**Sustainable Port Operations: Identifying Barriers in Aligning to Sustainable Development Goals: The Case of the Port of Colombo**

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**INTRODUCTION**

The term “sustainable” as a broadly used term, consists of three dimensions: economic environmental, and social and, which are known as triple bottom lines of the concept of sustainability. United Nations (UN) Member States adopted the 2030 agenda for achieving Sustainable Development Goals (SDGs) which can be addressed by any industry. Balancing land related to the environmental aspect, balancing labour combined to social aspect and balancing technology according to economic aspect led to the sustainability and the performance of port operations as multifunctional business centres which create value creation and growth of merchant cities[1][2] Sustainable Development Goals (SDGs) published in 2015 are considered as the most profound plan to reach global sustainability by 2015. SDGs provide a holistic view of the concept of sustainable development and it comprises of 17 goals and 169 targets [3]. At present many international efforts are put forward towards achieving SDGs in terms of capacity building, knowledge management, agency level coordination, stakeholder engagement, and active communication within the society [4].

With respect to maritime industry, the preliminary intention of the International Maritime Organization (IMO) 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. Seaports are in the best position to take a lead in sustainable development goals because of the ports’ wide role in the society and their significant contribution to the national and world economy. Now, more than ever ports have begun to incorporate different sustainability practices into their operations because of increasing pressure from regulatory authorities [5]. Yet only a few ports perceive them in terms of SDGs. Paradigms change of sustainability from the triple bottom line to SDGs calls for action for ports to incorporate SDGs into their operations at the policy level. Incorporating SDGs into any field is not an easy task especially due to its complexity and diversity of the global agenda [6]. Let alone applying them in the port sector is quite challenging. The complexity in ports in terms of implementing new tools, discourages ports from reaching their full potential of sustainability [7].

Failure to align ports’ operations with SDGs can damage the business and the reputation of ports. The increasing pressure from shipping lines as they are building their public image as sustainable entities makes port sustainability a mandatory requirement. Moreover, port sustainability in a particular port can be used as an advantageous strategic tool to attract investors and trading partners. Thus, the objectives relating to sustainability also should be a priority among other management objectives like cost and risk reduction [8]–[10]. Economic stability and corporate social responsibility are among the main drivers for sustainability hence, port functions and operations behave as an economic catalyst and international trade’s midpoint [11]. Other driver is the continuation of environmental standards under all rules and regulations [12][1]. Releasing limber water, harmful emissions, waste disposal, noise production and pollution are related to one pillar- environmental [13].

Sustainability in port operations aims the integration of sustainability into all port activities/functions. Earlier it was a side-line management concern. But nowadays, it reflects as a core issue directly related to efficiency and competitiveness [14][11][1]. 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 and clear image on the public related to their broad support. From the business point of view, competitiveness, and attractiveness to shipping lines directly relates to the operational sustainability of a port. 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 and operations. 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 [15].

An adverse effect can result in the environment due to the running process/operations of organizations. 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. Contriving more sustainable maritime operations, decreasing potential risks and emboldening relevant authorities to adhere to sustainability agendas and manage development proposals proactively are the deeds supported by building an accessible generic framework [12]. The incline on the significance of sustainability issues has been increased throughout the decades and ports’ sustainability concept was not studied or researched for 10 years from the beginning of 1987 where the pure concept of sustainability was dawned and the year 2008 is a highlighting year which shows a start-up of the higher rising of several focused studies on sustainability issues of ports [13].

## THE PROBLEM

There is a developing unanimity to fulfil SDGs inside seaports for structuring sustainability based on the Triple Bottom Line (TBL). South Asia which is the region of Port of Colombo has a rivalry based on the sustainability of port operations in each port [1]. Port of Colombo’s operations also has not been aligned to such a sustainability framework including economic, social, and environmental sustainability. Lack of implementation of sustainability 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. Climate change causes the motivational power to adopt sustainable growth policies in maritime port operations. SDGs should relate to KPIs of a seaport. Assorted and adoptable SGDs 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.

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 and 2020 should be compared to find out the development of SDGs at Port of Colombo and what are the barrier to implementation of sustainability practices in the port operation. This paper deals with two objectives; (a) 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 and (b) to identify barrier hindering the port to implement sustainable practice in port operation. Hence, discovering barriers regarding the SDGs implementation in seaports is important because that is the only way to eliminate the barriers in the attempt of encouraging ports to adapt to SDGs.

## GENERAL OVERVIEW OF SDGS

Sustainable Development Goals (SDGs) are comprehensive, far-reaching and people-centred set of universal and transformative goals [16]. 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 “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. 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.

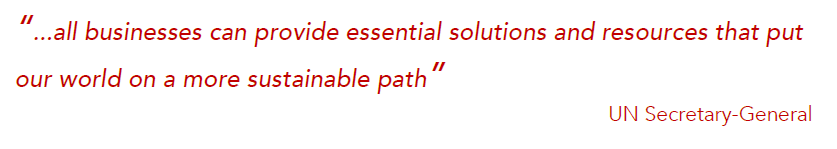




Figure 1-A diagram listing the 17 Sustainable Development Goals [16]

First, SDG is to **end extreme poverty** in all its forms everywhere by 2030. 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 relates to agriculture and health sectors. Ending hunger means establishing food security. Increasing food production, well-functioning markets, and increased incomes for smallholder farmers, similar accessibility for technology and land and additional investments caused a vibrant and productive agricultural sector [16]. Thus, 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 new-borns 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 and achieving the goal of universal primary and secondary education, affordable vocational training, access to higher education are the musts to be done in this regard. 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 childcare and domestic work, and discrimination in public decision-making. 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 [16]. Sixth SDG ensures **availability and sustainable management of clean 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. 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. 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 and 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. 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 [16]. 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). 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. 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. 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 and limiting global warming to 1.5°C is necessary to avoid catastrophic consequences and irreversible changes. 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 kilometre of ocean should be controlled and managed to achieve this SDG. 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 and biodiversity loss. 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 and governments, civil society and communities work together to implement solutions to reduce violence, deliver justice, combat corruption, and always ensure inclusive participation [16]. 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 [16].

## ALIGNMENTS OF SDGS TO MARITIME INDUSTRY

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 Brundtland Conference Report for the World Commission on Environment and Development in 1987. In the wider maritime industry, sustainability has been scrutinized by dividing it into three categories as shipping, maritime logistics, and ports [17]. In the shipping industry, the concept of green shipping is one of the emerging concepts where the key focus is regarding ship emissions. Shipping companies often seek ways to minimize their external costs by optimizing their transport networks and shipping routes [18]. Similarly in the maritime logistics sector, clean trucking programs in ports like long beach and Los Angeles and rail connection at the port of Rotterdam are taking efforts to create a sustainable modal shift in the hinterland connections [19].

Port sustainability has been explored by different researchers in the literature and has been given different definitions. Port sustainability is dealt with the triple bottom line concept of sustainability, and environmental sustainability in port is about providing necessary managerial facilities to mitigate the negative effects of operations like noise pollution, dredging, air, and water pollution [20][21]. Social sustainability has been pointed out as the port’s contribution to the direct and indirect employment, relationships maintained with the community, and liveability condition of the surrounding area. The efficient use of port facilities, the profitability of investments, and the provision of facilities to upgrade the port’s performance have been indicated as the economic aspect of port sustainability.

According to long-term use of port industry’s constructions, technology and 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 and operators must strive to the highest degree to optimize port space and ameliorate productivity. This will circumvent redundant terminal or berth expansion. Optimizing diffusions, upgrading information systems, occupying latest technological machineries and equipment, congruous cargo stacking and rationalizing resources and terminal design can be the recommended measures for such assaying [22]. This is already applied in the selected terminal, the first private public partnership port terminal in Port of Colombo. Environmental issues of container ports give the priority for “air pollution and air quality” within the most important first ten criteria for green container terminals and 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 [23].

The economies of scale resulted from much larger capacity of maritime transport than other modes of transport cause a lower social harmfulness of maritime transport [15]. Sustainability does not connect only with environmental policy but also it connects with the improvement of the welfare of human beings around a port [24][25]. According to economic point of view, the green collaborative activities provide advantages for supply chain members [26]. 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 and brand image leads to efficiency. Thus, depicts that financial, commercial, and marketing and procurement departments of a terminal also should be integrated with port operations in having successful integration regarding economic sustainability. Economic sustainability issues consist of assessment items such as the benefits of port operators, economic activity development, fair competition, infrastructure construction, employment and local development, leisure and tourism and investment [25]. Two factor types affecting for sustainable economic growth; endogenous factors such as an increase in labor efficiency, employees’ knowledge and experience and investment layouts and exogenous factors such as resource segregation changes in economy, legal regulation changes, cultural and social changes, access to natural resources [27]. The third dimension, “social sustainability” relates to population, port accessibility, security and safety, neighbouring interaction, communication, increasing awareness and participation of the public and engagement of stakeholders in developing port sustainability because they are the most relevant assessment items [25]. Provision of greater amount of direct employment, indirect employment and induced employment opportunities generate appreciable social benefits which cause economic growth as well [28]. In addition, 34-expert based port sustainability indicators based on social construction of technology extracted by local legislators and residents were proposed [29]. The highest ranked social issue is related to employee job security and job safety and followed by others which are deeming environmental protection when doing port operations, providing facilities to economic activities, preventing port traffic accidents and ensuring cargo handled safely and effectively [24]. Besides, the least ranked sustainability factors are mitigating light influence on neighbouring residents, deeming the arrangement of vehicles under construction of port transportation system, avoiding using unpolluted land in port area, hiring minority groups and consulting interest groups when creating port projects. Four sustainability assessment factors identified are economic issue, environmental practices, social concern and environmental material which are in a descending order relevant to the container port sustainability assessment context in Taiwan [24].

Common port environmental indicators include areas such as ballast water discharge, sediment quality, water purification, dredging, energy consumption, erosion, emission of greenhouse gases, biodiversity loss, and habitat destruction. Further, key environmental indicators as waste, water consumption, noise, air quality, carbon footprint, and marine ecosystems are also important apart from the above-mentioned indicators [30][31]. Green ports are also in the spotlight of attention at present specifically concerning the environmental sustainability of ports. A port that has taken a substantial amount of work to reduce negative environmental externalities such as emission and energy consumption, and has invested in new technologies to upgrade the environmental performance is on the path of becoming a green port [32]. Green Port Programme(GPP) in Port of Singapore, Vessel Speed Reduction(VSR) in Port of Long Beach and Electrification of Automated Guided Vehicles in Port of Hamburg are examples for such greening efforts that had been taken by Ports in the recent history[33][34].

Port customers seek efficient and cost-effective services. Those expectations cannot be met without carefully scrutinizing the economic sustainability of a port [35]. Economic sustainability has been measured using area productivity such as land reclamations, investments, and market share. Also, port cargo growth, tourism induces by cruise passengers, and port operational efficiency are also indicators of an economically sustainable port [30]. Since port competitiveness is crucial for economical existence, and environmental performance is often scrutinized by regulatory authorities, social sustainability had been given the least priority in past literature [36]. The social sustainability dimension in seaports are mainly divided into four categories as social capital, human capital, fairness, and health [37]. Under them, details such as employment, training, gender equality, occupational health and safety, and labour structure have been focused.

A wide scope of activities and multi-stakeholders involved in the ports have made it is easy to relate to many SDGs. However, only a few studies are focusing on the application of SDGs in Seaports. Application of SDGs on seaports and 24 SDG targets have been selected with a moderate to high appropriateness for seaports. These 24 targets belong to Goals 4,6,7,8,9,11,12,13,14 and 17 of the SDGs [38]. In the year 2018, the International Association of Ports and Harbours (IAPH) launched the World Port Sustainability Program (WPSP) intending to enhance sustainable efforts of ports globally. The primary intention of the WPSP is to set examples for all the ports around the world, by demonstrating sustainability initiatives of leading ports targeting the 2030 Agenda for Sustainable Development [39].

There is not much straight forward research on identifying barriers to implement and achieve SDGs in seaports except for case studies like the port of Klang. A conceptual framework regarding challenges in attaining sustainable development goals concerning the port of Klang highlighted predominant 4 challenges [40]. They are technology, financing, human capital, and suppliers. Under those categories, some of the important views such as lack of talent expertise, poor financial assistance from the government, and bargaining power of suppliers have been discussed. Some research exists concerning certain sustainable practices at ports. Critical barriers to implementing shore power supply in ports include operational barriers like frequency and voltage variations [41]. Apart from them, certain common barriers to any new implementation in ports such as financial difficulty, rigidity in the existing system, poor collaborations and ineffective monitoring process were also identified from different literature [42][43][38].

A main cause for the imbalance of the TBL is global civilization progress [28]. 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 and 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 CO2) to environment. Another transport externality is emission of the gasses (nitrogen oxides and Sulphur oxides) which cause acid rains, haze in air, eutrophication in water (as environmental effects), health issues for human (social effect) and 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. Further SDG assessments can offer a proven and practical approach for transitioning ports towards sustainability master planning, use as clear quantitative KPIs by many ports and coastal areas in the world, construct clear sustainability goals and objectives with stakeholders, ensure that all potentially effective measures towards sustainability transitions in ports are included, be effective and successful if different varieties of validated data are made publicly available, link sustainability achievements to UN-Sustainable Development Goals and be applied to incorporate sustainable goals in port design processes [38].

**SUSTAINABILITY PRACTICES IN PORT OPERATION IN THE PORT OF COLOMBO PORT (PoC)**

To address the objective (a), a questionnaire was developed, and data were gathered from both operational and management level port employees (n=182). Hypothesis testing and paired sample t-test were performed. Analysis results indicated that PoC is only aligned with 9 SDGs out of the 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 and 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 and Affordable-clean energy) which is specified for sustainability of PoC was derived using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) and Model Fit Analysis.

The respondents’ profile was scrutinized through descriptive statistics. There were 3 categories of respondents based on the working organization. The highest respondent category was private terminal operators which took a value of 44%. The second highest portion of the respondents was from the regulator, or in other words port authority. The remaining were from the government terminal operator. Also, respondents’ position in the company was questioned in the survey. Predominantly respondents were from four types of positions and the executive level respondents were rejected in the analysis due to the criteria demarcation of the sample as managers in the port sector. 43% of the respondents were from the middle management while 18% of the respondents belong to the top management in port organizations. In terms of the years of experience, 49% of the respondents have been in the port sector for more than 10 years. This is a fair indication of the credibility of respondents’ perceptions of existing barriers. Because it is more likely for more experienced managers to have a solid understanding of the deterrents in achieving port sustainability.

Table 1 Port operation practices related to SDGs.

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

To address objective (b), a questionnaire was developed, and data were gathered from 55 port managers from 2 international ports (Port of Colombo and Hambantota International port) in Sri Lanka. The research identified 20 barriers from the literature review and structured interviews with 4 port managers. The descriptive statistics of the barriers are shown in Table 2.

Table 2: Descriptive Statistics of barrier to implement sustainability practice in seaports.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Barriers | Mean | Std. Deviation | Skewness | Kurtosis |
| Not having a specified port sustainability framework to be followed | 4.12 | 1.07 | -1.26 | 1.21 |
| Absence of a central body to guide ports | 3.94 | 1.12 | -1.12 | 0.87 |
| Poor collaboration between the port regulator and other public institutions | 3.71 | 0.94 | -0.40 | -0.63 |
| Not having a clear-cut responsibility among stakeholders | 3.43 | 1.08 | -0.06 | -0.89 |
| Absence of accountability tracing directives and tools | 3.41 | 1.08 | -0.90 | 0.39 |
| Outdated regulatory and legal framework | 4.04 | 0.72 | -0.39 | 0.07 |
| Lack of progress in the technology adaption | 4.06 | 0.81 | -0.58 | -0.06 |
| Power of unions | 3.78 | 0.99 | -0.46 | -0.73 |
| Insufficient financials | 3.27 | 0.94 | -0.32 | -0.70 |
| Huge regional competition | 3.16 | 0.90 | -0.32 | -0.09 |
| Deficient sustainability knowledge of management | 3.61 | 0.98 | -0.31 | -0.27 |
| Perspective about sustainability as a non-mandatory costly endeavour | 3.51 | 0.86 | -1.02 | 0.50 |
| Other stakeholders not pursuing sustainability makes it difficult for the port | 3.92 | 0.94 | -0.30 | -0.98 |
| Existing limited capacity in the port | 2.69 | 0.99 | -0.04 | -0.59 |
| Lack of flexibility to change existing business models | 3.43 | 1.24 | -0.63 | -0.40 |
| Not having a learning culture inside the company | 3.37 | 1.26 | -0.70 | -0.55 |
| Commercial principles in the port are not aligned by data-driven decisions | 3.55 | 1.03 | -0.25 | -1.05 |
| Weak collaborations with shipping lines and international bodies | 3.25 | 1.09 | -0.53 | -0.12 |
| Fragmented policy framework regarding sustainability | 3.92 | 0.74 | -0.18 | -0.40 |
| Loosely enforced rules in the region | 3.82 | 0.56 | -0.80 | 1.90 |

Using EFA the relevant barriers were derived. Cronbach's alpha test was run to each factor to check the internal consistency of variables in a specific factor. All factors reported Cronbach's alpha values above 0.7 [44]. Thus, all extracted factors are reliable. Table 3 indicates the extracted barriers from the Exploratory Factor Analysis and Table 4 displays the output of Cronbach's alpha test conducted using SPSS.

Table 3: Significant barriers grouped in to four factors to implement sustainability practices in seaports.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Deficient Collaborative Policies | | Structural and Managerial Constraints | | Market Constraint | | Absence of an Established Framework | |
| Weak collaborations with shipping lines and international bodies |  | Outdated regulatory and legal framework |  | Insufficient Financial capability |  | Absence of a central body |  | |
| Lack of flexibility to change existing business models |  | Power of unions |  | Limited capacity inside the port |  | Poor collaboration between port regulator and other public institutions |  | |
| Fragmented policy framework regarding sustainability |  | Disconnected stakeholders |  | Huge regional competition |  | Absence of a port sustainability framework |  | |
| Poor learning culture inside port organizations |  | Perspective about sustainability as a non-mandatory costly endeavour |  | Inadequate alignment of commercial principles with data driven decisions |  | Loosely enforced rules in certain regions |  | |
| Absence of accountability tracing directives and tools |  | Non-existence of a clear-cut responsibility among stakeholders |  | - | | - | |
| - | | Deficient Sustainability knowledge of the management |  | - | | - | |

Table 4: Reliability Test Results of Factors

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Cronbach’s Alpha | Cronbach’s Alpha Based on Standard Items | N of Items |
| Deficient Collaborative Policies | 0.885 | 0.887 | 5 |
| Structural and Managerial Constraint | 0.826 | 0.838 | 6 |
| Market Constraint | 0.801 | 0.801 | 4 |
| Absence of an Established Framework | 0.742 | 0.748 | 4 |

Sustainability understanding of port managers was examined from the open-ended questions. Word frequency analysis conducted using NVivo 12 software and the word cloud presented in Figure 2 were derived.

Figure 2: Word Frequency Analysis

**DISCUSSION AND POLICY RECOMMENDATIONS**

Since numerous policies affect port operations, port sustainability cannot be the responsibility of one organization alone. Further, having dedicated an entire goal for the collaborations (Goal 17) proves the importance of different means of partnerships for the implementation of SDGs. When individual organizations take efforts in isolation, there is a high chance to occur contradictions with each other. Hence unanimous understanding among policymakers is essential for the success of port sustainability. Ports are perceived as strategic assets of a country, hence more often government is involved in the decision making at the policy level [35]. However, this might vary upon the management model of the port because port management is affected by the ownership model, regulatory frameworks, and administrative models. Nevertheless, having deficient collaboration among policymakers can deter the adoption of SDGs in any port.

The second identified set of barriers is the structural and managerial constraints of a port. This includes managing stakeholders and defining their responsibilities precisely. Moreover, a proper management structure should be able to maintain a good relationship with employees to avoid any adverse consequences from highly powered unions. The other key managerial constraint is the management’s perception and knowledge about port sustainability. Even though respondents were reluctant to admit that as a barrier, the answers for open-ended questions revealed their awareness regarding port sustainability is not at an acceptable level. Also, outdated legal and regulatory frameworks act as a structural barrier when keeping pace with the highly volatile industry. Thus, assurance of the managerial and structural agility enhances the implementation of SDGs in seaports.

The third factor unveils the market constraints that deter the implementation of SDGs in seaports. Market constraints including limited capacity and insufficient financials to invest in costly sustainable initiatives like renewable energy. Further, market constraints like regional competition discourage ports to impose strict regulations on sustainability. Unsound commercial decisions which are isolated from data and statistics also negatively affect port sustainability. On the contrary, most of the research has mentioned about the ways of incorporating marketing position to stimulate port sustainability [45]. There is not any mention about the market constraints like competition discouraging port sustainability in certain regions.

Absence of a globally established framework for port sustainability was also identified as a barrier. Even though, International Association of Ports and Harbours (IAPH) recently established the World Port Sustainability Program (WPSP) as an effort to integrate SDGs to Seaports, the global approach of such programs is very minimal. Further, there is a vast disparity among different regions in terms of their ports’ contribution to SDGs.

Apart from the significant barriers, understanding of the concept port sustainability of port managers was also examined from the open-ended questions in the survey. In the word frequency analysis, prominent words like “economic, environmental and social” imply that managers have a basic understanding of port sustainability. Also, words like efficiency, operations, and customers have been frequently mentioned. There is a possibility that this indicates an over-emphasis on economic sustainability. This tendency has also been revealed in previous research that port decision-makers are overly focused on short term economic goals rather than long term sustainability benefits [46].

When investigating the other barriers using thematic analysis, two main themes that were not covered from the questionnaire were prompted. They are attitude towards sustainability and undue political influence from the governments. A similar idea has been divulged that attitude towards sustainability differs from country to country and hence political partisanship changes accordingly regarding sustainability-related matters [47].

All four identified barriers may apply to any country, irrespective of their region, the size, or the development state of the country. All those barriers are man-made barriers and any port that faces the above barriers find to implement SDGs. Deficient collaborative policies and managerial constraints can be removed from an individual port level while the absence of an established SDG framework for ports needs to be addressed at the global level. Certain market constraints like extensive regional competition that are common to the region cannot be easily removed at the individual port level. There are success stories of ports like Port of Gothenburg and Port of Uslan that have eliminated these barriers to a greater extent and have adopted SDGs [48]. Elimination of these barriers is possible and that would lead all ports to be more efficient, environmental, and people-centric ports. The adoption of SDGs is more likely to reduce port costs in the long run and will create more equality among ports throughout the world.

All the three terminals of port of Colombo should work to adopt and increase performance or availability of undeveloped SDGs from 2015 to 2020. They are Clean Water and Sanitation facilities and Decent Work and 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 and modern financial analysis tools 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 fully automation at least in a part of port and 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, low emission locomotives and 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 and dust particles emit into atmosphere around port and 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.

The following sustainable strategies/solutions listed in Table 5 can be benchmarked by PoC which were explored from the researched literature.

Table 5 - Sustainable strategies/solutions for consideration by port of Colombo

|  |  |
| --- | --- |
| **Solution/Strategy** | **Example ports** |
| Environmental Management Systems (EMS) to implement regulations and policies for environmental issues |  |
| Eco Management Scheme and Audit Scheme (EMAS) |  |
| Emission Control Area (ECAs) |  |
| Self-Diagnosis Method (SDM)- Identify environmental risks and establish priorities for action and compliance |  |
| Speed Reduction Program - slowing down ships that can reduce emissions and pollution via using less fuel oil and port should serve the ships entering their speed restriction zone appropriately. | Los Angeles, Long Beach, San Diego |
| Vessel Main Engine Fuel Incentive Program -to use low sulphur fuel at the distance of 20 or 40 nautical miles from the port and port can cover the fuel price difference |  |
| Planning to replace the IC-powered automated guided vehicle (AGV) with electric vehicles | Hamburg |
| Diesel engines replaced by electric or hybrid diesel-electric ones or use biofuels and replacement of diesel to electric Automated guided vehicles (AGV) | Hamburg |
| Strategic overview of environmental aspects (SOSEA) – guide ports in gathering information to manage liabilities and responsibilities |  |
| Emission control areas (ECAs) sea areas in which stricter controls are established to minimize airborne emissions from ships as defined by Annex VI of the 1997 MARPOL |  |
| 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 |  |
| Eco-management scheme and adult scheme (EMAS) –promote on-going improvements/ improve environmental performance |  |
| Cold ironing (or “shore connection”) supply ships at berth in feeding points close to the mooring sites so that the diesel electric generators can be switched off and no exhausts are delivered during ship stay (electrical service connection even for barges, RO-RO vessels, cruise/ ferries) | Goeteborg, Lubeck, Kemi, Oulu, Zebruuge, Antwerp, Hamburg |
| Restrictions to the access in ports for old pollutant vehicles; |  |
| Restrictions to the speed of ships and road vehicles in port areas |  |
| The European EcoPorts framework |  |
| Building mega-ships and mega-container terminals to benefit from the economy of scale |  |
| Provision of financial incentives for vessel owners whose ships pollute port environment to a lesser content comparatively than others (to reduce pollution and greenhouse gas emissions) | Le Havre, Bremen, Hamburg, Rotterdam,Amsterdam, Antwerp |
| Introducing a system of port dues discounts awarded to ship owners depending on emission levels of their ships (granting based on Environmental Ship Index (ESI) to reduce pollution and greenhouse gas emissions) | Los Angeles, Long Beach, San Diego, Hamburg(HPA),Antwerp, Rotterdam, Amsterdam |
| Benchmarking the Clean Air Action Plan (which has been practiced by several ports outside Europe – San Pedro Bay Ports: Los Angeles, San Diego and Long Beach) |  |
| A ban on entry to port for vehicles with high emissions | Clean Trucks Program in , Los Angeles, Long Beach, San Diego |
| Increment of port fee for trucks in peak hours to reduce traffic congestion (benchmark Clean Trucks Program ran in San Pedro Bay ports; entry restrictions for vehicles based on year of manufacture) | Los Angeles, Long Beach, San Diego |
| Usage of engines with solid particle filters | Hamburg |
| Modal Shift strategies (From Road to Rail, Road to Inland Waterways, Road to Air) | European Ports, Poland Container Terminals |
| Identification of EPIs for Sustainable Port Management |  |
| Energy Efficient Plans |  |
| Adhere with IMO2020 Sulphur Cap Rules and Regulations |  |
| Usage of very low sulphur (0.05%) fuel oil by berthing and anchoring ships at port | EU ports under Directive 2005/33/EC |
| Charging extra fee for handling only the containers which were brought to terminals by road vehicles in peak hours (if there's another accessible mode and to increase nighttime container handling, an extra fee can be used to compensate additional operating and labor costs etc.) | PierPass Program of Ports of Los Angeles and Long Beach |
| Adopting port infrastructure for bunkering LNG fuel | Göteborg |
| Conducting Eco-partnership programs |  |
| Trying start a terminal which will only use renewable energy | HHLA Container Terminal in Altenwerder |
| Reorganizing port infrastructure with modal shift solutions, organizational and legal measures and etc. (If need, port connected hinterland transport structural changes also) | Rotterdam |
| Plan to start inland intermodal operating company (PPP/ Private/ Fully Gov. owned) | Hamburg, Barcelona |
| Changing PPP/lease agreements with existing terminals requiring them to increase environmentally friendly and other sustainable actions | Rotterdam |
| Operational integration with other Inland Ports | Le Havre |
| Improving the quality of barge handling with new IT systems (benchmark Barge Transport System in the port of Antwerp) | Rotterdam, Antwerp |
| Construction/Separation of dedicated barge terminals | Rotterdam |
| Improving IT Platform like ASYCUDA (in Sri Lanka) for all port users |  |
| Measuring KPIs to support sustainable management and competitiveness (benchmarking the proposed conceptual intelligent framework for Nordic container ports) [use of ERP systems and using RFID data or sensors data can be utilized for this kind of a project] | A proposed conceptual intelligent sustainability performance management framework for Nordic container ports (Narvik container port) |
| Following and absorbing the guidelines, reports and survey results of well-known international bodies like ESPO (European Sea Port Org.) and PEARL (Port Environmental information collector project) | European Maritime Ports |

Source: Based on [49] [50][51][15][52]

**CONCLUSION**

This paper showed that Port of Colombo has been aligning only with 9 SDGs out of the most relevant 11 SDGs. All the 8 Core SDGs has been developing during the period from 2015 to 2020. Factor analysis combined with EFA and CFA and Model Fit Analysis supported with positive results. Finally derived model/framework related to 4 SDGs out of the concerned 11 SDGs, and it is specialized for SL context only. Life below Water, Industry Innovation and infrastructure, Good Health and Well-being and Affordable and Clean Energy are the main SDGs which are mostly focused by PoC.

The literature explored was sufficient to extract sustainability challenges in maritime logistics and shipping Industry and the suitable strategies to mitigate the above challenges. Since the introduction of SDGs in 2015, every sector is attempting to incorporate SDGs into their strategic plans. Even though sophisticated sustainability measures such as shore power supply and port community systems are in place in developed countries, in other parts of the world incorporation of SDGs into port operations is very minimal. The paper also found that significantly four factors act as barriers in this regard. According to the research findings, deficient collaborative policies, structural and managerial constraints, market constraints, and the absence of an established global framework deter implementation of SDGs in seaports. Deficient collaborative policies imply contradictory policies that affect port sustainability negatively. While it is mandatory to perceive collaborations with all port stakeholders in the vision of promoting overall sustainability, it is equally important to have a unanimous policy regarding port sustainability. The research also found that structural and managerial components are capable of negatively affecting the port’s ability to adopt SDGs. Here the word “structure” implies the composition of the private entities, regulatory bodies, and other service providers inside a port and the word “management” imply the decision-makers of those entities that have the power to decide the success or failure of port sustainability. Market constraints mainly indicate the port’s limited financial capability and regional competition. Investing in sustainable efficient infrastructure like LNG terminals requires financial capability. And extensive regional competition can act as a marketing constraint. Having a mutual agreement in every region is vital concerning their policy towards port sustainability. The last identified barrier is the absence of an established framework that has the power to suppress the chances of ports embracing SDGs. There should be a sustainable guideline for ports depending on the size, location, region, and type of operations. Moreover, there should be a central body that is dedicated to port sustainability and regular communication should happen between the port and the central body. Apart from the above factors research revealed that the overall attitude towards sustainability in a particular country largely affects the sustainability of ports in that country.

There are several limitations to this research. Due to the unavailability of data inside the port regarding sustainability indicators, the research relied on the perception of port managers in Sri Lanka. Further, due to the limited number of managers who are aware of and involved in port sustainability, the sample size of the survey could not be increased as initially expected. By overcoming the above limitations, future research can be conducted in the following areas. Exploring the capabilities of ports to overcome the barriers and examining the underlying reasons for the existing regional disparities in port sustainability. Another timely research topic would be to explore how particular types of ports could incorporate SDGs into their daily operations and master plans without generalizing the type of ports.

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