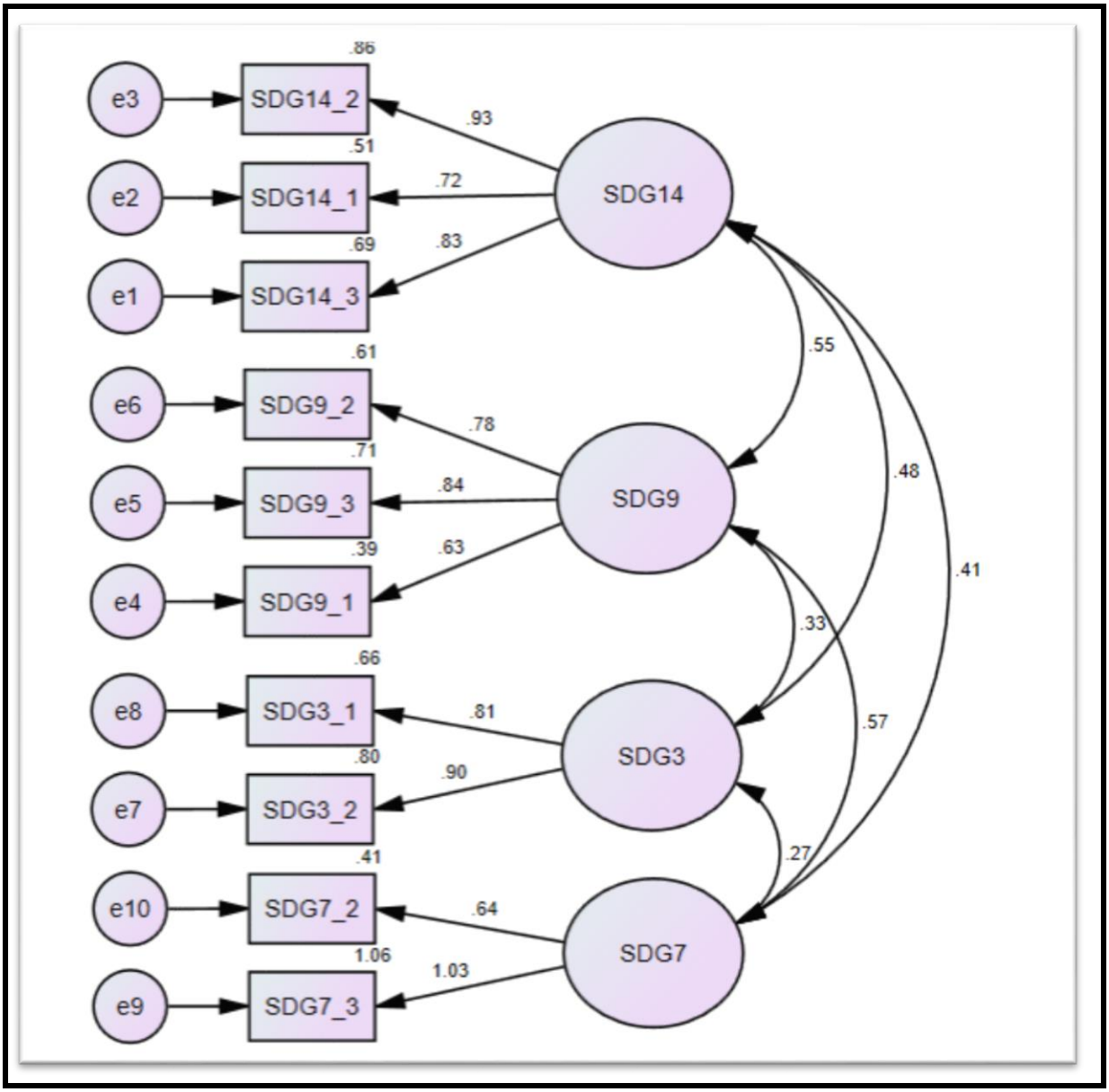

Figure 10-Last acceptable drawing model in SPSS-AMOS

Table 19-Regression Weights: (Group number 1 - Default model)

Factor		Main SDG	Estimate	S.E.	C.R.	P	Label
SDG14_3	<---	SDG14(Life below Water)	1.000				
SDG14_1	<---	SDG14(Life below Water)	.934	.107	8.720	***	par_1
SDG14_2	<---	SDG14(Life below Water)	1.138	.101	11.241	***	par_2
SDG9_1	<---	SDG9(Industry, Innovation & Infrastructure)	1.000				
SDG9_3	<---	SDG9(Industry, Innovation & Infrastructure)	1.389	.207	6.713	***	par_3
SDG9_2	<---	SDG9(Industry, Innovation & Infrastructure)	1.294	.198	6.544	***	par_4
SDG3_2	<---	SDG3(Good Health & Well-being)	1.000				
SDG3_1	<---	SDG3(Good Health & Well-being)	.822	.138	5.950	***	par_5
SDG7_3	<---	SDG7(Affordable & Clean Energy)	1.000				
SDG7_2	<---	SDG7(Affordable & Clean Energy)	.579	.113	5.131	***	par_9

*Estimates (Group number 1 - Default model)
*Scalar Estimates (Group number 1 - Default model)
*Maximum Likelihood Estimates

Source- SPSS/AMOS results of CFA analysis

The above analysis results reveal that the factors most influential to sustainability of port operations are SDG14, SDG9, SDG3 & SDG7 which are particular to SL context since the research was done with port workers of Port of Colombo. Therefore, it can be confirmed that the SDG14 factor (Component 1 in finally derived model) is related to all the three variables. SDG 9 also (Component 2 in finally derived model) is related to all the three variables. SDG 3 factor is left with only two practices (the SDG indicators – SDG3.1 & SDG3.2) while the SDG 7 factor also is included with only two practices (the SDG indicators –SDG7.2 & SDG7.3).

This final AMOS model was derived based on the responses given in SL context. This factor analysis supports to discover the most focused sustainable practices in SL port sector (especially in PoC) which support to achieve the relevant SDGs of the UN 2030 Agenda.

Table 20-EFA & CFA results-Summary

Most influential SDGs for port operations (specified for Sri Lankan Context)	***Respective variables for each SDG***
SDG 14 – Life below Water	Port terminal improves ocean health and contribution of marine biodiversity. [14.3]
	Port terminal maintains a clean basin water area with Zero oil spillage. [14.1]
	Port terminal identifies the need for marine Conservation & taking necessary actions against marine pollution.[14.2]
SDG 9 – Industry, Innovation & Infrastructure	Port terminal tries to apply artificial intelligence to do port operations. [9.1]
	Port terminal supports technology development, research and innovation. [9.3]
	Port terminal tries to mitigate the traffic Congestion inside the port via new technological developments. [9.2]
SDG 3 – Good Health & Well-being	Port terminal does health monitoring (or Check-Ups) of employees. [3.2]
	Port terminal provides prompt medical care services under occupational health. [3.1]
SDG 7 – Affordable & Clean Energy	Port terminal conducts awareness sessions to employees about sustainable energy.[7.3]
	Port terminal uses clean, affordable, reliable, renewable & modernized energy sources like Solar energy/ Wind energy/ Tidal & Wave energy.[7.2]

4.7.2 Model Fit Analysis

Measurement of goodness of model fit was needed regarding this research under Structural Equation Modeling (SEM) & it was done via SPSS AMOS Graphics software (Version 23). This analysis (Appendix 06 & 07) was done for the initial benchmarked model from *United Nations SDGs & Sea Ports-Assessing Relevance & Finding Opportunities* [Brochure] (2017). After constructing a completed proposed model, it was over-identified (because of having a positive Degree of freedom which is more than zero) by SPSS AMOS software & next step was to find out the model is fit or not. When considering absolute model fit type, one of main requirement; Chi-square value should not be very high than Degree of freedom. It is not very high (since nearby values) according to following results which were generated from AMOS.

Result (Default model)
Minimum was achieved

Chi-square = 344.963

Degrees of freedom = 224

Probability level = .000

When considering absolute model fit type, another main requirement was filled by AMOS factor analysis results; under model fit summary, probability value (following table's P value under Default model raw) was less than 0.05 & there the absolute fit is valid. P = 0.000 < 0.05 {Moreover additionally, under parsimonious model fit type also, this research model is a perfect model because the CMIN/DF value (1.540) is less than 5.}

Table 21-CMIN from Appendix 06

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	100	344.963	224	.000	1.540
Saturated model	324	.000	0		
Independence model	48	1621.959	276	.000	5.877

Also, the other requirement for absolute model fit was checking RMSEA (Root Mean Square Error of Approximation). It should be less than 0.08 for absolute fit. Below table evidenced that the generated RMSEA (0.067) was less than 0.08 which suggested a perfect fit of the proposed model for this research.

Table 22-RMSEA from Appendix 06

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.067	.052	.080	.028
Independence model	.201	.191	.210	.000

Finally, confirming from above evidences, the benchmarked model (from *United Nations SDGs & Sea Ports-Assessing Relevance & Finding Opportunities* [Brochure] (2017)) for this research is fit. The output drawings with standardized estimates & unstandardized estimates are attached with Appendix 07.

4.8 Chapter Summary

Both samples taken for different objectives of this research satisfied the expected levels of sample adequacy & sample reliability. “Responsible consumption & production”, “partnerships for the goals” and “sustainable cities & communities” are the most developed sustainable development goals of Port of Colombo from 2015 to 2020. Gender Equality of Port of Colombo has developed from 2015 to 2020 & it is the one & only secondary SDG which was developed in the period. Management level & operational level employees have same perceptions towards Life below water, partnerships for the goals, gender equality and decent work-economic growth inside Port of Colombo. Implementation of new vehicle touting system was the most preferred change to be done from the proposed future changes or solutions in this research. The practical framework specified for sustainability of Colombo Port operations finalized with only four SDGs.

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Introduction

Mainly two samples were analyzed based on several research objectives & the results were discussed accordingly.

5.2 Discussion

5.2.1 Interpretation of Univariate Analysis of Sample I

Port of Colombo's (PoC's) operations have performed satisfactorily to develop Good Health & Well-being (SDG 3), Affordable & Clean Energy (SDG 7), Industry Innovation & Infrastructure (SDG 9), Sustainable Cities & Communities (SDG 11), Responsible Consumption & Production (SDG 12), Climate Action (SDG 13), Life below Water (SDG 14), Partnerships for the Goals (SDG 17) & Gender Equality (SDG 5). But its operations have not been succeeded in developing Clean Water & Sanitation (SDG 6) & Decent Work & Economic Growth (SDG 8) satisfactorily. Therefore, Colombo Port operations should focus more on Clean Water & Sanitation facilities & should focus more on best Decent Work & Economic Growth practices. Sri Lanka's Sustainable development act No.19 of 2017 is being useful and will be highly supportive to improve institutional & policy coherence & also it is being the base for providing the legal framework for implementing these SDGs. Through the act, sustainability development council was formulated in order to guide & oversee SDG implementation & to formulate a national policy & strategy on sustainable development. The development of the Core SDGs for port operations should be monitored by this council and necessary actions to develop SDG 6 & SDG 8 should be advised by the council.

Highest developed (can be ranked as No.1) SDG inside Port of Colombo is Responsible Consumption & Responsible Production (SDG12). With the limited resources available inside Port of Colombo, its handling capacity is yearly increased. Achievement of ISO 140001 was highly affected for this SDG's development. Secondly, the usage of Recyclable Resources as a major objective of their consumption policies & thirdly usage of energy saving device caused some sort of effect in performing better responsible actions

in Port of Colombo's consumption and production procedures. Out of triple bottom line of sustainability, it is true that Port of Colombo is keen on economic sustainability than social and environmental sustainability because this highest developed SDG (Responsible Consumption & Responsible Production) is classified under economic pillar (Hettige, 2017).

According to above paragraph, Responsible Consumption & Responsible Production (SDG 12) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & all three variable indicators have significantly contributed for SDG3's development.

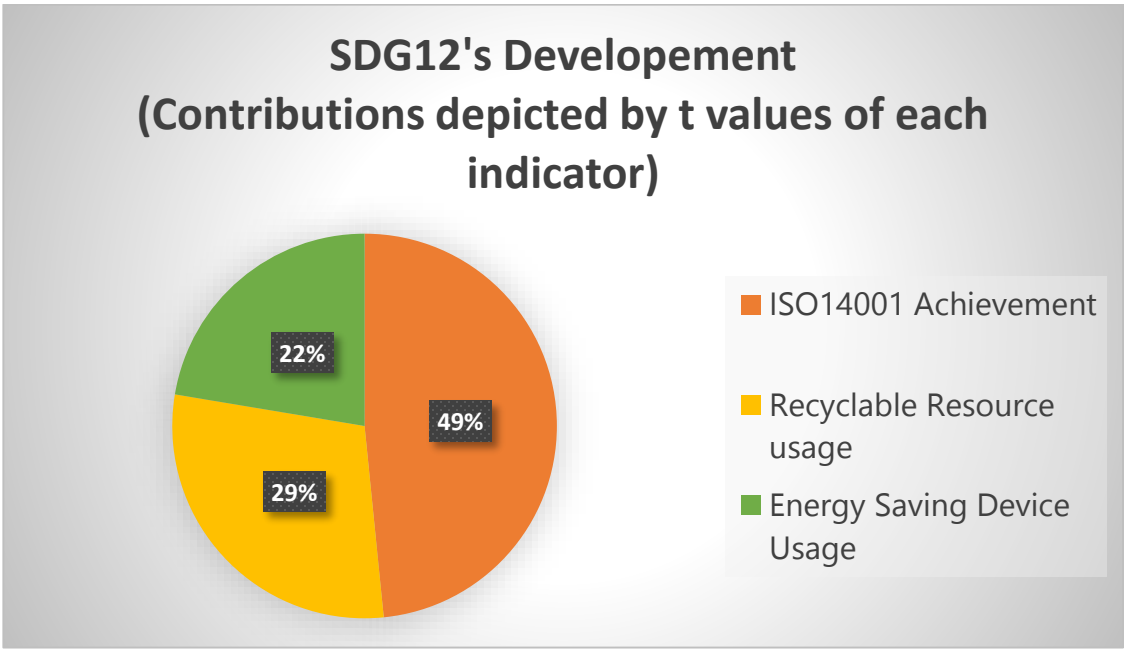

Figure 11- Contributions as t value percentages relevant for SDG12 from the Paired Sample t-test

Second highest developed (can be ranked as No.2) SDG so far from 2015 to 2020 inside PoC is Partnerships for the goals. Via promoting of financing, capacity building, trade & investments, multi-stakeholder partnerships, monitoring & accountability and also addressing systemic issues like policy and institutional coherence are contributing to maintain the better level of partnerships for the goals. Private Public Partnerships (PPP) are successfully maintained by Port of Colombo. Especially the already built two private terminals inside PoC & upcoming future terminal inside PoC showcase the strength of partnerships for the goals inside PoC. Colombo port expansion projects & Colombo Port

City Project were successful so far because of this 7th SDG's availability related with the port operations.

According to the above paragraph, Partnerships for the goals (SDG 17) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & all three variable indicators have significantly contributed for SDG3's development.

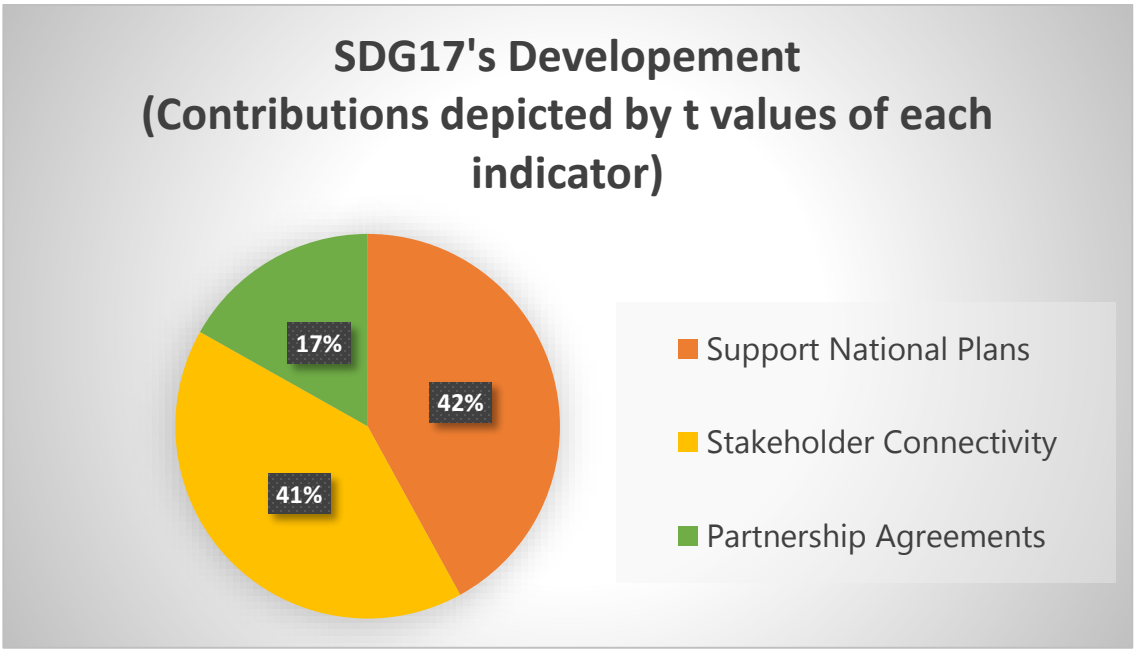

Figure 12-Contributions as t value percentages relevant for SDG17 from the Paired Sample t-test

Third highest developed (can be ranked as No. 3) SDG related with Colombo Port operations is Sustainable Cities & Communities (SDG 11). Providing only government owned land area to build up port infrastructure & offering BOT (Build, Operate & Transfer) investment opportunities for private sector based on PPPs are very essential to build up a future sustainable city because it has a centralized control. Therefore, nearby communities also accept the government decisions to develop a sustainable city around Colombo without any hesitation. Mobility and access was in a good condition with the existing 5 main gates of Port of Colombo and vast land area with good road connectivity & will be better with expressway connectivity in the near future. Therefore, existing traffic condition inside Colombo will be reduced & Colombo Port will be handling exports and imports comparatively better than 2015-2020 time-period and this practice will be more contributed further for SDG 11's availability within the port operations. PoC conducts

good CSR practices & each terminal has obtained attractiveness & a highlighting good will of local communities by executing such practices. Even though air quality controlling has been increased to a certain level, much more actions must be taken to deduct gas emissions which causes low air quality. As a result, nearby communities' livelihood will be protected & thus will formulate a sustainable city & community inside Colombo.

According to above paragraph, Sustainable Cities & Communities (SDG 11) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & all three variable indicators have significantly contributed for SDG3's development.

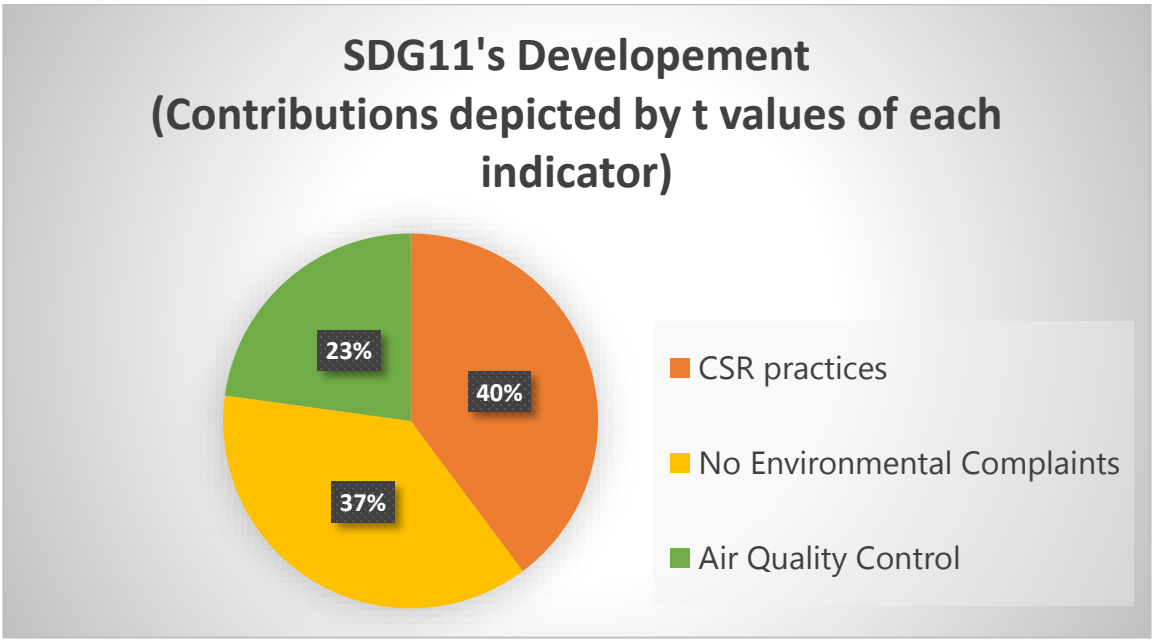

Figure 13- Contributions as t value percentages relevant for SDG11 from the Paired Sample t-test

Affordable & clean energy (SDG 7) can be ranked as 4th highest developed SDG inside Port of Colombo. Shifting into electrified cranes instead of diesel or hybrid cranes is good trend inside this port. Every terminal of PoC has moved to order electrified cranes and to start-up renewable energy based projects inside their terminals. Since Sri Lankan government is focusing continuously on developing infrastructure facilities, types of energy also should be considered prior to build-up the proposed infrastructure developments. Conduction of awareness sessions to employees about sustainable energy is the main cause for this SDG's development. But practice of provisioning of onshore power supply (OPS) which allows ships to "plug in" effectively to a land-based electrical

grid while at port docks was not being occurred up to a desired level for a statistical development. Therefore, PoC should concern on this practice more than before.

According to above paragraph, Affordable & Clean Energy (SDG 7) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & only two variable indicators have significantly contributed for SDG3's development.

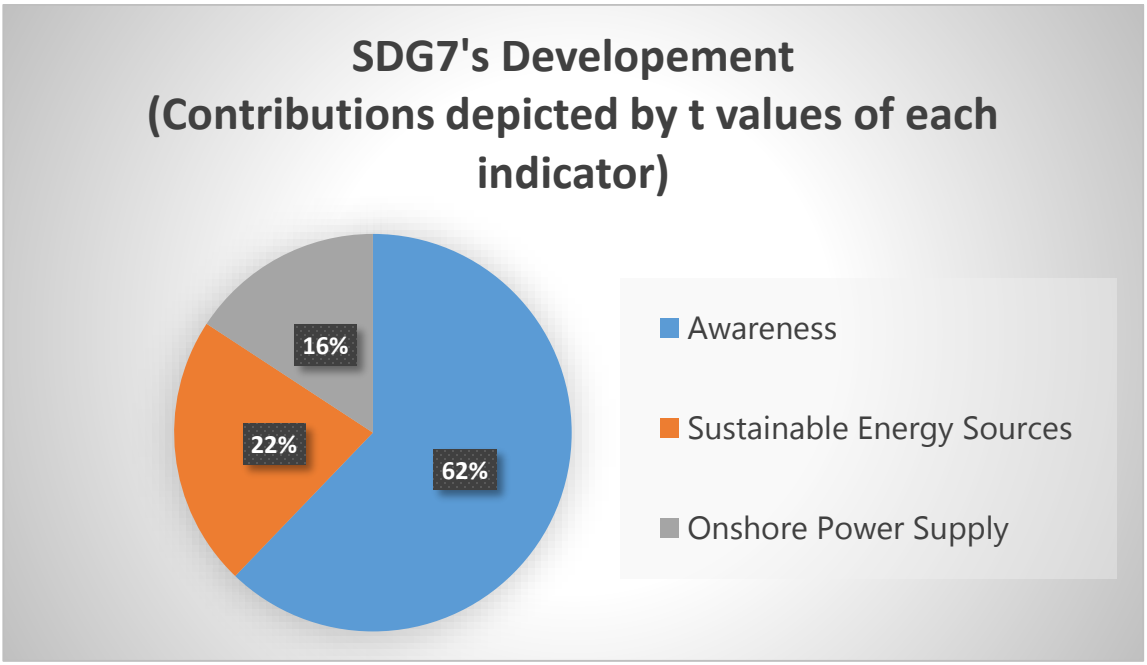

Figure 14- Contributions as t value percentages relevant for SDG7 from the Paired Sample t-test

Meanwhile, Gender Equality (SDG 5) being a secondary SDG, has developed convincingly than several core SDGs & it can be ranked as 5th highest developed SDG. Actually, in the past (2015 & earlier) very less women worked at PoC. But current status is totally different. Women has been involved in not only management aspects of Port of Colombo & there are several remarkable female crane operators inside the Port. Today, while shattering rooted societal myths on male-dominated societies, women empowerment has been increased inside Port of Colombo. IMO has declared that women empowerment fuels thriving economies, spurs productivity and growth, and benefits every stakeholder in the global maritime community.

Therefore, Gender Equality (SDG 5) related with port operations of PoC has been developed from 2015 to 2020, as a secondary SDG. But other two secondary SDGs (Clean

Water & Sanitation – SDG 6, Decent Work & Economic Growth – SDG 8) has not been developed significantly.

When focusing of another developed SDG (Good Health & well-being – SDG 3) from 2015 to 2020 which is related to Colombo Port operations, provision of health monitoring (or Check-Ups) has been practiced well. Provision of prompt medical care services under occupational health also has been increased. Therefore, employees were very much satisfied with physical medical care provided by PoC during this time period. But Colombo port was not caring/concerning about the mental health of port workers and it can be caught as a weakness here. The employees should be given a niche to communicate their mental health issues. Starting a mental consultancy service inside Port of Colombo can be a good solution for these types of concerns.

According to above paragraph, Good Health & Well-being (SDG 3) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & only two variable indicators have significantly contributed for SDG3's development.

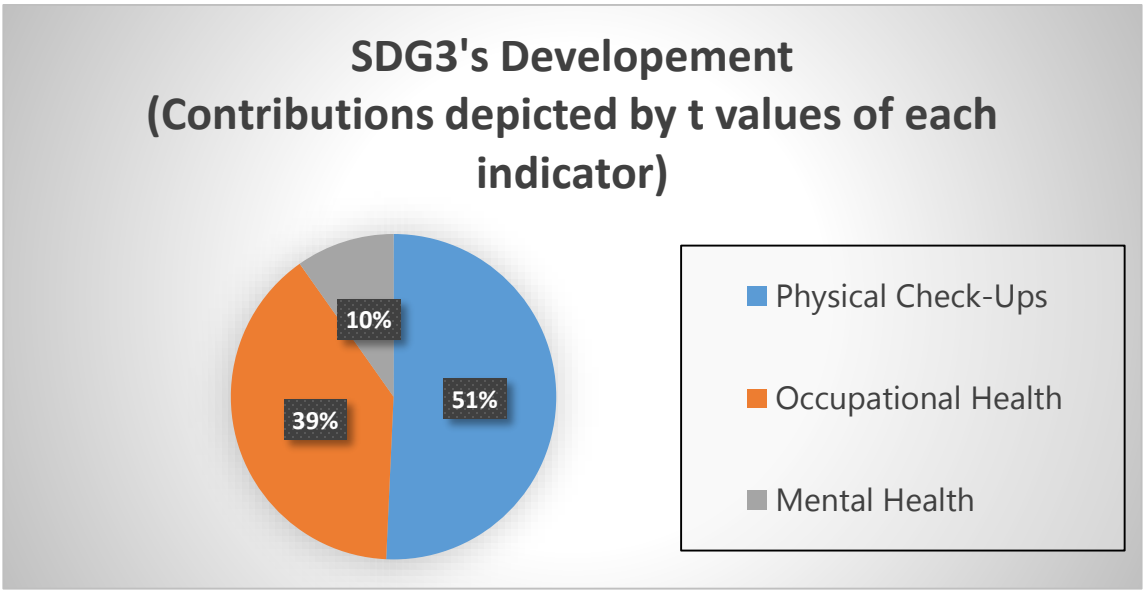

Figure 15- Contributions as t value percentages relevant for SDG3 from the Paired Sample t-test

PoC has been performed good practices to develop SDG 14 – Life below Water inside Colombo Port & therefore it has been developed as the 7th highest developed SDG. Identification of the need for marine conservation & taking necessary actions against marine pollution has been mainly caused for this out of selected indicators. Improvement

of ocean health and contribution of marine biodiversity also increased moderately. But PoC has failed to maintain a clean basin water area with zero oil spillage.

According to above paragraph, Life below Water (SDG 14) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & only two variable indicators have significantly contributed for SDG3's development.

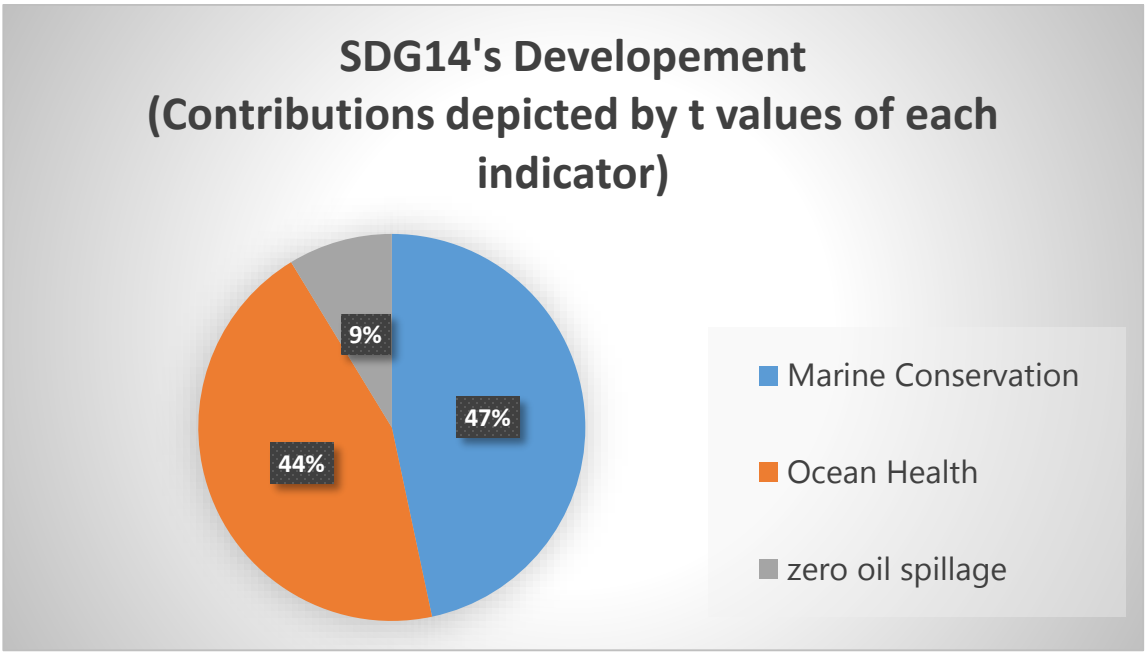

Figure 16- Contributions as t value percentages relevant for SDG14 from the Paired Sample t-test

Industry Innovation & Infrastructure (SDG 9) related with the port operations has increased from 2015 to 2020. Main cause behind this development is mitigation of the traffic congestion inside the port via new technological developments. Secondly, application of artificial intelligence to do port operations has developed. But PoC has not been able to support for technology development, research and innovation. It is a weakness and it should be focused more because there are more graduates passing out yearly from several universities of Sri Lanka who can conduct projects & researches to develop port operations. Not only that, plenty of research institutes are being eager to conduct experiments, researches, surveys & projects to develop operations of PoC or any other port.

According to above paragraph, Industry Innovation & Infrastructure (SDG 9) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & only two variable indicators have significantly contributed for SDG3's development.

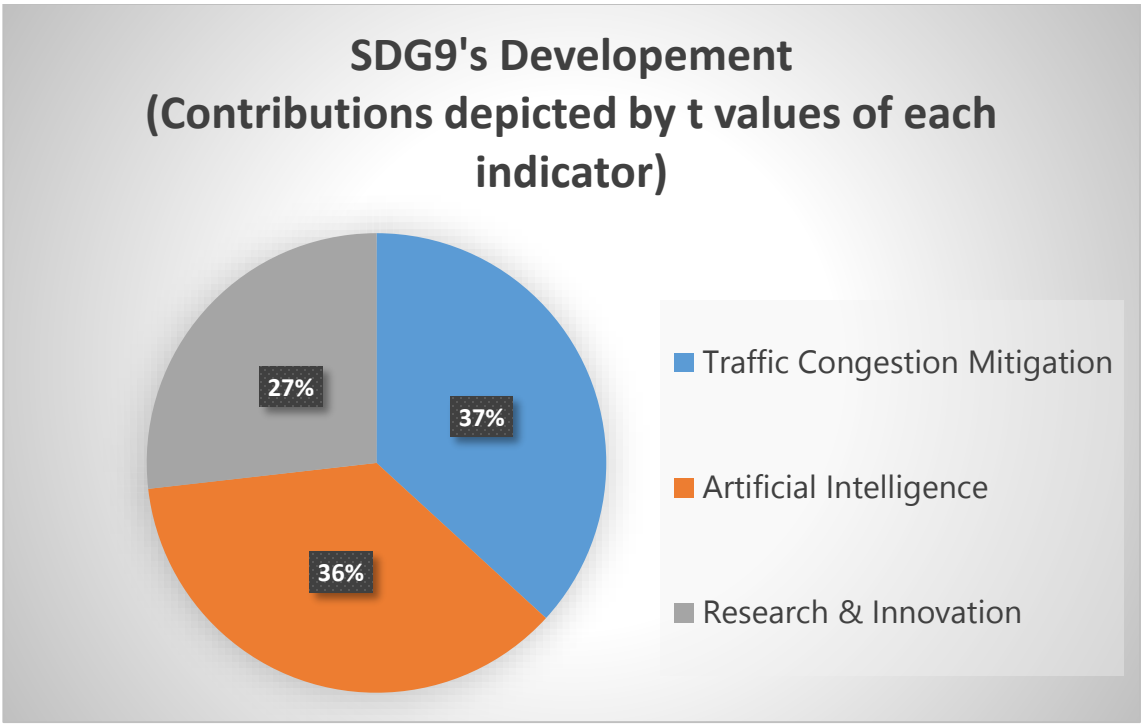

Figure 17- Contributions as t value percentages relevant for SDG9 from the Paired Sample t-test

Moreover, SDG 13 -Climate Actions also has been conducted by PoC. (Can be ranked as 9th highest developed SDG). Shifting into electrified cranes instead of diesel or hybrid cranes, start up for the implementation of the IMO2020 Global Sulphur Cap, conducting climate risk assessments for proposed projects (Ex; key climate change risks identified with regard to initial environmental examination for the SASEC Port Access Elevated Highway Project were increase in temperature, increased frequency and intensity of rainfall and related flooding triggered by precipitation, and storm surge) & taking proactive decisions to mitigate the risks are several reasons behind this development in Climate Actions related with Colombo Port Operations.

Preparation practices of Port of Colombo for usage of Very Low Sulphur Fuel Oil (0.5%) (VLSFO) according to IMO2020 regulation will continue the development of SDG13. As an example, one research done in Mediterranean ports has concluded that introduction of a directive of European Union which required all ships at berth or anchorage in European

harbors to use low sulphur fuels (0.1%) led to a decrease in the sulphur dioxide concentrations up to 66% (Schembari *et al*, 2012) (Kotowska, 2016). Climate Action (SDG 13) related with port operations of PoC has been developed from 2015 to 2020, as a core SDG & only two variable indicators have significantly contributed for SDG3's development.

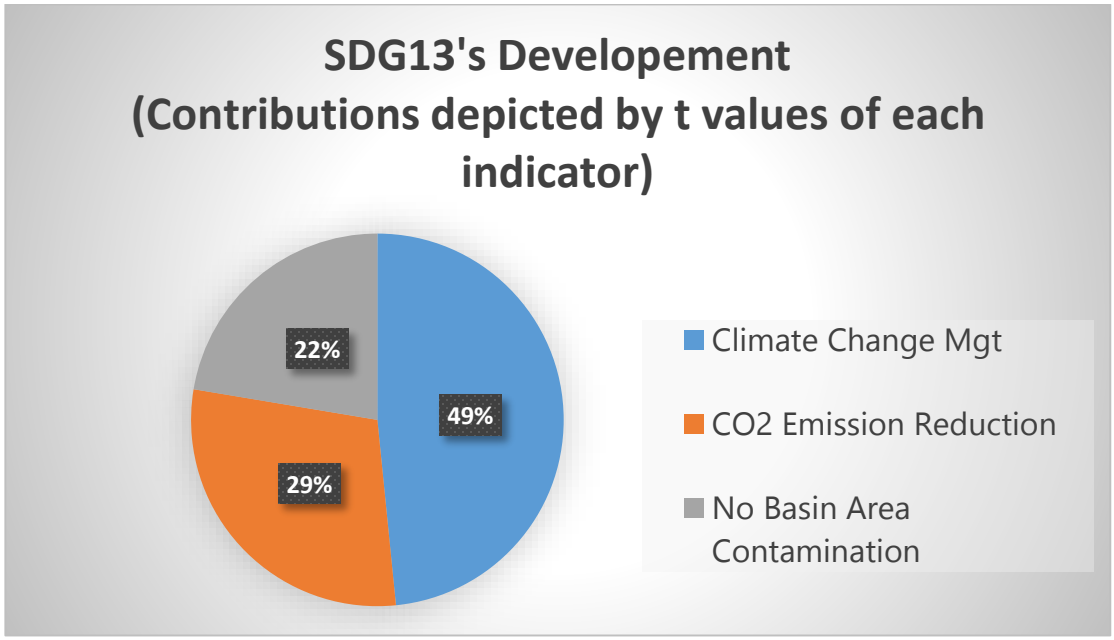

Figure 18- Contributions as t value percentages relevant for SDG13 from the Paired Sample t-test

From above pie charts, ash colored SDGs should be concerned more than before by PoC & necessary actions should be taken to develop them because during the 2015-2020 time period, no significant & statistical development could be identified in those SDG indicators. They are, consideration of mental health of all employees, provision of onshore power supply (OPS) which allows ships to effectively "plug in" to a land-based electrical grid while at port docks, supporting technology development, research and innovation, being proactive to not to contaminate basin's seawater area & maintaining a clean basin water area with zero oil spillage.

5.2.2 Interpretation of Multivariate Analysis of Sample II

For the development of overall sustainability of port operations in side PoC, each entire SDG has contributed as follows.

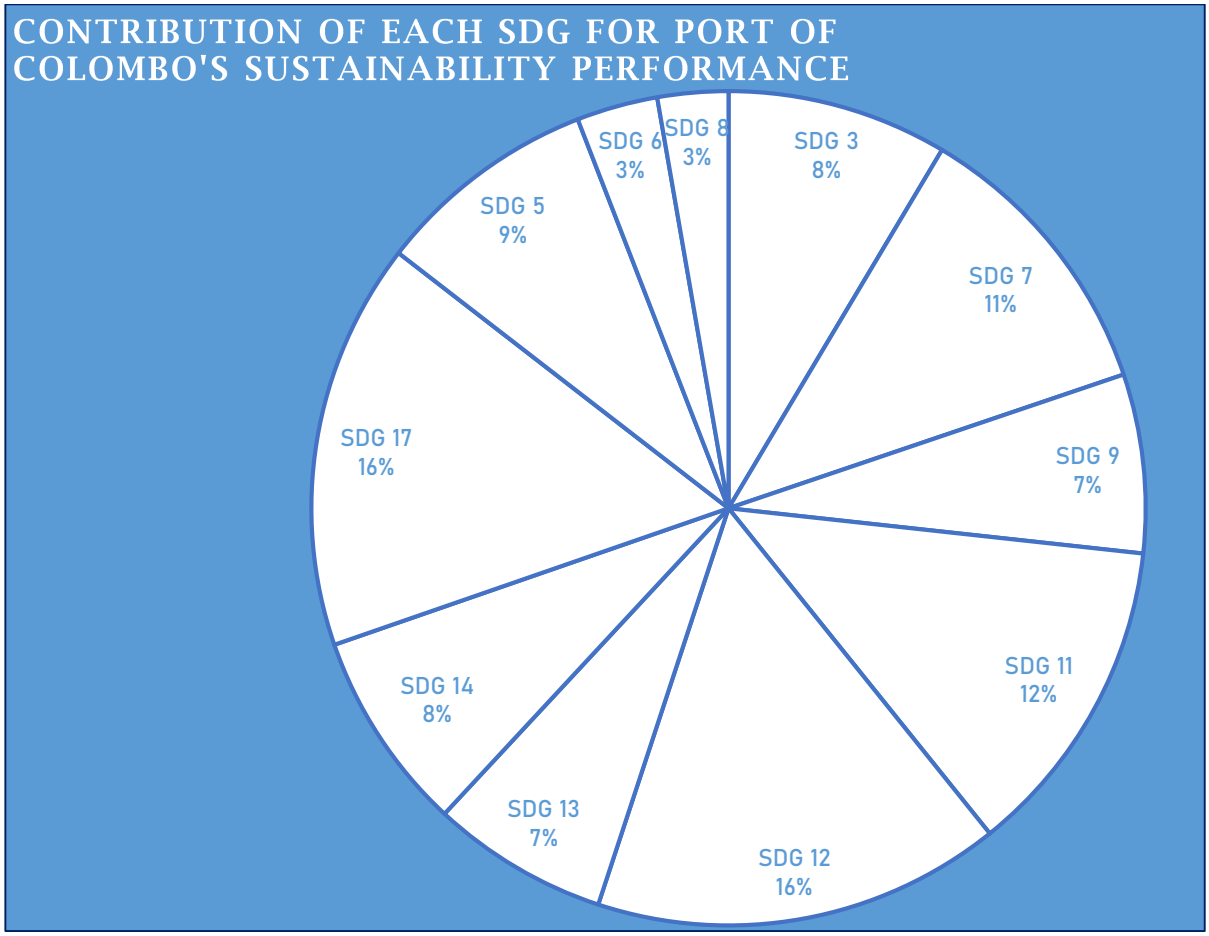

Figure 19-Contribution of all SDGs for Colombo Port operations' Sustainability Performance

As the result of factor analysis, all the Core SDGs loaded on the component (named as "the overall sustainability performance of PoC") as a clean & very straight forward solution which depicts that all the 8 Core SDGs significance is quiet similar for the overall sustainability performance of PoC. It can be considered as an evidence that the benchmarked study of *United Nations SDGs & Sea Ports-Assessing Relevance & Finding Opportunities* [Brochure] (2017) which is a well-known & leading Australian based practice (serving private & public clients across a range markets within Australia & abroad) & which is focusing on seaport industry mainly, is matching greatly with the performance of Colombo port operations. Also, the model fit analysis also acts as an

evidence for the accurateness of benchmarking the framework of Core SDGs & Secondary SDGs for port operations of PoC.

As per the factor analysis combined with EFA & CFA, PoC's operations' sustainability mainly depends on 4 factors only. They are 4 main SDGs out of the concerned 11 SDGs in UN's 2030 agenda (consisting 17 SDGs). Life below Water, Industry Innovation & Infrastructure, Health & Well-being and Affordable & Clean Energy have been covered so far strategically for the sustainable development of PoC. It means, the most focused sustainable practices in SL port sector are SDG 14, SDG 9, SDG 3 & SDG7. But for overall sustainability performance, other SDGs also should be focused by PoC. Then, the adherence with UN's 2030 agenda will have been achieved nearly 100%.

According to independent sample T-test, a conclusion can be made that most of the times, management level & operational level employees have different perceptions/attitudes towards the Core SDGs & Secondary SDGs inside PoC. Their educational difference, occupational experience differences & other differences might be caused for this perceptional difference. Management & Operational level employees had perceptional difference towards Good Health & Well-being, Affordable & Clean Energy, Industry Innovation & Infrastructure, Sustainable Cities & Communities, Responsible Consumption & Responsible Production, Climate Action and Clean Water & Sanitation. But about Life below water, partnerships for the goals, Gender Equality and Decent Work & Economic Growth, they had same level of attitudes.

Because of the mean for management level employees are always slightly higher than the mean for operational level employees. It means, management level port workers always give better response swaying towards more availability of a SDG. But operational level port workers give a lower response comparatively to the management level employees,

Respondents in Sample II have been responded very positively for the proposed changes for PoC (Solutions) from the researcher side. The solutions can be implemented to uphold the sustainability status of Port of Colombo which is globally identified as a very busy international maritime port. Highest number of "Very Like" Statuses (as a percentage 68%) was achieved by Solution No. 2. It means, implementing a New Vehicle Routing System (to reduce traffic congestion) is the most preferred change to be execute at PoC.

Next highest number of “Very Like” Statuses was achieved for the Solution No.4. It means, second preferred change is to practice a Green building certification like LEED Plus (which assesses building design and construction in terms of energy efficiency, water usage, air quality, and choice of building materials as well as environmental factors such as access to public transportation and responsible land use) inside Port of Colombo. Third priority was given to Solution No.3 which is to develop a Multi Model Split (Rail-Road-Sea-Inland Waterways Connectivity). Fourth place was taken by Solution No.5 & it will implement full automation at least in a part of port. Fifth preference was attracted by Solution No.1 & it suggested to implement Drone technology (to assess container damages, vessel damages, yard control etc.) Ex. DRAGONFLY DELIVERY CONCEPT) related with the port operations. When looking at the macro picture of this Solutions analysis, a conclusion can be made that as a whole, port workers prefer to have new change in PoC, & they have declared their attitudes towards likeness & Very likeness with regard to the proposed changes in this research.

Respondents in Sample II have been responded very positive attitudes toward the proposed solutions (new changes to be implemented at PoC). As a conclusion, port worker will not hestitate to change some exiting practices inside the port & they prefer to have new sustainable solutions to develop the sustainability of the port operation of PoC. The solutions can be ordered into a decending preference style as follows; Implementing a New Vehicle Routing System (to reduce traffic congestion), Practicing a Green building certification like LEED Plus (which assesses building design and construction in terms of energy efficiency, water usage, air quality, and choice of building materials as well as environmental factors such as access to public transportation and responsible land use), Developing a multi model split (Rail-Road-Sea-Inland Waterways Connectivity), implementing Full automation at least in a part of port & implementing Drone technology (to assess container damages, vessel damages, yard control etc.)(Ex. DRAGONFLY DELIVERY CONCEPT).

Table 23-Suggested solutions for PoC

Solution No.	Solution in detail
SOLUTION1	Drone technology (to assess container damages, vessel damages, yard control etc.) should be implemented in port.(Ex. DRAGONFLY DELIVERY CONCEPT)
SOLUTION2	New Vehicle Routing System (to reduce traffic congestion) should be implemented in port.
SOLUTION3	Developing a multi model split (Rail-Road-Sea-Inland Waterways Connectivity) should be done in port.
SOLUTION4	Green building certification like LEED Plus (which assesses building design and construction in terms of energy efficiency, water usage, air quality, and choice of building materials as well as environmental factors such as access to public transportation and responsible land use) should be practiced in ports.
SOLUTION5	Full automation should be implemented at least in a part of port.

Source- Solutions in Questionnaire I

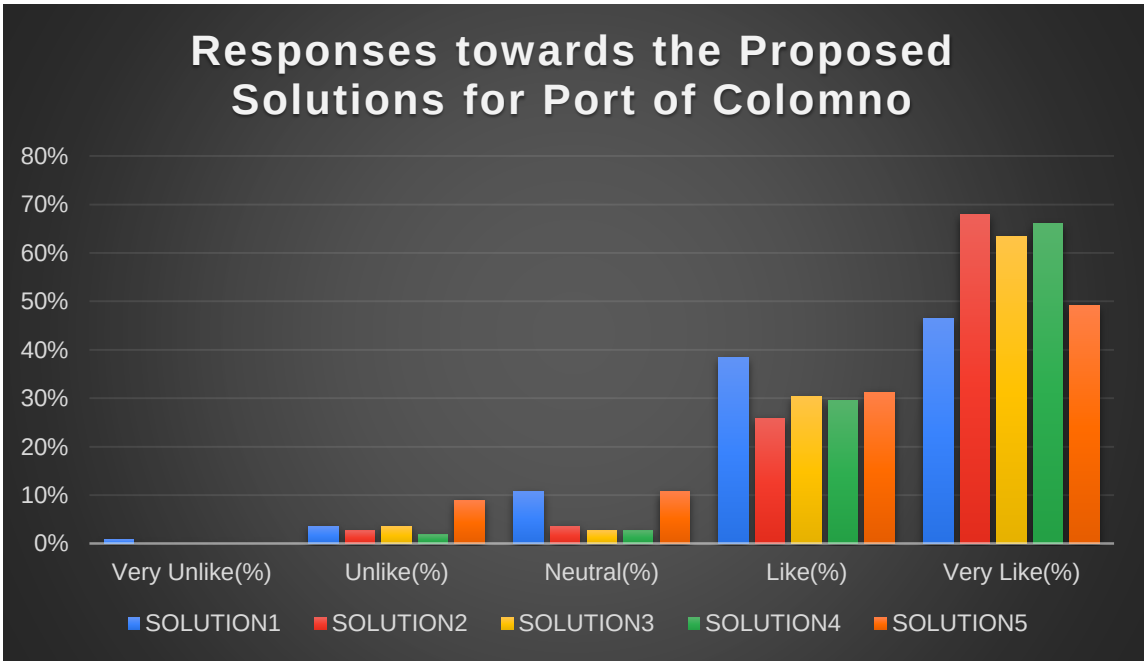

Figure 20-Preference Chart for suggested solutions for PoC

The results of EFA analysis identified five components which could be declared as specific sustainability indicators exclusive for Sri Lankan Ports. They are “Life below Water”, “Industry Innovation& Infrastructure”, “Good Health & Well-being”, “Affordable & Clean Energy” & “Clean Water & Sanitation”. When considering global

context, County to Country, Port to Port, & region to region, these kind of specific sustainability indicators have been identified via many researches. Hossain (2018), illustrated 7 out of 18 Canadian Ports had been proactively integrating sustainability into their operations & twenty five pre-defined indicators had been used to identify operational trends connected to port sustainability. Being a very small country than Canada, Sri Lanka's main port, "Port of Colombo" also practices above five specific sustainability indicators.

Furthermore, based on a case study of Busan Port, Kim & Chiang (2014) concedes the differentiation of sustainability frameworks for port operations from country to country. Through a thematic analysis, interview results has revealed four attributes; environmental technologies, continual monitoring & upgrading, internal process improvement & cooperation and communication (Kim *et al*., 2014).

But after the confirmation of CFA results SDG 6 ("Clean water & Sanitation" had to be removed from final EFA based conclusion. Therefore, only 4 sustainability factors or SDGs remained as the most influential factors for sustainability of port operations which are specified to Sri Lankan context. All the terminals of Port of Colombo must be keen on these remained factors; SDG 14-Life below water , SDG 9 – Industry Innovation & Infrastructure, SDG 3 - Good Health & Well-being & SDG 7 –Affordable & Clean Energy in order to improve the sustainability status of Colombo Port operations. The main objective of the research was to formulate a framework relevant to sustainable operations of a container port like Port of Colombo & the framework was successfully derived with these 4 SDGs. The respective government bodies & all the port terminals of Sri Lanka can use this framework to develop port dedicated tools because Hakam (2015) also admitted that pursuing generic global management system standards like ISO 14001 & EMAS becomes impractical for small ports to implement them correctly. For an example, "the Self Diagnosis Method" [SDM] was a port specific tool for port environmental management performance review which can be implemented in a matter of a one-day work maximum & the tool was ameliorated from the European Eco-Ports Framework (Hakam, 2015).

IMO has developed sustainability-related protocols, conventions and regulations in association with the United Nations Convention on the Law of the Sea (UNCLOS). They are the London Convention and Protocol (LC/LP), the Hong Kong Ship Recycling Convention, Annex VI – Prevention of Air Pollution from Ships of the International Convention for the Prevention of Pollution from Ships (MARPOL) & the "2030 Agenda for Sustainable Development" with 17 SDGs adopted by the UN on September 2015 (Lee *et al*., 2019). Hence, SDG 14 – Life below Water which is a main factor of the emerged sustainability framework of this research aligns with LC/LP which is to control all sources of marine pollution and prevent pollution of the sea through regulation of dumping into the sea of waste materials. Hence, SDG 7 - Affordable & Clean Energy which is a main factor of the emerged sustainability framework of this research aligns with the Hong Kong Ship Recycling Framework because it aspires to facilitate safe and environmentally sound recycling, without compromising ships' safety and operational efficiency & also aligns with Annex VI – Prevention of Air Pollution from Ships of MARPOL. Therefore, "Life below Water' & "Affordable & Clean Energy" which are almost directly connected with environmental sustainability shows that the derived framework is more flexible into environmental sustainability. Because 2 out of 4 factors are related with environmental sustainability. This fact was admitted by Yam & Lam (2013); "While prior studies and the port industry started in recent years to take note of green port practice when the port is already in operations, it is even more important to address ecological issues at the planning stage and before terminal construction for any future port development projects".

SDG 9 – Industry Innovation & Infrastructure behaves as the economic pillar inside the derived sustainability framework of this research. Further, SDG 3 – Good Health & Well-being acts as the social connector inside the derived framework. Therefore, the derived framework from EFA & CFA analysis is very well-balanced with TBL. Simultaneously, Yap & Lam (2013) contributes to both policy and research by conversing the necessity for a balanced approach in sustainability for ports and coastal development.

5.3 Chapter Summary

Based on Sample I analytics, the main research question was answered. Main research problem was "How far the focused port ("Port of Colombo") aligned with most relevant/specific SDGs (for port operations) of UN 2030 agenda from 2015 to 2020?"

Based on Sample II analytics, formulation of practical sustainability framework, analysis of perceptional standards between management level & operational level employees towards the SDGs & checking the model fitness of the suggested sustainability practical framework were performed.

CHAPTER SIX: CONCLUSION

6.1 Introduction

Final conclusions which were extracted from data analysis & discussion chapter were explained in this chapter.

6.2 Findings & Conclusion

The main research objective was successfully achieved. It was to determine how far Port of Colombo aligned with the most relevant 11 SDGs out of all 17 SDGs in the UN 2030 agenda from 2015 to 2020.This research results conclude that Port of Colombo has been aligning only with 9 SDGs out of the most relevant 11 SDGs. All the 8 Core SDGs have been developing during the period from 2015 to 2020. Amazingly, only one Secondary SDG (Gender Equality – SDG 5) has developed more than 4 Core SDGs. Other Secondary SDGs has not been developing from 2015 to 2020 inside PoC.

From 5 out of 9 developed Core SDG have 5 SDG indicators to be more focused. The reason is their contribution for relevant main Core SDG was very low & the research findings present them as owning insignificant development. They are consideration of mental health of all employees, provision of onshore power supply (OPS) which allows ships to effectively "plug in" to a land-based electrical grid while at port docks, supporting technology development, research and innovation, being proactive to not to contaminate basin's seawater area & maintaining a clean basin water area with zero oil spillage.

Another objective of this research was to formulate a framework relevant to sustainable operations of Port of Colombo. The formulation of conceptual framework with only Core SDGs & Secondary SDGs based on the SDG classification given by "United Nations SDGs & Sea Ports" (2017) was congenial to PoC's port operations. It is because both factor analysis combined with EFA & CFA and Model Fit Analysis supported with positive results. Finally derived model/framework was connected with 4 SDGs out of the concerned 11 SDGs & it is specialized for SL context only. Life below Water, Industry Innovation & infrastructure, Good Health & Well-being & Affordable & Clean Energy are the main SDGs which are mostly focused by PoC currently. Also the Modal Fit

Analysis results confirm the fitness of the benchmarked conceptual framework for the sustainability of port operations of PoC. It was benchmarked from *United Nations SDGs & Sea Ports-Assessing Relevance & Finding Opportunities* [Brochure] (2017).

The third research objective was to identify what type of perceptional difference is available between Operational level & Management level employees (Port workers) about the availability/current performance of each selected SDG inside PoC. The conducted Independent Sample T-test resulted that the mean for management-level employees is always slightly higher than the mean for operational level employees. It concludes that always management level port workers gave higher perceptional positive response than operational level port workers about the availability/current performance of each selected SDG inside PoC. Perceptional attitudes between operational level & management level workers towards the availability/performance of SDG3, SDG7, SDG9, SDG11, SDG12 & SDG13 were statistically & significantly different. But both group had same the perceptional attitude about SDG14 & SDG17. Therefore, the management-level & operational level employees had different levels of perceptions towards the availability of 6 Core SDGs out of all 8 Core SDGs. When concerning Secondary SDGs, the both groups of port workers has similar perceptions about SDG 5 & SDG8. But towards SDG 6, they had different perceptions about the availability.

The explored literature was sufficient to extract sustainability challenges in Maritime Logistics & Shipping Industry & the suitable strategies to mitigate the above challenges. Therefore, the final objective also was achieved satisfactorily.

6.3 Recommendations

All the three terminals should work to adopt and increase performance or availability of undeveloped SDGs from 2015 to 2020. They are Clean Water & Sanitation facilities & Decent Work & Economic Growth practices because all the Core SDGs and only one Secondary SDG has been developed so far inside port of Colombo. More collaboration is needed between organizational units (three terminal of Port of Colombo).

Decision makers and policy makers of Port of Colombo should use program prioritizing tools & modern financial analysis tools in order to move forward with sustainability of

port operations. New solutions such as implementing a New Vehicle Routing System, practicing a Green building certification like LEED Plus, developing a multi model split, implementing Full automation at least in a part of port & implementing Drone technology should be imposed immediately for better future.

If the Port authority of Port of Colombo wants to develop railway connectivity inside port under Solution 3 (suggested in this research), low emission locomotives & engines equipped with solid particles filters should be used (like Port of Hamburg).

If Colombo port is going to start a new terminal, the terminal can be planned only to use renewable energy for its port operations.

Not only the three terminals, other parts like Dockyard also should contribute for the overall sustainability performance of port of Colombo. Two common surface preparation methods used by industrial painters today are water-blasting and sandblasting. Normally in the dockyard of PoC, a vessel-hull is cleaned with sandblasting. It produces a large amount of secondary waste (abrasive & dust particles emit into atmosphere around port & it not used to make any industrial by-product). Therefore, it should be done in an enclosed place. The waste is dumped into sea as a regular practice. But water-blasting is the eco-friendliest way to clean and maintain a surface like hull of a vessel. In respect to sustainability aspects, the dockyard can make suitable decisions such as replacing water-blasting instead of sandblasting.

Appendix 12 represents sustainable strategies/solutions which can be benchmarked by PoC which were explored from the researched literature. Table demonstrates each strategy/solution with other columns indicating relevant sustainability pillar, the research article & if there are port which have executed the solutions.

6.4 Future Research Areas

I. The impact of all the 17 SDGs of UN's 2030 agenda towards the port operations of Port of Colombo can be researched in the future in order to identify all 17 SDGs' availability & performance/behavioral patterns

II. New research can be conducted via adding more indicator variables (here in this research, maximum only 3 indicator variables have been comprised for a SDG) for each SDG under same practical framework used in this research.

III) Future research idea is investigating how to reorganize freight transport chain by connecting all ports of Sri Lanka as a modal shift solution. It will reduce road transportation inside this island. The coastal connectivity around this island can be developed by combining all internal ports of Sri Lanka and coastal rail way line. Strong connectivity between foreland & hinterland can be sharpen from modal shift via creating an investment network.

IV) A feasibility study can be conducted to commence a railway operating company (PPP based or Fully Government owned or Private) inside Colombo Port area

REFERENCES

1) Arisha, Amr & Mahfouz, Amr. (2009). *Seaport Management Aspects and Perspectives: an Overview.*

2) Awad-Núñez, S., Soler-Flores, F., González-Cancelas, N., & Camarero-Orive, A. (2016). *How should the Sustainability of the Location of Dry Ports be measured? Transportation Research Procedia, 14, 936–944. https://doi.org/10.1016/j.trpro.2016.05.073*

3) Bandara, Y. M., H.-O. Nguyen, and S.-L. Chen. 2013. *"Determinants of Port Infrastructure Pricing."* The Asian Journal of Shipping and Logistics 29 (2): 187–206. doi:10.1016/j.ajsl.2013.08.004.

4) Bandara, Y. M., Nguyen, H.-O., & Chen, S.-L. (2016). *Influential factors in the design of port infrastructure tariffs*. Maritime Policy & Management, 43(7), 830–842. https://doi.org/10.1080/03088839.2016.1173735

5) Bjerkan, K. & Seter, H. (2019). *Reviewing tools and technologies for sustainable ports: Does research enable decision making in ports?*. Transportation Research Part D Transport and Environment. 72, 243–260. 10.1016/j.trd.2019.05.003

6) Boerema, A., Van der Biest, K. & Meire, P. (2017). *Towards sustainable port development*. Terra et Aqua. 149. 5-17.

7) Bryant, F.B., Yarnold, P.R., 1995. *Principal-components Analysis and Exploratory and Confirmatory Factor Analysis.*

8) Canbulat, O. (2014). *Sustainable operation management: Green performance criteria for container terminals*.

9) Child, D. (2006). *The Essentials of Factor Analysis*. A&C Black.

10) Chiu, R.-H., Lin, L.-H., & Ting, S.-C. (2014). *Evaluation of Green Port Factors and Performance: A Fuzzy AHP Analysis*. Mathematical Problems in Engineering, 2014, 1–12. 10.1155/2014/802976

11) Cudeck, R., 2000. *Exploratory factor analysis*. Handbook of Applied Multivariate Statistics and Mathematical Modeling, pp. 265–296.

12) del Saz-Salazar, S., L. García-Menéndez and O. Merk (2013)*, "The Port and its Environment: Methodological Approach for Economic Appraisal",* OECD

Regional Development Working Papers, 2013/24, OECD Publishing. ttp://dx.doi.org/10.1787/5k3v1dvb1dd2-en

13) Dinwoodie, J., Tuck, S., Knowles, H., Benhin, J., & Sansom, M. (2012). *Sustainable Development of Maritime Operations in Ports. Business Strategy and the Environment*. 21(2), 111–126. 10.1002/bse.718.

14) Dushenko, M.; Thærie Bjorbæk, C.; Steger-Jensen, K. *Application of a Sustainability Model for Assessing the Relocation of a Container Terminal: A Case Study of Kristiansand Port.* Sustainability ***2019***, 11, *87.*

15) Emas, Rachel. (2015). *The Concept of Sustainable Development: Definition and Defining Principles.* 10.13140/RG.2.2.34980.22404.

16) Gupta, J., & Vegelin, C. (2016). *Sustainable development goals and inclusive development. International Environmental Agreements: Politics, Law and Economics*, 16(3), 433–448. https://doi.org/10.1007/s10784-016-9323-z

17) Hakam, M.H. (2015). *Nordic Container Port Sustainability Performance—A Conceptual Intelligent Framework.* Journal of Service Science and Management. 08(01), 14–23. 10.4236/jssm.2015.8100

18) Henriques, A., & Richardson, J. (2004). Introduction: The Triple Bottom Line does it all add up? In A. Henriques & J.Richardson (Eds.), The Triple Bottom Line does it all add up? Assessing the sustainability of business and CSR (pp. xix-xxii). London: Earthscan.

19) Herath, Gamini. (2018). *Challenges to Meeting the UN Sustainable Development Goals in Sri Lanka. Asian Survey.* 58. 726-746. 10.1525/as.2018.58.4.726.

20) Hinkka, Ville & Porkka, Janne & Fatima, Zarrin & Hyvärinen, Juha & Huovila, Aapo & Morales Fusco, Pau & Martin, Enrique & Soley, Gisela. (2018). *Terminal Planning: The Selection of Relevant KPIs to Evaluate Operations. 10.13140/RG.2.2.31916.92807.*

21) Hlali, Arbia & Hammami, Sami. (2017). *Seaport Concept and Services Characteristics: Theoretical Test. The Open Transportation Journal. 11. 120-129. 10.2174/1874447801711010120.*

22) Hossain, T., Adams, M. & Walker, T. (2019*). Sustainability initiatives in Canadian ports. Marine Policy*. 10.1016/j.marpol.2019.103519.

23) Jedliński, M. (2012), The Polish transport, forwarding and logistic market (TFL) and requirements of Sustainable Economic Development [in:] Witte, H., Jedliński, M., Dichiara R.O. [Eds.], *Sustainable Logistics*, Editorial de la Universidad Nacional del Sur. Edinus, 2012, 107.

24) Jeevan, J., Bandara, Y., & Park G.K., Nguyen, D. & Agupo, R. (2019). *Pollution management at a seaport territory in east coast of peninsular Malaysia: issues and panaceas*. 049-061.

25) Kang, D.; Kim, S. *Conceptual Model Development of Sustainability Practices: The Case of Port Operations for Collaboration and Governance. Sustainability* 2017, *9*, 2333.

26) Kim, S. (2014). *Mega port competitiveness and sustainability practice in container shipping logistics in Northeast Asia.*

27) Kim, S., & Chiang, B. (2014). *Sustainability practices to achieve sustainability in international port operations*. Journal of Korea Port Economic Association, 30(3), 15-37

28) Koralova, P. (2016). *Human Resources Management at Bulgarian Sea Ports Problems and Perspectives for Development. SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.3005379

29) Kotowska, I. (2016). *Policies Applied by Seaport Authorities to Create Sustainable Development in Port Cities*. Transportation Research Procedia. 16. 236-243. 10.1016/j.trpro.2016.11.023.

30) Lee, P., Kwon, O., & Ruan, X. (2019). *Sustainability Challenges in Maritime Transport and Logistics Industry and Its Way Ahead*. Sustainability, 11(5), 1331. 10.3390/su11051331

31) Lim, Sehwa & Pettit, S. & Abouarghoub, W. & Beresford, Anthony. (2019). *Port sustainability and performance: A systematic literature review. Transportation Research Part D: Transport and Environment*. 72. 47-64. 10.1016/j.trd.2019.04.009.

32) Lu, C.-S., Shang, K.-C., & Lin, C.-C. (2016). *Identifying crucial sustainability assessment criteria for container seaports.* Maritime Business Review. 1. 90-106. 10.1108/MABR-05-2016-0009.

33) M. P. A. Perera and B. Abeysekara. (2016). *Defining KPIs to measure eco-sustainable performance at container terminals in Sri Lanka - 2016 Moratuwa Engineering Research Conference (MERCon), Moratuwa, , pp. 315-320, doi: 10.1109/MERCon.2016.7480160.*

34) Melnyk, Steven & Stewart, Douglas & Swink, Morgan. (2004). *Metrics and Performance Measurement in Operations Management: Dealing With the Metrics Maze. Journal of Operations Management.* 22. 209-218. 10.1016/j.jom.2004.01.004.

35) Muangpan, T. & Suthiwartnarueput, K. (2019). *Key performance indicators of sustainable port: Case study of the eastern economic corridor in Thailand.* Cogent Business and Management. 6. 10.1080/23311975.2019.1603275.

36) Munasinghe, Mohan. (2018). *Sustainable Sri Lanka 2030 Vision, Strategic Path and Sustainable Development Goals (SDG).*

37) Notteboom, Theo. (2004). *Container Shipping And Ports: An Overview. Review of Network Economics. 3. 86-106. 10.2202/1446-9022.1045.*

38) Nyenno, Iryna & Nitsenko, Vitalii. (2017). *BUSINESS MODEL FOR A SEA COMMERCIAL PORT AS A WAY TO REACH SUSTAINABLE DEVELOPMENT GOALS. Journal of Security and Sustainability Issues. 7. 155-166. 10.9770/jssi.2017.7.1 (13).*

39) Özispa, N. & Arabelen, G. (2018). *Sustainability issues in ports: content analysis and review of the literature (1987- 2017).* SHS Web of Conferences. 58. 01022. 0.1051/shsconf/20185801022.

40) Özispa, Nergis & Arabelen, Gamze. (2017). *Assessment of Port Sustainability Indicators in The Sustainability Reporting Process.* 10.18872/DEU.df.ULK.2017.022.

41) Rijks, D. & Vizcaíno, Juan & Vellinga, Tiedo & Lescinski, Jamie. (2014). *SUSTAINABLE APPROACH TO PORT DEVELOPMENT CONSTRUCTION*.

42) Rijks, D. & Vizcaíno, Juan & Vellinga, Tiedo & Lescinski, Jamie. (2014). *SUSTAINABLE APPROACH TO PORT DEVELOPMENT CONSTRUCTION.*

43) Schipper, Cor. (2019). *Understanding the sustainable development goal approach for ports of the future.* E-proceedings of the 38th IAHR World Congress September

1-6, Panama City, Panama.

44) Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production, 16*(15), 1699-1710. doi:10.1016/j.jclepro.2008.04.020

45) Shemon, Wahidul & Kadir, Abdul & Hasan, Khandaker. (2019). *Human Resources Competitiveness in Shipping Industry: Bangladesh Perspective.*

46) Tarantola, S. (2005). *Puertos como nodos integrados a la cadena logística. Informe especial: Intermodalismo y Logística Internacional. FCL, Año XI, nº5.*

47) Yap, W. Y., & Lam, J. S. L. (2013). *80 million-twenty-foot equivalent-unit container port? Sustainability issues in port and coastal development*. Ocean & Coastal Management, 71, 13-25.

Others (Not journal articles):

1) *United Nations SDGs & Sea Ports-Assessing Relevance & Finding Opportunities* [Brochure]. (2017). Retrieved from: http://www.sprottplanning.com/pdfs/2017-12%20SDG%20brochure%20outline.pdf

Referred Websites:

1. *http://crossasia-repository.ub.uni-heidelberg.de/4077/1/sai-paper3.pdf*
2. *http://www.imo.org/en/MediaCentre/HotTopics/Documents/IMO%20SDG%20Brochure.pdf*
3. *http://www.portopia.eu/wp-content/uploads/2016/07/Vincent-F.-Valentine-UNCTAD.pdf*
4. *http://www.portopia.eu/wp-content/uploads/2016/07/Vincent-F.-Valentine-UNCTAD.pdf*
5. *http://www.sprottplanning.com/pdfs/2017-12%20SDG%20brochure%20outline.pdf*
6. *http://www.statistics.gov.lk/sdg/application/publications/book.pdf*

7. *https://aapa.files.cms-plus.com/PDFs/08HARBORS_Goldman_Matt.pdf*
8. *https://maritimecyprus.files.wordpress.com/2019/07/imo-and-the-sustainabe-development-goals.pdf*
9. *https://ppp.worldbank.org/public-private-partnership/sector/transportation/ports*
10. *https://safety4sea.com/cm-shippings-critical-role-in-meeting-many-of-the-un-sdgs/*
11. *https://sdgs.un.org/goals*
12. *https://sustainabledevelopment.un.org/content/documents/10364Velasco.pdf*
13. *https://sustainabledevelopment.un.org/content/documents/1684SF_-_SDG_Universality_Report_-_May_2015.pdf*
14. *https://sustainabledevelopment.un.org/content/documents/195532018_background_notes_SDG_7Final1.pdf*
15. *https://sustainabledevelopment.un.org/content/documents/19677FINAL_SriLankaVNR_Report_30Jun2018.pdf*
16. *https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf*
17. *https://sustainabledevelopment.un.org/post2015/transformingourworld*
18. *https://sustainableworldports.org/wp-content/uploads/wpsp-declaration.pdf*
19. *https://unctad.org/meetings/en/Presentation/ditc-ted-25042017-OceansHK-Panel%203A%20-%20LU%20_%20YIP%20-%20Sustainability%20in%20Shipping.pdf*
20. *https://unctad.org/meetings/en/SessionalDocuments/webdtltlb2013doc1_en.pdf*
21. *https://unstats.un.org/sdgs/files/report/2017/thesustainabledevelopmentgoalsreport2017.pdf*
22. *https://unstats.un.org/sdgs/report/2019/The-Sustainable-Development-Goals-Report-2019.pdf*
23. *https://www.brisdgs.org/sites/default/files/inline-files/Presentation%20Sri%20Lanka_National%20Workshop_8.08.2019%20-%20Ganga%20Tilakaratna.pdf*
24. *https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/statistics/otherpub/ess_2020_e.pdf*

25. *https://www.espo.be/media/Annual%20Report%202018-2019%20FINAL.pdf*
26. *https://www.globalgoals.org/15-life-on-land*
27. *https://www.ilo.org/ilostat-files/Documents/Guidebook-SDG-En.pdf*
28. *https://www.local2030.org/library/529/The-Contributions-of-Marine-and-Coastal-Area-Based-Management-Approaches-to-SDGs-and-Targets.pdf*
29. *https://www.local2030.org/library/529/The-Contributions-of-Marine-and-Coastal-Area-Based-Management-Approaches-to-SDGs-and-Targets.pdf*
30. *https://www.oecd.org/greengrowth/45312720.pdf*
31. *https://www.portstrategy.com/news101/port-operations/planning-and-design/un-sdgs-to-be-adopted-by-ports*
32. *https://www.porttechnology.org/news/terminal_drones_game_changing_or_hot_air/*
33. *https://www.un.org/depts/los/global_reporting/8th_adhoc_2017/Technical_Abstract_on_the_Ocean_and_the_Sustainable_Development_Goals_under_the_2030_Agenda_for_Susutainable_Development.pdf*
34. *https://www.un.org/sustainabledevelopment/development-agenda/*
35. *https://www.undp.org/content/dam/undp/library/corporate/brochure/SDGs_Booklet_Web_En.pdf*
36. *https://www.unescap.org/sites/default/files/7_Sri%20Lanka%20BRI%20and%20SDGs.pdf*
37. *https://www.unescap.org/sites/default/files/publications/bulletin87_Fulltext.pdf*
38. *https://www.unescap.org/sites/default/files/UN%20and%20SDGs_A%20Handbook%20for%20Youth.pdf*

BIBLIOGRAPHY

- A diversified port. Port de Barcelona (2012). http://www.portdebarcelona.cat/cntmng/d/d /workspace/SpacesStore/26d9a368-1c1f-4636-b8d4-60d12be27607/111209_DossierEN_2012.pdf.
- Acciaro, M., Ghiara, H., & Cusano, M. I. (2014). Energy management in seaports: A new role for port authorities. Energy Policy, 71, 4-12.
- Darbra, R.M., Pittam, N., Royston, K.A., Darbra, J.P. and Journee, H. (2009) Survey on Environmental Monitoring Requirements of European Ports. *Journal of Environmental Management*, 90, 1396-1403.
- Darbra, R.M., Ronza, A., Casal, J., Stojanovic, T.A. and Wooldridge, C. (2004) The Self Diagnosis Method: A New Methodology to Assess Environmental Management in Sea Ports. *Marine Pollution Bulletin*, 48, 420-428.http://dx.doi.org/10.1016/j.marpolbul.2003.10.023
- ESPO (2005) Environmental Code of Practice. ESPO, Brussels
- Green Port of Hamburg - Combining economic growth and sustainability. *New European Economy*, http://www.neweuropeaneconomy.com/topstories/363-green-port-of-hamburg-combining-economic-growth-and-sustainability.
- Kerr, K. (2011). Signing-up for new index could bring cheaper tonnage dues at ports. Lloyd's Loading List, http://www.lloydsloadinglist.com
- Klopott, M., (2009). Cooperation in supply chains, Logistics, 4, 25 [in Polish]
- Port competition and Hinterland Connection. Joint Transport Research Centre, Round Table, 10-11 April 2008, Paris, Discussion Papier No. 2008-19, October 2008.
- Puig, M., Wooldridge, C., & Darbra, R. M. (2014). Identification and selection of environmental performance indicators for sustainable port development. *Marine Pollution Bulletin*, 81(1), 124-130.

APPENDIXES

APPENDIX 01 – Questionnaire 1 for Sample I

APPENDIX 02 – Questionnaire 2 for Sample II

APPENDIX 03 –AMOS First Output of First Run [SAMPLE II]

APPENDIX 04 –AMOS Second Output of Second Run [SAMPLE II]

APPENDIX 05 – AMOS Final Successful Output-Third Run [SAMPLE II]

APPENDIX 06 - Amos Final Successful Output-Third Run [SAMPLE II]

APPENDIX 07 - Amos Output for Benchmarked Model's Model Fit Analysis [SAMPLE II]

APPENDIX 08-Results of Paired Sample t-test

APPENDIX 09-Expanded Conceptual Framework

APPENDIX 10-Results of Independent Sample T-test

APPENDIX 11-Bivariate analysis for each SDG's three indicators

APPENDIX 12-Solutions & Strategies for Sustainability Challenges extracted from journal articles

APPENDIX 13-Indicator Variables considered for each SDG

ANNEXES

ANNEX 01 – United Nations SDGs & Seaports [Brochure] (2017) – Assessing Relevance & Finding Opportunities by http://www.sprottplanning.com/