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Emissions control investment policy for the 2020 sulphur cap implemented by Port of Gothenburg as a model for the Port of Mombasa

Luis M. Colmenares

Wachira W. Margaret

WORLD MARITIME UNIVERSITY
Malmö, Sweden

EMISSIONS CONTROL INVESTMENT POLICY FOR THE 2020 SULPHUR CAP IMPLEMENTED BY PORT OF GOTHENBURG AS A MODEL FOR THE PORT OF MOMBASA.

By

LUIS MIGUEL COLMENARES (Venezuela)

MARGARET WANJIKU WACHIRA (Kenya)

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DECLARATION

We certify that all the materials in this dissertation that is not our own work have been identified and that no material is included for which a degree has previously been conferred on us.

The contents of this dissertation reflect our own personal views, and they are not necessarily endorsed by the University.

Name 1: Luis Miguel Colmenares

Signature: ________________

Name 2: Margaret Wanjiku Wachira

Signature: ________________

Date:

Supervised by: Dr. Fabio Ballini (Ph.D.

Assessor:

Institution/Organization: World Maritime University

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ABSTRACT

Title of Dissertation: **Emissions Control Investment Policy for the 2020 Sulphur Cap Implemented by Port of Gothenburg as a model for the Port of Mombasa.**

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This Research paper examines the investments in infrastructures implemented by the Port of Gothenburg and Stena Line as a port operator in order to comply with low Sulphur limits regulation introduced in the SECA's on 1st January 2015 as a benchmark for the Port of Mombasa in readiness for the IMO 2020 global regulatory Sulphur limits in fuel oil used onboard ships.

The researchers specifically analyzed four key SECA compliance activities in the SECA regions undertaken by ports in the Baltic Sea regions in order to investigate the decisions and outcome of infrastructural policies made by the port of Gothenburg to comply with low Sulphur limits regulation of 0.1% effective from January 2015.

Qualitative tools were used for the collection, assessment and analysis of the data and collected from the port of Gothenburg, Stena Line, Kenya Ports Authority and MTCC-Africa through extensive desktop research, interviews and by use of questionnaires. The data was analyzed by use of KPI's analysis for the port of Gothenburg, SWOT analysis for Stena Line and PESTEL analysis for the port of Mombasa in order to evaluate the current situation for both ports, determine infrastructure requirements as well as aid in appropriate investment policies and measurement of outcomes for policies undertaken by the port of Mombasa to achieve the required level of readiness for the 2020 Sulphur Cap.

A discussion was undertaken to analyze and link the result of the analyses made in coming up with possible solutions for the port of Mombasa. Finally, recommendations were made upon completion on the effective control mechanisms and necessary actions on the port of Mombasa to ensure compliance and consistency in the implementation of IMO 2020 Sulphur Cap.

Keywords: KPIs, SWOT, PESTLE, Benchmark, 2020 Sulphur Cap, Investment, Policy, Infrastructure, Cold Ironing, Tax Incentives, SECAs, Emissions, Port of Mombasa

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1.0. INTRODUCTION

1.1. Background

Seaborne trade is very essential to the ever-growing global economy and provides the most cost-effective means for the transport of large quantities of goods over large distances as compared to other means of transport. Over 80% of international trade by volume is carried by sea thereby making seaborne trade as the key platform to global trade development (UNCTAD, 2017). In its assessment, the IMO Port Emissions Toolkit 1 describes maritime ports as the main hubs of economic activity globally and which are majorly located at the vicinity of densely populated regions.

However, despite enormous development of the shipping sector in the past century, pollution prevention from a global perspective has been focusing more on the marine shipping sector while least attention being drawn on the port sector. However, port sector has been driven to understand the magnitude of impact due to emissions from ship operations globally and to develop strategies for emission reduction (Stiglitz, 2006).

Over the last century, the growth and development of the maritime sector has received a lot of attention due to the substantial effects of pollutants released to the environment. According to the third IMO GHG in 2014, international shipping is responsible for the emission of approximately 12% and 13% of global sulphur dioxides (SOX) and nitrogen oxides (NO2) respectively on an annual basis. Ships emissions cause acidification and eutrophication to the environment by forming poisonous compounds that cause lung infiltration, blood poisoning, heart failure and consequently premature death (Alcamo et al., 1987; Corbett & Farrell, 2002; Cullinane & Bergqvist, 2014).

Emissions in the port areas and cities only account for a small portion of the total ship emissions mainly during cruising, maneuvering and hotelling. However, they are the most noticeable portion for shipping emissions which pose harmful health effects to the people living along these coastal areas, and thus ought not to be ignored nor undermined (Jiang et al.2014).

The clean shipping vision was established to ensure greener maritime transport (Stipa,2013). This is to be achieved through the development of newer technologies and change of behaviour across all maritime stakeholders (Stipa, 2013). The integrated approach on clean shipping focusses on ships that are allowed in ports with near nil emission targets, ports that are efficient, competent and equipped with the necessary facilities that are environmentally friendly for clean shipping and cargo with appropriate footprint and whose owners incorporate environmental issues in their decision making processes (NSF 2008).

These efforts are also in line with the Europe 2020 objectives for sustainable growth (Prause,2014a). As a result, shipping was no longer allowed as usual and international legislation became strengthened. This policy particularly focused on a reduction of the sulphur content in marine fuels expressed in terms of %m/m(mass). The International Maritime Organization (IMO) established an international legislation on shipping by taking a landmark decision of implementing a limit of sulphur emissions in the non-SECA areas worldwide from 3.5% to 0.5% sulphur limit for marine fuel oil used as bunkers for ship operations under regulation 14.1.3 of the MARPOL Convention Annex VI and other soft law instruments such as the Initial IMO Strategy on reduction of GHG emissions adopted in April 2018 (IMO, 2018).

The main concern of IMO for reducing sulphur content in marine fuel oil is the adverse effect on human health. High sulphur fuel consists of condensed hydrocarbons and sulphur compounds, which are potentially hazardous (IMO, 2014; 2016; EU, 2015). Annex VI of the Convention also covers the provisions which allow for the establishment of specific Sulphur Emission Control Areas (SECAs) specifically located in the Baltic Sea, North Sea, North American and the United States Caribbean Sea (IMO, 2018a). The SECA area comprises about 0.3% of the world’s waters (Notteboom, 2010). The SECA areas have more stringent controls that have reduced the allowed sulphur content to 0.1% since 1st January 2015.

However, for vessels operating in the European Union ports, the limit was introduced in the year 2010 (European Parliament, 2016). Figure 1 indicates the global sulphur limits that have been implemented as from July 2010 as well as the limit areas.

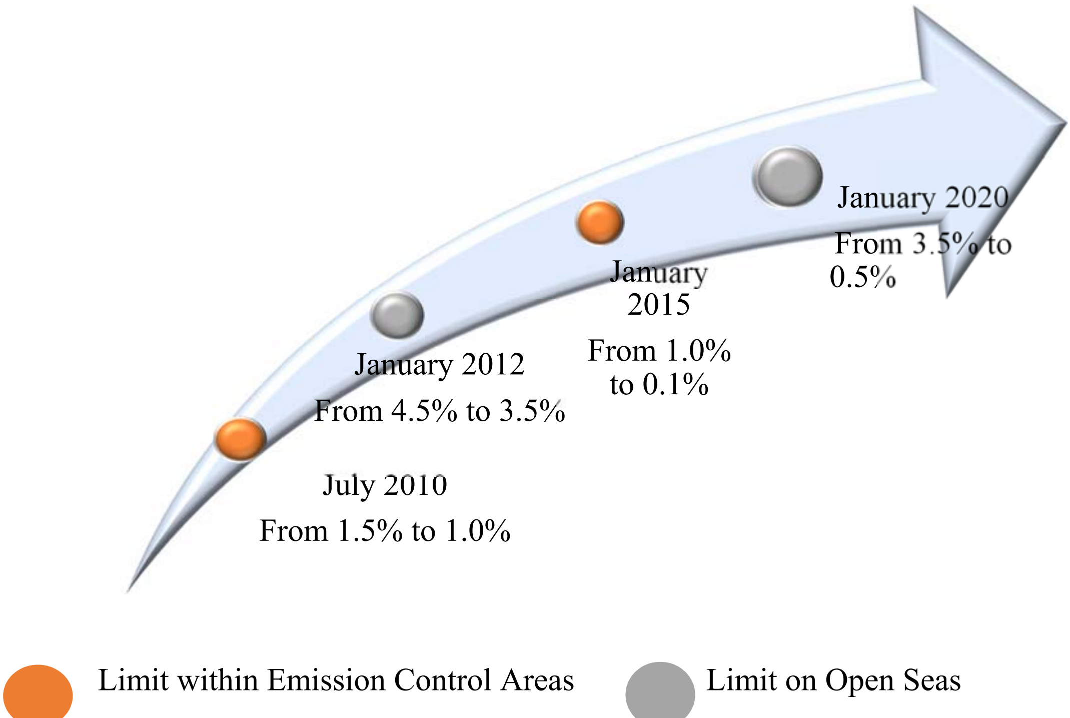


Figure 1:Global Marine Sulphur Limits(Author 2019)

Efforts made worldwide to establish guidelines related to secure social relationships of production with minimum impacts on the environment are also in line with Sustainable Development Goals (SDG's) 7,13 and 14, which are linked to this research as a framework to understand the impact of the 2020 Sulphur Cap regulation compliance. It also calls for cooperation between the States, their Governments, private companies, collectives, and individuals to participate in the Global Governance of the Seas.

Ports are very vital in the logistics chain processes. They are central hubs for the globalized and complex global logistics network which provide interconnections between regions and countries where they are located, thereby facilitating trade and enabling effective communication, resources and people. Ships generate emissions at sea while maneuvering in and out of the ports and at berth. The main concern with emissions of pollutants by ships while at sea is the release of poisonous gases that can harm the environment as well as the crew on board the ship.

However, while at closer proximities to the ports, the major concern is the quality of water and the negative impacts on people's health, while at the port areas and within the port cities (Cullinane & Cullinane, 2013). Ships generate about 55-57% of total emissions to the environment while at the ports (Hulscote & Gon,2010).

The European Union has taken effective measures in the control of emissions from ships by implementing Directive 2012/33/EU of the European Parliament of 21 November 2012 and the Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 related to marine fuel consumption, sulphur content in it, implementation of Cold Ironing in the European ports and setting of SECAs in the North and Baltic Seas, with a maximum of 0,1% of Sulphur content in the marine fuel consumed by vessels in these areas. In this sense, as an impact of the implementation of SECA in the Baltic Sea, (Barregard, 2019, p. 13) alleges that the implementation of the regulation annually "has saved annually 500 –1000 premature deaths, 500 non-fatal myocardial infarctions, and 500 cases of stroke".

Various ports along the Baltic Sea region have developed approaches that have impacted their infrastructure and investment policies in order to address the negative impacts of ship emission by sulphur compounds. These approaches include the development of liquid natural gas bunkering infrastructures, development of onshore supply, establishing incentives for the shipping companies and compliance and monitoring mechanisms for control (Ölcer, Kitada, Dalaklis, & Ballini, 2018).

In addition, the International Maritime Organization (IMO) adopted mandatory requirements under the FAL Convention for the maritime single window system, whereby electronic data on cargo, crew and passengers are required to be captured and exchanged between public authorities (IMO 2018b). The purpose is to reduce ship dwell time in ports and consequently the ship emissions. These and more approaches as will be discussed in detail in the following chapters have enhanced clean shipping as well as providing significant benefits in the Baltic region where more stringent control of the sulphur regulations have already been implemented.

In this context, the implementation of the low sulphur limits in the SECA's will serve as a model for other countries around the world to develop regional policies to improve performance of ports aiming to not only comply but to reach new levels of quality in health, environmental friendly marine operations, energy development and stronger port systems. This specific research focuses on the emissions control policy implemented by the port of Gothenburg due to the IMO 2020 Sulphur regulation as a model for the port of Mombasa, Kenya.

1.2. Problem Statement

Ports in the developing economies lack stringent regulations for environmental conservation and emissions control within the port region. The inefficiencies in the operations of ports in most developing economies have led to increased ship delays at the ports, increased human intervention and consequently increased the amount of emissions within the port areas and the coastal communities. Additionally, there is little knowledge in the developing economies on the Sulphur regulation thus the readiness is at its minimum. This has brought a lot of anxiety on which appropriate measures to be undertaken within the ports and shipping sector.

The port of Mombasa is the gateway to eastern and central Africa and plays a key role in the facilitation of international seaborne trade in the region. It has 19 deep-water berths and is well connected with over 33 shipping lines calling and providing direct connectivity to over 80 ports globally and handling millions of imports and exports for the region. Over the last few years, the port of Mombasa has immensely increased the cargo traffic handled. The increase is mainly attributed to improvements in productivity which arise from additional investments in modern port infrastructure associated equipment and automation of port processes.

In terms of compliance with the IMO Sulphur Cap requirements, Kenya has actively participated in the global campaign on MARPOL 73/78 Convention Annex 6 to familiarize its Port State Control Officers and ship inspectors on the areas to be focused on during inspection of compliance with requirements on sulphur limit in ship fuel oils. Ships that are docking at the port of Mombasa are subject to inspections by the Maritime administration's state control officers. There is awareness and sensitization to a certain degree within the Environment and Marine Operation sector at the port of Mombasa regarding the IMO 2020 Sulphur directive.

This can be supported by the fact that currently the port is collaborating with the Jommo Kenyatta University of Agriculture (JKUAT) and Technology in Kenya and IMO in a project named Maritime Technology Corporation Centre for Africa (MTCC-Africa), a project which aims to among others, facilitate compliance with MARPOL Annex VI by working with maritime administrations, relevant state departments, port authorities and port community stakeholders in facilitating compliance with international regulations.

The government of Kenya does not own any ship. However, various initiatives have been considered to operationalize the Cold Ironing as a complimentary for the vessels that calls at the port of Mombasa. According to the information received from Kenya Maritime Authority via telephone conversations, the Maritime Administration in Kenya intends to hold sensitization campaigns to familiarize shipping agents with the Sulphur Cap requirement and the available licensed fuel oil suppliers.

Ships agents have also been engaged in the sulphur limit on fuel oil requirements through various initiatives such as workshops under the MTCC Africa. However, despite all these arrangements, there exists a high level of uncertainty on the impact of the new Sulphur regulations on the port of Mombasa in terms of the investments that need to be put in place.

1.3. Objectives and Research Questions

The overall aim of the study is to evaluate the implications of IMO 2020 Sulphur Cap on the investment decisions of the infrastructure of the ports in developing economies with particular focus on the port of Mombasa by using the port of Gothenburg in Sweden and Stena Line, a private port operator as a benchmark. This research is also focused on researching the effects regarding infrastructural and investment costs on a short-term, the viability of migrating between oil to low sulphur emissions fuel in ships and the sustainability of this policy in time. The study will focus on stakeholder's views on how the IMO Sulphur regulations have affected their investment policies for port operations. The research objectives are as follows.

1. Describe the Investment Policy adopted by the port of Gothenburg and Stena Line as a port operator in the context of for the IMO 2020 Sulphur Cap.
2. Analyze the structure and application of the Investment Policy adopted by the port of Gothenburg related to Emissions Control for the 2020 Sulphur Cap.
3. Propose to the Kenyan Government on effective control mechanisms and necessary actions to ensure compliance and consistency in the implementation of IMO 2020 Sulphur Cap to the port of Mombasa based on the experience of the port of Gothenburg and Stena Line as a port operator.

1.4. Research Questions

In order to achieve the objectives of the study the following questions have been made to direct the research:

1. What investment policy control measures were put in place by the port of Gothenburg to enforce the IMO global Sulphur requirements?
2. Why does the decrease of the sulphur emissions originated by the Shipping Industry require an Investment Policy in ports?
3. What are the elements that can be proposed to the Kenyan Government in order to create effective control mechanisms and necessary actions to ensure compliance and consistency in the implementation of IMO 2020 Sulphur Cap to the port of Mombasa?

1.5. Research Limitations

On the one hand, the fundamental assumption for this research is that the data required for the study will be available from the port of Gothenburg and Stena Line as a port operator at the port of Gothenburg as well as from online desktop research information.

On the other hand, the researchers' lack of knowledge of the Swedish language for documents obtained by the above named company could be a limitation as long as some might not be found in English. Furthermore, if it is not possible to access the information via official channels, it might be possible to find the data through secondary sources.

The expected responses in the questionnaires may not be filled out with total honesty which could give rise to unreliable information. In addition, most of the interviewees at Stena Line may be away from their workplaces on summer holidays and thus unavailable to fill out the questionnaires on time as expected.
Time limitation is also a challenge due to the expected adherence to strict deadlines as compared to a large amount of information and data sources the authors will be required to read and analyze for comparison purposes.

1.6. Research Methodology

The study is in essence descriptive employing qualitative techniques to understand the implications of the IMO Sulphur regulation. The best way to understand numeric results and implemented policies is through analysis of qualitative data obtained from publications, official and commercial reports, interviews and digital mail with executive officers of the company and also through digital and physical sources from the World Maritime University library and the allied libraries linked to the database.

Given the nature and aims of this study, in identifying and interpreting the current mechanisms being developed by and for the shipping industry, narrowing the scope in a particular company will be the approach to collect both types of data.

1.7. Research Structure and Organization

In order to achieve the desired objectives of this research, the dissertation is organized as follows:

Chapter one consists of introducing the research topic by describing the background of the IMO Sulphur regulation. The aims and objectives of the research, problem statement, the expected results, assumptions as well as the research limitations.

Chapter two describes the existing literature review on the investments policy implemented by ports for emissions reduction along the Baltic Sea region where more stringent conditions of the Sulphur regulation are already in place. It also describes the indicators used by ports to measure performance of the mechanisms implemented to enhance compliance. This chapter provides a better understanding of the problem at hand from a theoretical perspective.

Chapter 3 provides the methods and the conceptual framework used for the investigation of the research topic. This chapter also provides the research design and the methods used for collection and analysis of the data by the use of the analytical tools as described in chapter one.

Chapter 4 provides the framework of the legislation put into place to govern emissions reductions of ships in the ports from the regional, national and international perspectives.

Chapter 5 focuses on the case study of the port of Mombasa in terms of its performance and the level of readiness of the port of Mombasa to implement the Sulphur regulation as well as its potential in view of the available resources it has at hand and the expected cost effectiveness. It also presents the analysis of findings of the research.

Chapter 6 contains the conclusion and recommendations. The approach that has been used for this research is described in Figure 2.

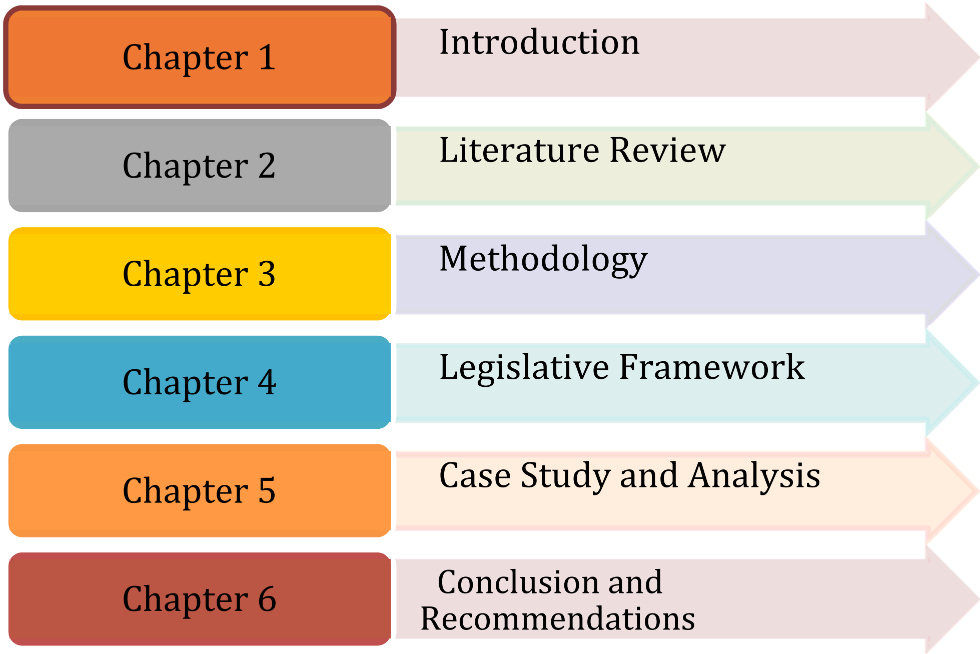


Figure 2:Research Structure

2.0. LITERATURE REVIEW

According to Moon, (2019, p. 14), ports are “Places where there is the interchange of cargo and passenger traffic among vessels, and between vessels and overland carriers or sites alongshore”. Ports are interfaces between ships and hinterland, where all the operations linked to load, discharge and movement of cargo are performed, hence, these facilities work as a sort of ecosystems where the participation of different institutions is done in a synergetic way where the main stakeholders are the shipping companies (Moon, 2019).

The International Transport Forum report, published in 2014, describes a situation where most of the emissions of carbon, nitrates, sulphur compounds and particulate matter takes place at the sea but their effects in terms of direct impacts on humans and the environment are more visible in the port areas and the port cities. According to the same report, shipping emissions in the ports account for 0.2 million tonnes of sulphur dioxide among other compounds. In addition, containerships and tankers produce the highest percentage of emissions in ports, accounting for 85%. This is besides the fact that containerships spend less time in the ports but they produce a high amount of emissions during their port stays (ITF 2014).

Various authors have conducted evaluations on the different available options for the IMO 2020 Sulphur regulation compliance. According to Farrell et al. (2002), Brynolf et al. (2014) and Wisnicki et al. (2014), the best and most convenient option for sulphur emissions control is by changing from the heavy marine fuel to lighter and cleaner fuel distillates that emit less waste after the combustion such as Marine Gas Oil (MGO) and Marine Diesel Oil (MDO) Jiang et al. (2014) and Hämäläinen et al.(2016) refuted the aforementioned opinion by stating that the option of switching fuel is subject to fluctuating prices of fuel in the fuel market.

The other option would be to use alternative fuel such as Liquefied Natural Gas (LNG), which has been in use for land transportation as well as heating for a long time. LNG is low in sulphur, thus satisfying the low Sulphur regulation requirements (Jiang et al., 2014). Additionally, the ships which operate on LNG vessels emit almost zero sulphur emissions. It also reduces the emissions of other pollutant compounds such as nitrogen oxides and particulate matter Wiśnicki et al. (2014) stated that LNG fuel is more conveniently used for vessels which trade on a fixed ports schedule where the LNG is available as opposed to its requirement by larger ships which require deep-sea shipping (Wiśnicki et al., 2014).

Bergqvist et al. (2015), however, explained that LNG in its liquid form requires temperatures that are below its boiling point of 163° C and kept under pressure and requires large tanks which may be installed either inside the ship or above the deck. This takes up a lot of space, equivalent to three times more than the normal fuel tanks, thus making it be more expensive especially when converting old vessels to LNG. It is, therefore, more convenient and cost-effective to use LNG powered new building vessels (Bergqvist et al., 2015).

The other option which is also considered to be popular is the use of the scrubber, a technology which removes sulphur deposits from ship exhaust systems and also permits the use of HFO which is considered to be cheaper (Concawe, 2013). Jiang et al. (2014) described the two types of scrubbers to be dry and wet scrubbers. The wet scrubber is categorized into the open loop, the closed loop scrubber and the hybrid scrubber system. The use of scrubbers has been explained to have its drawbacks too. The wet scrubbers challenge is experienced in terms of where to discharge the acidic wash water (Jiang et al., 2014). The discharge sludge, therefore, has to be stored onboard the ship until berthing, thus adding up to the weight of the ship while cruising (Jiang et al., 2014). The cost of fitting the scrubber is estimated to be between 2 to 4 million euros but subject to size and age of the ship (Brynolf et al., 2014). According to Atari and Prause (2017), it takes around 3 to 5 years for the repay back period. However, the scrubber can be installed on both new and old ships (Bergqvist et al., 2015).

According to the second IMO GHG study conducted in 2009, many technical and operational measures that may be used to reduce GHG emissions from ships have been identified. However, these measures may not be implemented unless policies are established to support their implementation. The options that are relevant to the current IMO debate are analyzed in detail. The Sulphur regulation is expected to increase the cost of maritime transport. Additionally, concerns have risen that the IMO Sulphur regulation has the ability to alter the competitiveness of the maritime sector as well as the level playing field of growing industries economic growth. COMPASS (2010) speculates that the Global Sulphur Cap will cause an increase in the price of fuel globally by 2020.The aforementioned speculation could lead to some industries relocating to better businesses with better conditions. Hämäläinen et al. (2016) stated that some private port operators might face closure as a result of the SECA directive due to cost-related challenges. However, OECD/ITF (2016) refuted the impact of the Sulphur regulation on the trade flows globally by stating that the impact has been negligible.

Special measures for sulphur emissions control have been implemented in ports. Such is the use of onshore power supply (OPS) which utilizes land power grid connection to vessels while at berth in ports. This corresponds to the EU (Directive 2014/94/EU), which enforces the supply of shore-side electricity infrastructure installation on all TEN-T core network ports as well as other ports by 31st December 2025. In this case, ships normally shut off their main engines and leave the auxiliary engines running in order to stop the use of fuel and generate electricity.

The use onshore power has made it possible for the ports to achieve a reduction of emissions, noise and vibrations that are generated by ships while at the ports. This technology is also very useful for the vessel crew, the passengers as well as the people who live in the port cities. This technology is currently provided by the ports of Gothenburg, Helsinki, Ystad, Stockholm, and Lubeck. However, there exists no specific standard for the supply systems for ship to shore-electricity supply systems. However, a high-voltage system is more recommendable since it has the ability to transfer 25 times more power than a normal 400V cable which has the same dimension. It is even better when a quay is situated close to an industrial area as this increases the chance for the availability of high voltage power (Borkowski, & Tarnapowicz, . (2012).

According to the analysis of OECD/ITF (2016), it was established that shore-side electricity connections have the ability to reduce air pollution as well as noise from ships while at the port, emissions on deck and consequently providing environmental and health benefits. In the report, the operators interviewed preferred the high voltage shore-side electricity system at berth. It was also established from the report that the value attached to external costs associated with emissions of pollutants from vessels while at the port is significant as compared to the costs incurred in installing the shore-side electricity system. From the report, it was also established that the direct costs for shore-side electricity onboard are four times higher than the costs of generating onboard electricity by the use of auxiliary engines which run on heavy fuel oil.

According to a study by the North Sea Commission (NSC), the marginal benefits of using shore-side electricity was investigated by analyzing ship calls to the port of Gothenburg. According to the results, it was determined that out of all the vessels which call at the port of Gothenburg in a year, a total of 20 ships were indeed responsible for close to 30% of the total sulphur and nitrogen oxides emission at berth. It was, therefore, established that the most effective way to curb quay emissions is by closely monitoring the ships that frequently call at the port. These are the same ships that are more suitable to fit with shore-side electricity connections as compared to other vessels. While these investments in infrastructure are put in place at the ports, ship-owners are encouraged to make their ships adaptable to onshore power when at berth (OECD/ITF, 2016). Ecofys (2015) and OECD/ITF (2016) further state that this option is becoming a mandatory necessity for ships to use on-shore side electricity while berthing.

LNG is so far the cleanest marine fuel that is available for large scale shipping (Van Biert, Godjevac, Visser & Aravind, 2016). In terms of LNG infrastructure, immense developments have been made so far, especially within the Baltic Sea region, initiated by the Baltic Sea Organization in their project aimed to harmonize pre-investment activities of the port networks. This initiative was implemented as a result of the EU Directive 2014/94/EU that required all TEN-T core seaports to be equipped with LNG bunkering points by 2025.

Incentives for shipping companies are also a very important instrument that has been used in ports as an emissions control mechanism. In recent years, most incentives adopted by ports are more geared towards the ships using LNG, low generation of nitrogen and sulphur oxides or use of OPS. The port of Gothenburg, for instance, uses incentives, such as CSI (Clean Shipping Index) and ESI (Environmental Ship Index) as rewarding criteria for ships that use LNG.

The most common method practiced in the SECA where more stringent measures are put into place is the inspection of IAPP6 and IOPP7 certificates. Bunker delivery notes, oil record books and logbooks among other records. The inspections are made mainly on vessels without installed emission abatement equipment. In countries like Poland, fuel samples for each vessel are collected and inspected. However, in some other countries, the sample is usually only analyzed whenever abnormalities are noticed in the course of vessel inspection. In this case, the samples are usually taken from the return pipe, service tank or fuel filter for analysis by accredited laboratories. In Kenya currently, ships that are docking at the port of Mombasa are subject to inspections by the Maritime Administration's state control officers who have been mandated to verify compliance with applicable sulphur limits in fuel oil by examining bunker delivery notes, oil record books and fuel consumption data. Results obtained by use of this method are only indicative and thereby needs further inspection by accredited laboratories (KPA, 2019).

According to a research conducted by Mellqvist (2016), 6801 inspections were conducted from the beginning of 2015 to March 2016 into the monitoring of emissions as well as measure the path concentration of sulphur and nitrogen oxides. It was established that there is 95% consistent compliance in the Baltic Sea region ports.

Aiming to control and follow the emissions of harmful gasses from fuel consumption called IMO Data Collection System on Fuel Consumption (IMO-DCS), which is of mandatory compliance around the world from January 1st of 2019, and the required details are: year for which the data is submitted, distance travelled, type of fuel consumed, hours underway under own propulsion, DWT to be used as cargo proxy, all of which are centralized by the Flag State and then reported to the IMO (DNV-GL, 2018).

In this contextual frame, the ports in the Baltic SECA are members of Eco Ports, an environmental initiative of the port sector in Europe, with the objective of improving environmental practices through shared knowledge and cooperation between ports of the region including 25 countries, 116 members, and a considerable number of certified ports (Eco Ports, 2019).

Figure 3:SECAs in Northern Europe.

Source-United Kingdom Parliament,2012

Furthermore, Eco Ports are also part of ESPO, an institution based in Brussels with the objective to assists port authorities and policymakers in the implementation and dialogue between them reaching also other stakeholders in the port and maritime sector providing knowledge, reliable data and information and as well as a network for them (ESPO, 2019). This organization provides a set of tools to measure the port ́s performance in the following matters:

- Market trends and structure
- Socio-economic impact
- Environment
- Logistic chain and operational performance
- Governance (ESPO, 2012)

As this is an environmental topic, in particular the measurements more related to this investigation are as follows: wastes, energy consumption, water quality, air quality, sediment quality, water consumption, noise, carbon footprint, soil quality, marine ecosystems, and terrestrial habitats (ESPO, 2016). In 2016, Air Quality was selected as the most important issue to be targeted by the ESPO Member States.

In the same way, all the port authorities should develop a strategic plan, which is a mechanism to design long-term policies related to infrastructure or integration of facilities and procedures in the port and to cooperate with different stakeholders in terms of investment in order to build infrastructure aiming to satisfy the market´s demand and international regulations. Also, it allows establishing an estimated budget of the cost of infrastructure and energy taxes to develop sustainable ports (PIANC, 2014).

The Entec-Study (2002) estimated the ship emissions within the vicinity of the port areas in the European countries by assigning emissions by ships on 50 by 50 kilometers grid squares and where the ship emissions in port areas are made visible. This study used port time data based on questionnaires

Dalsøren et al. (2008) approximated port time in order to calculate the ship emissions while in the ports. However, he did not give the details on individual ports except Singapore. This research took actual time in the ports and considered to be more accurate than the Entec-study. However, is not very precise because it used days, not hours. Ports are also increasingly using emission inventories to measure emissions within the port areas. However, it is not always easy to separate the effects of emissions to shipping, ports' commercial operations as well as hinterland operations and development of the industry.

According to the Port Emissions toolkit, published by GEF-UNDP in collaboration with IMO GloMEEP Project and IAPH, 2018, port emissions assessment was conducted in the U.S by use of an emissions inventory, emissions forecasts and by focusing on data on equipment and port activities, energy consumption and cargo throughput.

Emissions inventory provides a catalogue of categories of port activities that generate emissions and converts these activities into energy consumption levels and finally into emissions sources. A comparison is then done between the various categories of activities and the corresponding emissions produced by these activities within defined geographical and operational domains of port emissions.

The emissions inventory by equipment, activity and emissions metrics provide emissions measurement through data on the equipment, activities and by the energy consumed, the sources that produce emissions and by the cargo throughput. These are used as indicators, which show the intensity of the damage and also create standards in which can be measured and efforts put in place to mitigate for emissions control. The emissions forecasts provide projections in future based on increases of cargo throughput in the port as well as changes made in terms of demand for equipment and change in operations with time. These forecasts can be used to develop targets for emissions control in the future as well as planning for energy efficiency.

According to a Port Emissions toolkit published by Port Inventories can be developed according to the levels of details that are available, the intended purpose of the inventory, time availability and the data available for compilation. The inventory for port emissions can be conducted by regulatory bodies, such as maritime administration in Kenya in this case because it is mandated to regulate the maritime service providers which include the port of Mombasa. The port emissions inventory can also be conducted by the port authority itself as well as private operators or terminals or even joint collaborations by several port authorities in a region. Data is the most important element in a port inventory which can be collected by the port itself by taking note of the cargo throughput for instance or by government agencies through timely publications. Lastly, while conducting these operations, it is important to note the uncertainties associated with each data element (IAPH,2018).

Narrowing down the scope, the port of Gothenburg is strategically located and is also a place where shipping companies possess interest making it a terminal for Ro-Ro and Cargo Container vessels in addition to its condition as a hub with a railroad terminal (Port of Gothenburg, 2014). The port of Gothenburg offers onshore power supply with vessels that have signed agreements with the authority, giving additional incentives to shipping companies and whereby vessels connected to an onshore power supply score higher in the indexes on which the environmentally discounted port charge is based (Port of Gothenburg, 2016).

The port of Gothenburg aims to reduce GHG, sulphur and other harmful gas emissions in the port due to vessel´s activities while loading or discharging cargo. The port also offers an LNG bunkering service to promote using alternative fuels, according to their statistics using LNG reduces between 85 to 90% of sulphur and nitrogen emissions and 20 to 25% of CO_2 emissions with the current technology (Port of Gothenburg, 2017).

Figure 4:Geographical Location of Port of Gothenburg.

Source-Google Maps, 2019

However, to reach these goals, it is mandatory to invest in infrastructure and develop procedures to follow up the policies. According to Ölçer, Kitada, Dalaklis, and Ballini (2018), there are four key elements considered in the Baltic Sea Ports in order to create the optimum conditions for a green port:

1. LNG Infrastructure: for core seaports to standardize and facilitate bunker supplying;
2. Onshore Power Supply: aiming to avoid the use of ship's generators to provide electricity on ports through the use of cold ironing service reducing emissions, noise and vibrations on ports;
3. Incentives for Shipping Companies: tax reductions for green operations in shipping companies, less emissions-less taxes;
4. Compliance Monitoring and Control: It is required to analyze and inspect the IAPP6 and IOPP7 certificates, Oil Record Book, Bunker Delivery Notes, logbooks and records before the navigation inside the SECA, in addition to the mandatory monitoring system required by the IMO.

In this way, to replicate the experience of the ports of Europe, focusing on Sweden, it is probably an assertive approach to study the case of a private company interacting with the Port State. In this particular research, the port of Gothenburg and Stena Lines as a port operator are working in a symbiotic way The Swedish government offers tax incentives and free electricity in cold ironing services to registered ships in the port of Gothenburg.

In a similar way Stena Lines uses these advantages but also invests in the use of current technologies to reduce the dependence of fuel on departing and arriving ports through the implementation of navigation with batteries in short routes.

3.0 METHODOLOGY

3.1 Introduction

As it was described before, this chapter aims to explain the methodology to be used to perform a qualitative approach of four KPIs previously mentioned as well as employing SWOT and PESTEL analysis tools for this study. Therefore, due to the nature of the study and data collected, an empirical research is the most adequate approach to the topic in order to answer the proposed questions implementing qualitative methods. Table 1 indicates the approaches of the methodology as well as the analysis method applied.

Table 1:Review of Methodology

Problem	Approach	Method
Investment Policy in the Port of Gothenburg in Sweden by Stena Line for the 2020 Sulphur Cap	Qualitative	KPIs Analysis
Structure and application of the Investment Policy in the Port of Gothenburg in Sweden by Stena Line for the 2020 Sulphur Cap	Qualitative	SWOT Analysis
Effective control mechanisms and necessary actions to ensure compliance and consistency in the implementation of IMO 2020 Sulphur Cap to the Port of Mombasa	Qualitative	PESTLE Analysis

(Source: Authors, 2019)

The qualitative data collection was undertaken by collection of questionnaires, informal short phone interviews, emails and literature review to fill the blank spots and to further research the underlying items related to the investment policies in terms of infrastructure facilities in ports with the objective of facing the industry demands and regulations. Kuada (2012, p. 94) suggests: “Qualitative methods also allow the participants to raise topics and issues that are not anticipated and might be critical to the investigation".

Once the qualitative techniques (see Table 1) have been utilized and supported by the questionnaires and literature verification results, the researchers will proceed with the benchmark analysis of the port of Gothenburg and Stena Line as a port operator. An analysis is made by using methods indicated in Table 1, to generate a discussion and propose recommendations to the Kenya Ports Authority. To conclude, the case study was developed for possible ways to implement the required policies and improve the current state of the port of Mombasa.

The proposed methodological path to develop the research followed the scheme as shown in Figure 5 in order to reach the aimed results:

Figure 5:Research Design

3.2 Data Collection Methods

According to Perri, and Bellamy (2012, p. 11): “The process of data collection almost always requires the researcher to ‘interpret’ the data”, requiring an active participation from the researchers to classify and depurate the raw information, to avoid biased or misleading analysis, but also this process must support conclusions and answer the research questions. Likewise, the existence of an iteration between the empirical data and the theoretical information is mandatory in order to link the findings with a supporting theory. Through this process, information is systematized in a way that patterns can be identified and presented to answer and solve the research questions having the stakeholders in mind to maximize the outcomes.

3.2.1 Data Collection Methods

3.2.1.1 KPIs Analysis

The Key Performance Indicators is a useful tool to measure the level of accomplishment of set targets for effective monitoring and control of performance. Subsequently, the KPIs lead to delineating and developing protocols in order to plan and collect data to improve port operations providing information used for planning and execution of policies. According to UNCTAD (2014), the KPIs are just measures related to various aspects in a way that is easy to understand and measure performance for effective monitoring and control as well as providing insights to support management activities and at the same time, information to compare the trends and performance of the port with set targets (Banu, 2017).

The analysis of the KPIs mentioned in Chapter II is the focus in the port of Gothenburg as the benchmark for the port for Mombasa as a starting point to develop goals and strategies based on data collected from Stena Line as port operator and the available information of the port of Gothenburg.

3.2.1.2 SWOT Analysis

According to Sammut-Bonnici and Galea (2017), SWOT evaluates strengths, weaknesses, opportunities and threats inside and around an organization. It is employed to recognize resources, capabilities, competencies, and advantages of the organization. It identifies opportunities and threats in the context of the industry related to market forces, economics and governmental policies in order to develop potential actions or policies to face the challenges around the organization.

According to Pickton and Wright (1998), a SWOT analysis requires the use of a matrix to draw and schematize the features of a particular organization in a feasible way to describe and explain the set of tools and flaws inherent as well as the challenges and opportunities offered by the context in which this institution performs. Additionally, Pickton and Wright (1998, p. 101-109) stated that: "environmental analysis is a critical part of the strategic management planning process".

3.2.1.3 PESTLE Analysis

Rastogi and Trivedi (2016, p. 384-388) conceptualize PESTLE Analysis as: "a strategic planning tool used to evaluate the impact of political, economic, social, technological, environmental and legal factors might have on a project. It involves an organization considering the external environment before starting a project". PESTLE analysis should be performed before commencement of projects involving resources of any nature especially if the project involves building superstructures that may affect the lives of a population as well as the legal regime. In addition, PESTEL analysis serves to elaborate a crossover study, and at the same time, it considers a holistic spectrum of elements focused on resources, context, environment and boundaries.

In the current case, the PESTEL analysis is applied to the port of Mombasa, as the target recipient of the benchmarking analysis study. This was conducted in order to evaluate the external environment to ascertain the threats and opportunities for the port of Mombasa. Adopting the four indicators was considered from a political, economic, social, technological, environmental and legal aspects, to identify the opportunities as well as the threats of the four identified indicators implemented in the port of Gothenburg and whose experience is replicable to the port of Mombasa.

Also, an evaluation of the legal frame in terms of the international, regional and domestic instruments was conducted as shown in the next chapter.

4.0 LEGISLATIVE FRAMEWORK

The last century has seen immense growth in seaborne trade globally. The increased demand for transport, as a result, has increased the tendency for emissions over time. The pollutants emitted are associated with shipping activities driven by the world economy. The Intergovernmental Panel on Climate Change (IPCC) guidelines categorize emissions arising from waterborne navigation into international and domestic. The effects of the pollutant compounds have drawn the attention of international and national organizations in their efforts to combat GHG emissions and their effects.

Remarkable improvement has been made in terms of regulations that have been established as a result of the adverse effects of the pollutant compounds due to maritime activities. Nevertheless, it is possible to reduce exhaust emissions upon improving energy efficiency. However, their effectiveness varies according to the context applied (IMO GHG Study, 2014).

4.1. International Perspective

According to the U.N. Framework Convention on Climate Change (FCCC) report, the abrupt climate change experienced worldwide, which has over the last century gained widespread recognition, has mainly been attributed to human activities among other major causes. In recognition of the adverse effects of climate change and the need to bring together nations across the world to a common agreement to fight as well as adapting to its adverse effects, countries across the world signed the Paris Agreement as a global response to threats imposed by climate change by regulating the temperature rise globally below 2 degrees Celsius, which is above industrial levels. In order to achieve these ambitions, it is imperative that new technologies be developed, proper establishment of financial flows and invaluable support by many countries especially the vulnerable ones by the implementation of international relative regulations in accordance to national objectives of the parties (Del Pilar Bueno & Pascual, 2016).

This is also in line with similar efforts that have been made worldwide to establish guidelines related to secure social relationships of production with minimum impacts on the environment and are in line with the Sustainable Development Goals (SDG's) 7,13 and 14, which are linked to this research as a framework to understand the impact on domestic policies of the 2020 Sulphur Cap regulation compliance. It also calls for cooperation between the States, their Governments, private companies, collectives, and individuals to participate in the Global Governance of the seas.

In recognition of the climate change impacts and the importance of incorporating global action to combat its global effects, the International Maritime Organization (IMO) has been establishing and developing regulations in a bid to address GHG emissions emanating from international shipping. UNFCCc-Kyoto PROTOCOL stipulates that IMO is best placed as the competent and global regulatory body with the mandate to develop an effective GHG control regime for international shipping (IMO GHG, 2014).

The IMO was established to ensure cooperation between governments in the regulation of practices regarding technical matters of all shipping activities engaged in international trade in order to facilitate the adoption of the highest practicable standards in matters concerning maritime safety and efficiency in terms of navigation as well as control of marine pollution from ships. IMO is also empowered to deal with administrative as well as legal matters related to these purposes. The enforcement of the regulation lies with flag states who are parties to the regulations and who incorporate them into their national laws for enforcement (IMO, 2013).

IMO established strict regulations to reduce the emission of sulphur oxides (sox) from ships. However, in order to ensure harmonization of the sulphur directive with international law and to ensure effective implementation, the directive 1999/32/EC was enacted and further amended by directive 2005/33/EC in MARPOL (73/78) Convention Annex VI. This law provides restrictions of the sulphur content in marine fuel in the Sulphur Emission Control Areas (SECA) to 1.5%m/m, further to 1.0% in July 2010 and later to 0.1% w/w at the beginning of January in 2015 (IMO, 2008; 2009; 2013).

The designation of SECA was first made in 2006 and the Baltic Sea was the first region to be designated. However, in 2007 the English Channel and the North Sea areas were designated (Nugraha, 2009). In recent years, the global sulphur cap has been reduced from 3.5% to 0.5% for ships moving outside the emission control areas (ECAs) effectively from January 2020. This measure is expected to significantly reduce the volume of sulphur oxides emissions from ships and pose great environmental benefits globally (IMO, 2016).

The sulphur oxides, as well as the particulate matter emission controls, apply to all fuel oil as stipulated in IMO regulation 2.9. and devices on board as well as equipment for combustion. It, therefore, includes both the main and auxiliary engines as well as inert gas generators and boilers. The controls applicable in ECA are, therefore, established to limit the sulphur oxides emission and particulate matter while those that apply outside the ECAs are achieved through limiting the sulphur content of marine fuel oil loaded on bunkers (IMO 2017). The sulphur, as well as particulate matter limits established in and outside ECAs, has been subjected to various transitions over the years as shown in Table 2.

Table 2: Sulphur and Particulate Limits established in and outside ECAs

Outside ECA	Inside ECA
4.5% m/m prior to 1 January 2012	1.5% m/m prior to 1 July 2010
3.5% m/m on and after 1 January 2012	1.00% m/m on and after January 2010
0.5% m/m on and after 1 January 2020	0.10% m/m on and after 1 January 2015

Source: IMO 2019

The Emission Control Areas established in the IMO regulation for sulphur oxides (SOx) are the Baltic Sea area as defined by Annex I of the MARPOL Convention and the North Sea Area as defined by Annex V of the MARPOL Convention. Other Emission Control Areas established to include the North American Area and the United States Caribbean Sea Area which entered into effect on 1st August 2012 and 1st January 2014 consecutively. The last two ECAs are defined in Appendix

VII of MARPOL Convention Annex VI for Sulphur oxides, nitrogen oxides and particulate matter (IMO, 2017).

Compliance with IMO regulations require that ships should use different marine fuel oils while operating within and outside ECA's. This is because ships will be required to use the compliant marine fuel oil prior to entering the ECA (IMO Regulation 14.6) and also have written procedures on how the fuel transition procedure is to be undertaken. These records are to be maintained in the logbook as prescribed in the ships' flag state if such requirement exists, otherwise, these recordings can also be made in Annex 1 of the ships' record book in the absence of such procedures in a particular flag state.

Under regulation 18, it will be required for the sulphur content in bunker fuel to be declared by the bunker supplier and recorded in the bunker delivery note. It will, therefore, be the responsibility of the crew members to confirm the sulphur content in the bunker fuel oil with respect to the applicable sulphur content in the marine fuel oil as well as effective transitions in and outside the ECAs in a bid to prevent mixing up of compliant and non-compliant fuel oils. Consequently, regulation 14.1 enhances the application of the aforementioned methods subject to the approval by respective administrations' relevant national guidelines.

4.2. Regional Perspective

At the regional level, the European Union (EU) regulates SOx emissions from ships by Sulphur Directive (EU) 2016/802, which establishes the maximum limits for the sulphur content of heavy fuel oil used inland and marine fuels. This directive contains specific requirements for fuel for the ships that call at EU ports as well as specific marine fuel requirements. This directive was lastly amended in 2012 to include the EU legislation to the developments at the international level under MARPOL Annex VI. However, since January 2015, more stringent rules on the sulphur limits in marine fuel oil were applied at the SECAs at 0.1% and 3.5% outside the SECAs.

The maximum sulphur requirement of 0.1% for fuel for ships at berth while in the EU ports was established as from January 2010. Stringent measures were also implemented on passenger vessels that operate on regular services in and outside EU ports. They were required to use a maximum fuel content of 1.5% outside the SECAs.

The European Union directive 2014/94 also provides regulations for alternative fuel whose development and the appropriate use of infrastructure is considered essential in meeting the requirements for the Sulphur directive (2012/33/EU) as well as reduction of dependency of oil to transport, thus improve the security of European's energy supply and reduce GHG emissions.

Directive (EU) 2016/802 allows the use of Emission Abatement Methods (EAM) as a substitute for traditional marine fuels for all flagged ships in the territorial waters and EEZ of the European Union. According to Annex I, the EU recognizes that ships using this method in the aforementioned areas will achieve emission reduction that is equivalent to the emissions reduction achieved by the use of marine fuels. In accordance to article 4c of the EU directive, the use of marine fuel and boil-off gas for liquefied natural gas (LNG) carriers, cleaning gas systems which are popularly known as scrubbers, biofuels and on-shore electricity supply, in addition to alternative fuels where applicable, have to be put into consideration.

The African Union has established various regulations for environmental protection against emissions from ships. The African Union established the 2050 Africa's Integrated Maritime (AIM) Strategy to provide a framework for the protection and sustainability of the African Maritime Domain (AMD) for the creation and generation of wealth and the sustainable governance of Africa's inland waters, oceans and seas. The AIM strategy was developed in recognition of the realization that the African oceans, seas and the inland waters are under intensified pressure of degradation due to exploitation by ships related activities, the fall of biodiversity and other adverse effects due to climate change (2050 Aim Strategy).

The revised Africa Maritime Transport Charter, on the other hand, promotes the growth of Africa and the economic development by advocating for the cooperation of member states' maritime authorities and promotion of funding of research.

Innovations for the development of the maritime transport sector, operations of the ports and promotion of maritime education and training for member states countries are also promoted.

However, the charter does not address measures envisioned by member states for emission control from ships within the region. Additionally, most African nations are IMO member states and are subject to the implementation of IMO regulations. The level of implementation is usually based on the capacity and the availability of resources.

4.3. Kenya Perspective

Kenya has ratified a number of IMO Conventions aiming for protection of the marine environment from pollution arising activities. Kenya is a party to the Facilitation of International Maritime Traffic (FAL) Convention, which aims to reduce the amount of time spent by ships in ports and also as a way to reduce shop emissions when ships spend less time in the ports. Due to the fact that ship dwell time increases the emissions produced by ships especially in the ports, the FAL Convention implementation ensures the reduction of the main pollutant compounds, such as NOx, SOx, CO2 and PM by reducing dwell time for ships.

Kenya is also a party to the MARPOL Convention Annex VI, which aims at pollution reduction from ships (IMO, 2018c). The National Environment Management Authority (NEMA) is a state corporation which was established under the Environment Management and Coordination Act No 8 in the Kenya Constitution to implement the policies regarding protection of the environment from all forms of air pollution and to instill harmony in managing the environment of Kenya (NEMA, 2014).

NEMA has established regulations on excessive noise which arise from vibration from machinery and other forms of equipment, such as air conditioning equipment and other devices of similar nature. These laws apply to port areas as well. The Port of Authority in Kenya has implemented a Green Port Policy which entails the certification of ISO 14001:2015, Environmental Management System (EMS) and ISO 18001:2015 for Occupational Health and Safety Management Systems (OHSAS).

These safety standards target the highest attainable environmental standards for the benefits of all port community stakeholders and which is aimed to transform the port into a premier port of "clean fuels" in Africa (Gok, 2009). With environmental protection regulations becoming more stringent, many alternative measures have been explored to reduce the emission footprint from shipping and the related negative social externalities.

5.0 CASE STUDY: PORT OF GOTHENBURG AS BENCHMARK FOR PORT OF MOMBASA

In this chapter, the key elements of the research are presented in a logical and structured order, to fulfil the roadmap described in chapter three whereby three approaches are performed to analyze the collected data for the port of Gothenburg as a benchmark element, Stena Line as a port operator and the port of Mombasa as the main beneficiary of the results of this research. The first part is a KPI analysis of four items evaluated at the port of Gothenburg as described in the methodology chapter, followed by a SWOT analysis developed using the information received from high executive officers at Stena Line and finally a PESTLE analysis, based on information collected from different sources for the port of Mombasa.

The information will be in the form of a matrix to provide a comparison and give added value to the collected and reported information. This follows a path as shown in Figure 6, where the information collected from the port of Gothenburg as a benchmark model and Stena Line as a private entity is applied to the port of Mombasa linking the results of the three types of approach to develop different ways to improve the latter.

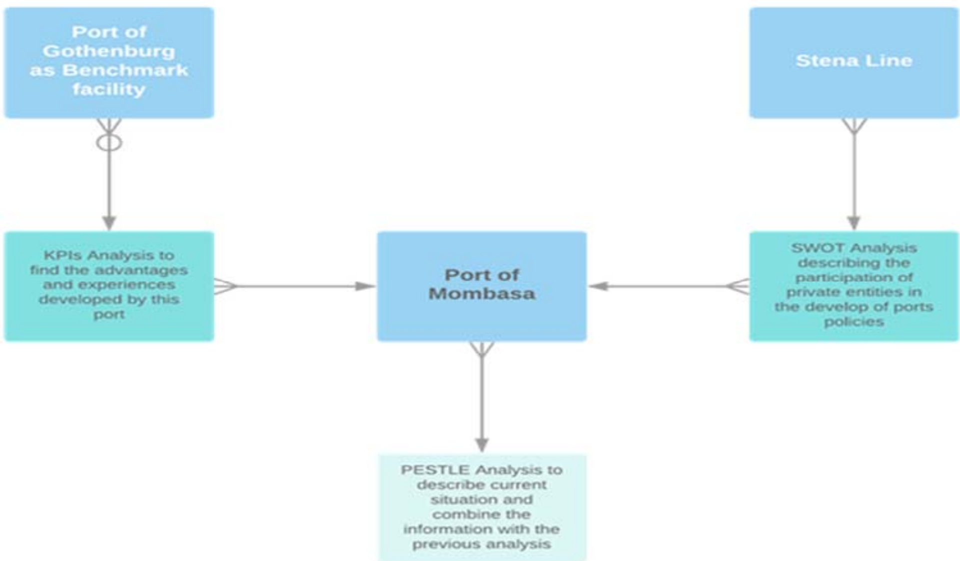


Figure 6:Case Study Strategy

5.1 KPI Analysis the port of Gothenburg

As it was described in chapter three, the Key Performance Indicators analysis is a tool implemented to evaluate, monitor and control performance on selected indicators to measure performance. The researchers specifically analysed four key SECA compliance activities in the SECA regions undertaken by ports in the Baltic Sea regions in order to investigate the decisions and outcome of infrastructural policies made by the port of Gothenburg to comply with the low sulphur limits regulation.

5.1.1 LNG Infrastructure

According to its condition as a port in the SECA region of the Baltic Sea, facilities for LNG supply have been established in the port of Gothenburg in partnership with private companies, such as Skangas and Swedegas to provide the fuel to ships. Varvne and Tselepia (2018) describes the port of Gothenburg as having 130 direct connections to the rest of the world with more than 50% connections within the Nordic regions that are within 500 kilometers reach and a total of 70 freight trains calling the port each day. Since 2018 the port of Gothenburg has been offering the LNG fuel service in the energy terminal distributed through a 450-metre vacuum-insulated cryogenic pipeline to the supply point (Port of Gothenburg, 2018).

The port has been offering a ship to ship LNG supplying service since 2017 and the shore to ship LNG supply service as from 2018 (Sharples, 2019). The port became a source of LNG fuel allowing distribution of the fuel to ships with a maximum flow rate of approximately 100-150 m3/h" (Swedegas, 2017). This led to a major increase in the ship calls with the appropriate technology installed onboard. According to LNG World News, 2018, the port of Gothenburg reported a rise in the number of LNG calls at the port from 16 in 2016 to 111 in 2018.

In 2018, 56 LNG vessels called at the port of Gothenburg with 135 expected to call the port by the end of this year. This is expected to increase the capacity of husbandry for LNG fueled vessels from 12 to 18 for supplying the vessels in a 24/7 basis for the 365 days of the year.

The establishment of an LNG fueling station is estimated to cost 1 000 000 -1 500 000 EUR depending on the specific circumstances (Albrecht, 2015), around 114, 667, 500 – 172,001,250 KSh (Central Bank of Kenya, 2019). This investment can be established single handedly by private companies or by the government of Kenya through the relevant ministries and port community stakeholders' intervention as described in Table 3.

Table 3: Stakeholders Role in Establishment of LNG Infrastructure

Stakeholder	**Function**	**Barriers-Drivers**
Port authority with an LNG project	o Plan the project with municipality, ship owners and gas supplier o Providing external infrastructure	o Port's competitiveness o Provision LNG to its customers
Gas supplier	o Develop and invest in the LNG project	o Entry to the market and sell the product o Demand for LNG from customers o Public funding for the projects
Energy company	o Develop and invest in the LNG project	o Demand for LNG from customers o Energy security
Municipality	o Owns the port, Approves and coordinates the LNG project	o Local economic development o Contentment of local communities
Governmental authority	o Allocates public funding programs o Coordinates and monitors LNG development financially	o Economic development o Compliance with regulations
Ship-owners	o Purchase of LNG vessels o Customers of LNG	o Compliance with regulations o Reliable LNG availability

Source: (Albrecht, 2015)

5.1.2 Onshore Power Supply (OPS)

OPS which is also referred to as shore connection or cold ironing, is one of the main features considered by the port of Gothenburg in complying with the SECA requirements for emissions control whereby ships do not need to burn their fuel to produce energy while they are alongside port, but at the same time, decreasing also noise and vibrations (Ölçer, Kitada, Dalaklis & Ballini, 2018). According to the port of Gothenburg (2018), 34% of the vessels calling at the port of Gothenburg also involve private companies like DFDS and Stena in the creation of connections for onshore power supply at the RO-RO terminal. Nevertheless, the efforts made in the onshore power supply started in a small scale with Stena Line in 1989 with a low voltage power supply, and then with a high voltage power supply in 2000 by Stora Enso and then from 2008 as an adaptation for the SECA regulation with a capacity of 6-20 kV in the high voltage system (Varvne, & Tselepia, 2018). In 2013, the OPS service was offered in the port of Gothenburg quays as described below.

1. Quay 24, Masthugget, Stena Line - Gothenburg-Denmark, OPS for passenger fast ferry - Stena Carisma, 50 Hz & low-voltage, 400 v, 1 installation
2. Quay 28-32, Masthugget, Stena Line - Gothenburg-Denmark, OPS for ro/pax-vessels – Stena Jutlandica & Stena Danica, 50 Hz & high-voltage, 11 kV, 3 installations.
3. Quay 46-49 Majnabbe, Stena Line - Gothenburg- Germany, OPS for ro/pax-vessels – Stena Scandinavica & Stena Germanica, 60 Hz & high-voltage, frequency converter, 11 kV, 1 installation, prepared for 50 Hz
4. Quay 700, ro/ro-terminal -Gothenburg – Finland, Belgium, OPS for ro/ro-vessels – Transtimber, Transpaper, Transpulp, Schieborg, Slingeborg & Spaarneborg, 50 Hz & high-voltage, 6 kV, 1 installation
5. Quay 712, ro/ro-terminalen - no vessels are equipped at the moment OPS for ro/ro-vessels, 50 Hz & high voltages, 11 kV, 1 installation (Dutt, 2013).

At the same time, these facilities do not impose major technical implications in normal occasions for any kind of vessels (new-buildings or more than 15 years but less than 20). However, differences in AC frequency (50 or 60 Hz), require that often the ships visit the same berth for compatibility issues (Styhre & Winnes, 2016).

Building on the previous statements and according to Jíven (2004), the following factors must be considered to plan and develop an OPS system:

- Shore-side frequency (50 Hz in Europe).
- Onboard frequency (60 Hz or 50 Hz).
- Shore side supply of high voltage electricity (voltage, distance to nearest supply point and installation practicalities).
- Required power level.
- Available spaces for onboard transformer, and weight restrictions of the vessel. The extra weight of equipment (transformer) or loss of cargo space may for some vessels result in reduced profitability or increased fuel consumption. In most cases these costs can be neglected, but for high-speed crafts or other special vessels the factors could be of importance.
- If the space where the onboard transformer is being located can be weather sheltered or not.
- Onboard cable installation practicalities and distances.
- Cost for shore supplied electricity versus that for onboard generated electricity cost (fuel, maintenance etc.).

The cost of installation of an OPS system takes into consideration the harbour canalization which costs approximately around 100-150 euro/m and high voltage cable (10kV) with an average cost of 10-15 euro/m. On the one hand, usually, the distance between the berth supply point and the high voltage source can be between 30 m to 500 m in ports. On the other hand, the connection cable between the shore connection and the vessel (10kV), is around 20-25 euro/m. Finally, the supply cost for a terminal with the features mentioned before can be between 10000 and 500000 euros (Varvne & Tselepia, 2018).

5.1.3. Incentives for Shipping Companies

As part of the strategies adopted by the port of Gothenburg to meet the requirements of the SECA regulation, the Authority of the port of Gothenburg offers a tax reduction for energy use making almost free the cold ironing service paying only SEK 0.5 öre (cents) per kilowatt per hour (Port of Gothenburg, 2016). Additionally, one of the policies related to incentives for cleaner and environmental friendly shipping is the discount of 10 percent on the port charge based on GT every time the vessels using the facilities have a score of 30 points according to the Environmental Shipping Index (ESI) or 4 stars according to the Clean Shipping Index (CSI) (as minimum requirement) in an automatic way as well as a discount up to 30 percent for LNG propelled vessels until December 2019 (Port of Gothenburg, 2019) and 10 percent from 2020 aiming to develop an environmental discount (Port of Gothenburg, 2018).

Furthermore, the aforementioned indexes are on a scale of 0 to 100 (ESI), where the higher the number, the better the performance (World Ports Sustainability Program, 2019) The second case (CSI) goes from 1 to 5 stars, where the lower the number, the better the performance (Clean Shipping Index, 2018). This is well described in Table 7.

Table 7:Incentives offered by the Ports in Northern Europe

Incentive \ Port	Hamburg	Antwerp	Gothenburg	Rotterdam
ESI Score	20 ≤ x ≤ 24 = 0.5 % (max. 250 €) 25 ≤ x ≤ 34 = 1.0 % (max. 500 €) 35 ≤ x ≤ 49 = 5.0 % (max. 1,000 €) 50 ≤ x =10.0 % (max. 1,500 €)	31 ≤ x ≤ 50 = 5.0 % 50 < x < 70 = 10.0 % 70 ≤ x = 15.0 %	30 ≤ x = 10.0 %	31 ≤ x = 10.0 %
ESI-NO_x	-	-	-	31 ≤ x = 10.0 %
CSI	-	-	4 Stars or more = 10.0 %	-
Green Award	= 3.0 %	-	-	= 6.0 %
Blue Angel Award	= 2.0 %	-	-	-
LNG Propulsion	= 15.0 % (incl. ESI)	-	= 30.0 % (incl. ESI)	-
Use of Onshore-Based Power Supply	= 15.0 % (if ESI-registered or/and Green Award Certificate)	-	-	-

Source: (Meister & Wagner, 2018)

From Figure 5 on page 32, it can be observed that in the Baltic and North Sea ports, Port States have a policy of using tax incentives to promote green shipping and maintain the quality of the air in their waters, having if not common, similar rates and taxes. In addition, competitiveness is promoted based on quality of service more than based on tax reductions. In 2011, incentives to the use of LNG as fuel for navigation in the area contributed to additional incomes to the port of Gothenburg with estimates of up to SEK250,000 of reimbursement for the extra cost of fuel consumed during this period (Green Port, 2011).

5.1.4. Compliance Monitoring and Control

In conformity with the MEPC.278(70), which entered into force on March 1st 2018, the ships with more than 5000 gross tonnage trading around the world were required to report consumption data for each type of fuel they use. This data is required to be reported to the Flag State of the ship to summarize it and then reported to the IMO after the end of each calendar year transferring to an IMO Ship Fuel Oil Consumption Database, but at the same time as a Port State, once the data has been reported in as required. The Maritime Administration then issues a Statement of Compliance to the ship (IMO, 2018).

The Port Authority is obligated to produce the International Air Pollution Prevention Certificate (IAPP6) (IMO, 2012) in case it is required and the International Oil Pollution Prevention Certificate (IOPP7) (MARPOL Training Institute, Inc., 2013). These documents should be issued by a Maritime Administration or Organization authorized to do so.

Similarly, the Oil Record Book and Bunker Delivery Notes should be available to the Port Authority whenever required (International Registries, Inc., 2014) for purposes of having an overview of the utilization of oils in the daily operations of the ship and to the latter name of receiving vessel, port, date, data of a supplier, quantity and characteristics of fuel oil (Wärtsilä, 2017).The regulations on these certificates must not be older than 5 years for them to be effective as in the case in the port of Gothenburg (Port of Gothenburg, 2015).

5.2. SWOT Analysis Stena Line

As it was described in Chapter three, this section is built employing the information received from high ranked officers of Stena Line with more than 10 years of experience at top management level. Their active and helpful participation in the development of this research is reflected in the detailed information provided. Furthermore, the main goal of using this methodology is to get a wide picture of Stena Line’s achievements as Port Operator in the Port of Gothenburg and as a private entity.

The information on Stena Line was collected by the researchers and categorized into four main sub-topics as outlined below:

- Readiness to face the 2020 Sulphur Cap
- SECA Policies
- Investment, Internal Policies
- Public Sector Role

Building up on these items and employing the SWOT analysis of the resources and capabilities, and the threats and opportunities identified in a particular organization patterns can be recognized in its structure and operations. The next step requires matching strengths with opportunities, ward off threats, and overcome weaknesses (Pickton & Wright, 1998). In Table 4 and according to the information received by the company, the SWOT analysis is presented in a summarized way to make it understandable and clear for the use of the data collected.

Table 4: SWOT Stena Line

Strengths	**Weaknesses**
Readiness to face the 2020 Sulphur Cap -STENA Line's readiness to face the challenges of the 2020 Sulphur Cap due to the fact that two thirds of their operations are performed in SECAs. -Stena`s fleet is composed for 38 vessels and only 10 of them operates outside of a SECA and fall under Global Sulphur Cap regulation.	**Readiness to face the 2020 Sulphur Cap** -Stena Line has been operating for decades, with experienced staff, successful operations, and with little competition from major shipping lines especially in Sweden as well as and adapting to their operations during this time in the Baltic Sea with little or no space or improvement through the years since the implementation of the SECA directive. This may lead to a possible state of overconfidence hence no remarkable improvement from a general perspective.

SECA Policies -Conversion of one vessel to dual fuel MGO/methanol, installed 7 scrubbers with closed loop and initiated first battery hybrid conversion.	**SECA Policies** Stena Line is more a proactive ship-owner rather than a port operator.
Investment, Internal Policies -Shore side electricity connections at about 5-10 million SEK a piece (around USD500,000-1000,000). -Cost for receiving scrubber sludge (closed loop mode) is about 4-5 euro per ton of fuel equivalent. -Ships investment have been electricity connection at about 5-7 million SEK per ship (around USD500,000-700,000). -Stena Line has also invested in onshore power supply in many ships and ports. All 5 ships in the port of Gothenburg have OPS. -Stena started with cold ironing in Gothenburg already 1990.	**Investment, Internal Policies** -Bunker operations of LFO, LSFO, MGO and MDO are handled by another Stena Company; Stena Oil, meaning that the company only relies on itself and in case of a failure it might be difficult to solve issues in real time.
Opportunities	**Threats**
-Most ships will switch to compliant fuel but to support the investments in closed loop scrubbers, the ports be able to take care of the scrubber residue.	-Authorities in different countries might implement the regulation in different ways and the penalties for not fulfilling the regulation will be limited.

Investment, Internal Policies -Budget for the battery hybrid was about 25 million SEK (USD2,5 million USD). Scrubber installations are about 5-7 million Euro per piece but that is supposed to be recovered by lower fuel prices. -In 2018 they started long term electrification/hybridization project of their ships when Stena Jutlandica got a 1 MWh battery installed. The battery is used for maneuvering in the ports. In future, Stena Line has plans to install batteries on more ships in the future and by 2020, the shipping line intends to have a full electric ship between Sweden and Denmark.	**Investment, Internal Policies** -Methanol bunker station on Majnabbe terminal for bunkering vessels with extremely strict requirements on fire safety and environmental protection.
Public Sector Role -The state financially supported the battery hybrid installation with 20%. Through the Swedish fairway dues there is also an environmental incentive. -The budget for the methanol conversion was about 14 million Euros and it was subsidized by the EU. -Swedish system uses Clean Shipping Index or Environmental Ship Index to give environmental discounts on port due or fairway dues for ship-owners that invest ahead of regulation could serve as a best-case practice.	**Public Sector Role** Enforcement must be thorough and strong with sniffers, inspections and a functioning penalty/sanction system

Source: Adapted from Stena Line´s information.

Once these elements are analyzed, the outcome of the matrix provides an overview of the role of private entities as port operators to develop the infrastructure of ports in order to provide additional services or to add value to previous ones offered by the port.

In this sense, from the SWOT analysis described in Table 4, the main objectives for Port Authorities in developing economies such as Kenya to maximize their strengths and also take advantage of the opportunities it possesses for the application of the four indicators as indicated by the researchers. The implementation of the four indicators in the port of Mombasa in same way as has been previously implemented by Stena Line as a private port operator will present numerous benefits as implementation of the IMO Sulphur directive as well as emission reduction strategy for the port of Mombasa. It will also present numerous economic gains to the ship owners through the incentives to be initiated to shipping companies for vessels that comply with the low sulphur requirements as recommended by the researchers.

The major changes presented by the rise in the use of advanced technology in the maritime sector enhance the strengths of the analysis. However, the threats expected to be experienced through the use of the four indicators can be minimized by exploring the opportunities available in the external environment

5.3. PESTLE The Port of Mombasa

The port of Mombasa has a crucial and strategic role to play in the facilitation of seaborne trade for both Kenya and landlocked countries which partially depend on the port for importation of goods. The port of Mombasa is the main seaport in Kenya and the key entry and exit point for the movement of cargo to and from the vast hinterland, which include Uganda, Rwanda, Northern Tanzania, Burundi, South Sudan, Somalia, Ethiopia and the Democratic Republic of Congo. These transit countries contribute more than 30% of cargo throughput handled at the port of Mombasa on an annual basis. Figure 8 shows the average transit market share of goods transported through the port of Mombasa in 2018.

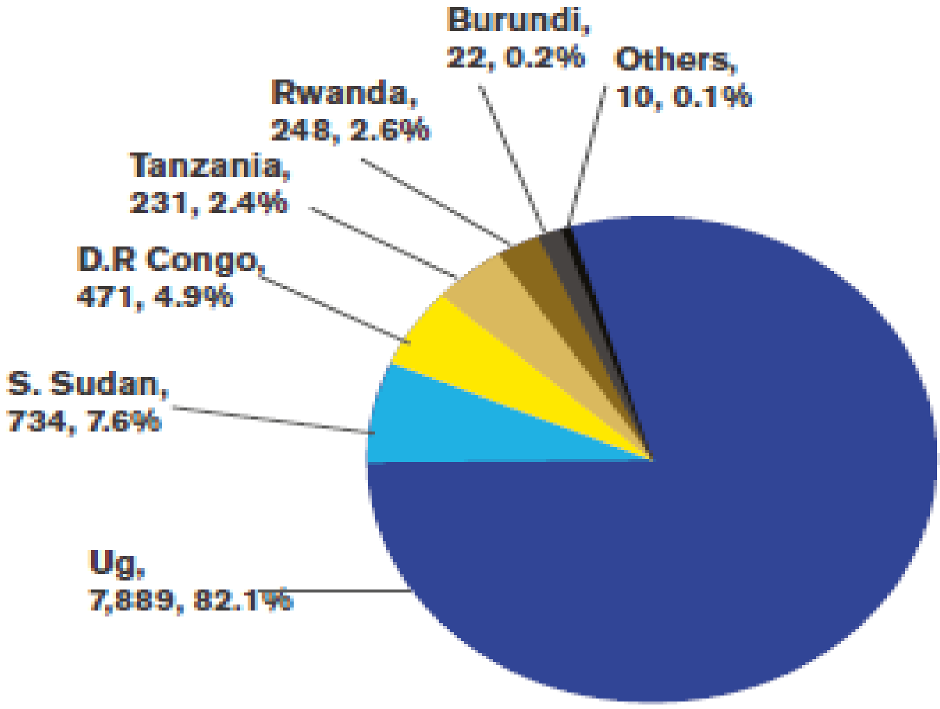


Figure 8: Transit Market Share (% share): 2018. Source: KPA

The port is managed by the Kenya Ports Authority, a state corporation under the Ministry of Transport, Infrastructure, Housing and Urban Development and fully owned by the government of Kenya. The Kenya Ports Authority is mandated to regulate all seaports on the Kenyan coastline and the inland waters. (KPA,2018)

The port comprises Kilindini harbour which is the main harbour where most of the shipping activities take place. The port also comprises Port Reitz on the eastern side, Port Tudor and Old Port on the northern side. Figure 9 gives an overview of the port of Mombasa.

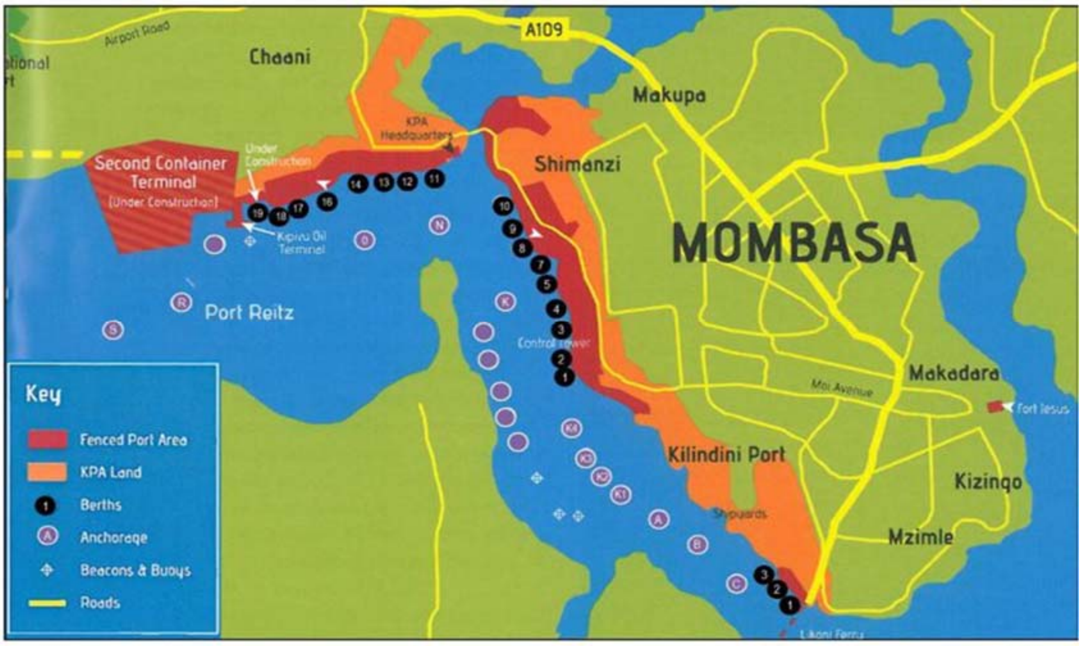


Figure 9: Map of The Port of Mombasa. Source: KPA

The port has 19 deep-water berths with 3,844 meters in total length and two oil terminals with safe anchorages as well as mooring buoys for seagoing vessels. The berths have been dredged to a depth of between 10 to 15 meters (KPA Annual Report, 2014-2015). The port has two container terminals, namely the Kipevu terminal and the Mombasa container terminal. The port is well interconnected with more than 33 shipping lines registered by Kenya Maritime Administration to operate to and from the port, thus providing connectivity directly to more than 80 ports which handle millions of exports and imports within the region.

The port of Mombasa lies in a strategic position on the East Africa Coast with maritime connections to other parts of the world. This is vital to the economy of Kenya as well as landlocked countries in East Africa, which rely on the port of Mombasa for imports. The port of Mombasa is connected to the vast hinterland through the roads and rail networks which are enabled to facilitate trade between Kenya and other parts of the region. Kenya is also part of the Northern Corridor, a multimodal trade route, which links the Great Lakes region landlocked countries with the maritime seaport in Kenya, the port of Mombasa.

The Northern Corridor member states in which Kenya is part signed the Northern Corridor Transit and Transport Agreement (NCTTCA), a treaty signed in 1985, whose main objective is trade facilitation which includes transit trade between the member states of Kenya, Uganda, Tanzania, Burundi, Democratic Republic of Congo(DRC), Rwanda and South Sudan.

Source: NCTTCA

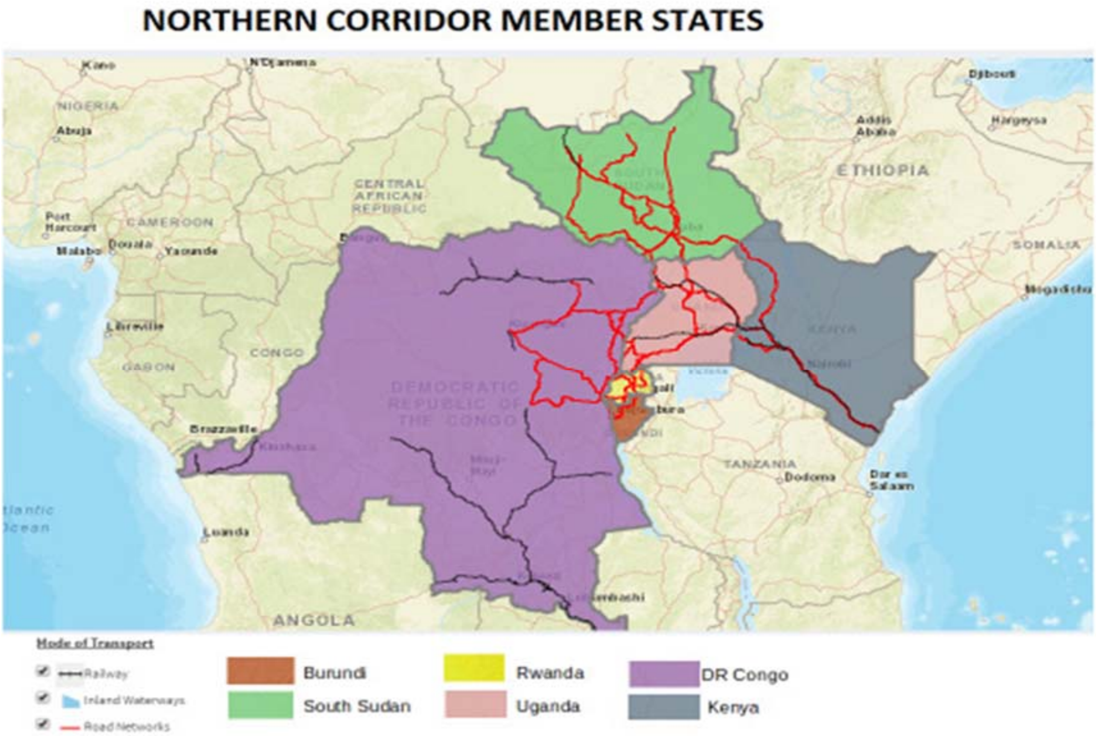


Figure 10:Northern Corridor Region:

The port of Mombasa is strategically located almost halfway between the major ports in the Middle East and the port of Durban in South Africa. It is the East African hub for international trade since its development in the late 19th century by the British during the colonial era. According to the information received, staff at the port authority were estimated to be 10,000 in total while the working days were estimated to be 255 per year less the national and international holidays. The information received also indicated that 30% of the port users use personal cars, 5% use commuter buses to and from work while the rest 65% which is the majority portion of staff commute to work by walking and live around the port area (KPA,2015).

It is estimated that over 70% of the cargo handled at KPA is destined for the Kenyan economy while 30% is destined for transit countries. China and India are so far the largest exporters to Kenya and account for 30% and 15.5% of cargo that is imported to Kenya through the port of Mombasa on an annual basis. This is followed by the United Arab Emirates in the Middle East, which accounts for 5.7% (KPA, 2015). In 2015, the top major export trading partners to Kenya was China, India, Pakistan and the United Arab Emirates with 486,212,191 and 135 deadweight tonnage of goods handled respectively. The top major import trading partners are India, the United Arab Emirates, China and Saudi Arabia at 4317,4138,3516 and 1585 deadweight tonnage of goods handled in 2015 (KPA,2015).

5.3.1. Current and Future Infrastructure Developments

The infrastructural developments and seaborne transport at the port of Mombasa support Kenya's economic development and are also in line with the Vision 2030 in ensuring the maritime industry in Kenya is supported by the development of infrastructure in order to fulfill the current and future demands of the shipping industry in Kenya. The infrastructural developments in the port of Mombasa were aligned by the Kenyan government in accordance with the Sustainable Development Goals (SDG's) among others.

Kenya is developing Lamu Port as part of the country's long term vision to transform Kenya's economy. Lamu Port is expected to have 32 berths, and a dredged channel of 18 meters in depth which is expected to enhance the accommodation of Post Panamax vessels of up to 100,000 tons (World Bank, 2017). Lamu Port development is also set to include development of Lamu Southern Sudan-Ethiopia Transport corridor (LAPSSET).

This project is categorized as one of the largest infrastructural developments in Africa and is also planned to include the port in Manda Bay, standard gauge railway to the capital of South Sudan, Juba three airports, oil pipelines to Ethiopia and Southern Sudan as well as resort locations in Kenya town of Isiolo, Lamu and shores of the second largest freshwater lake in the country, Lake Turkana. Once completed, the LAPSSET project is expected to be completed by 2030 and will directly link Kenya to the eastern Africa region, thus opening it up to socioeconomic development benefits and promote cross border trade relations (World Bank, 2017).

Other infrastructural developments have been realized at the port of Mombasa:

I. Construction of the first phase of the Standard Gauge Railway (SGR) which connects the port of Mombasa with the vast hinterland as well as the Dongo- Kundu road which since its construction has greatly contributed to ease the evacuation of imports from the port area to the vast hinterland. The third phase of the construction is expected to connect Kenya to Uganda which is the main transit country.

II. Expansion of the Inland Container Depot (ICDN)

III. Achievement of over a million TEUs in terms of cargo throughput between 2013 and 2017

IV. Completion of the first phase of the second container terminal (CT2) and launched in 2016.The CT2 increased the port capacity to handle containerized cargo from 180,000 TEUs to 450,000 TEUs.

V. Adoption of the Green Policy initiative

VI. Expansion of KPA gates 18/20 by increasing the number of lanes and canopy. Gate 10 has also been widened by 1 meter on each side; improvement of yard facilities and staking areas.

5.3.2. Mombasa Port Community Charter

The Mombasa Port Community Charter is a framework for collaboration that binds the Mombasa Port Community maritime service providers with specific obligations and collective obligations and targets with specific timelines under the following key pillars:

I. Operations Efficiency by elimination of manual processes through efficient IT platforms at the port of Mombasa
II. Development of infrastructure and capacity to effectively handle marine operations
III. Synergy and collaborative the port community
IV. Regulation and oversight engagement

It acts as a monitoring and control tool intended to realize the trade facilitation objectives of the Mombasa Port Community. The Port Community charter is comprised of a ten-member committee with member representatives from both the government and the private sector. It consists of 25 members who are assigned and tasked to fulfill certain key performance indicators each with specific targets and timelines. The KPIs are reviewed on a quarterly basis, i.e. 4 times in a year.

The Maritime Administration in Kenya is tasked as the secretariat to the charter to ensure the compliance of the port community members to the service delivery standards, establish a monitoring and evaluation framework and liaise with NCTTCA, TMEA and SCEA in monitoring the progress of the charter. In its obligations under the Port Community Charter, the Kenya Ports Authority is mandated to fulfill the following four KPIs.

I. Cargo dwell Time
II. Ship Waiting Time
III. Vessels Productivity
IV. Vessels Turnaround time
V. Integration with a national single window system
VI. Infrastructure developments

5.3.3. Population

The population of the coastal city residents and the country at large is 915,101 and 4,970,000 respectively as at the last census conducted in 2017. This high population presents a pool of qualified skilled laborers and provides immense opportunities for numerous economic interactions between the region and the outside world. The East Africa coastal region is windy with relatively high solar temperatures mainly throughout the year. This presents a good opportunity for the country to utilize solar and wind energy for industry use and also for electricity generation in the port as well as the promotion of environmentally friendly technology for the environment conservation.

5.3.4. Performance at the port of Mombasa

The following indicators of performance at the port of Mombasa were analyzed in order to partly justify the need for putting the necessary infrastructure in the port of Mombasa in light of the Sulphur directive:

5.3.4.1. Vessel Traffic Performance

The researcher undertook data for vessels that called at the port of Mombasa in 2015 as shown in Figure 11 in order to understand the current situation vessel traffic at the port and also to understand the berth related emissions in terms of port entries at the port by various types of vessels. Figure 11 also shows the nature of cargo shipped by the vessels.

5.3.4.2. Ship Turnaround Information

The researcher undertook an assessment of the time spent by vessels which call at the port of Mombasa from arrival to exit for the year 2015.This is in recognition of the fact that the emissions emanating from ships partly depend on the efficiency of the port, which is reflected by the amount of time the ship stays in the port. Data was taken from the time a ship arrives at the port to its exit.

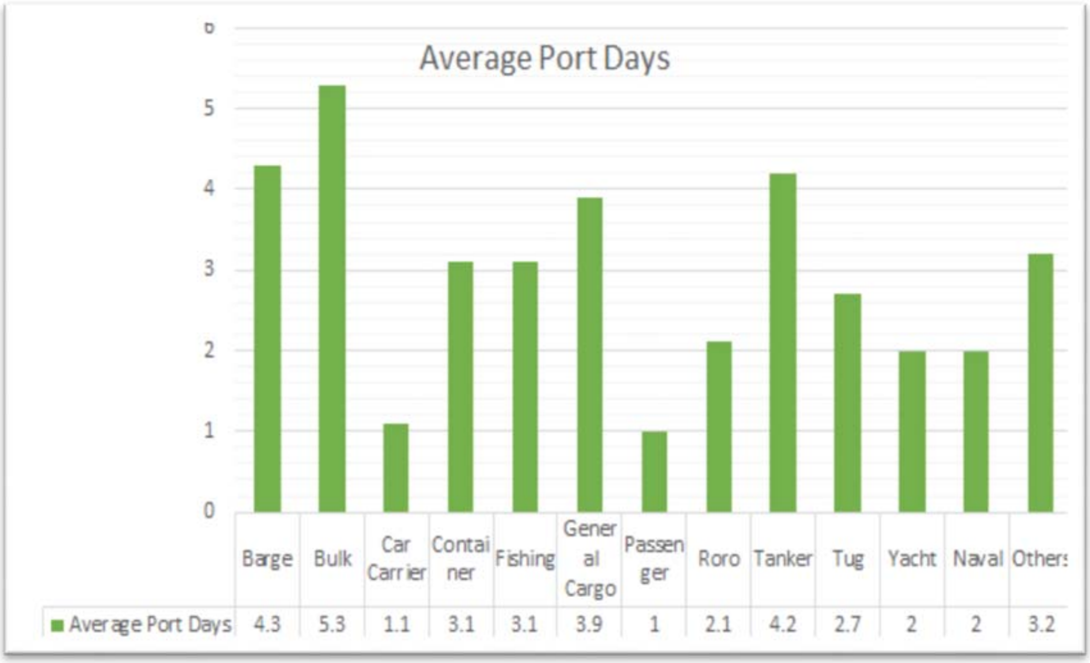


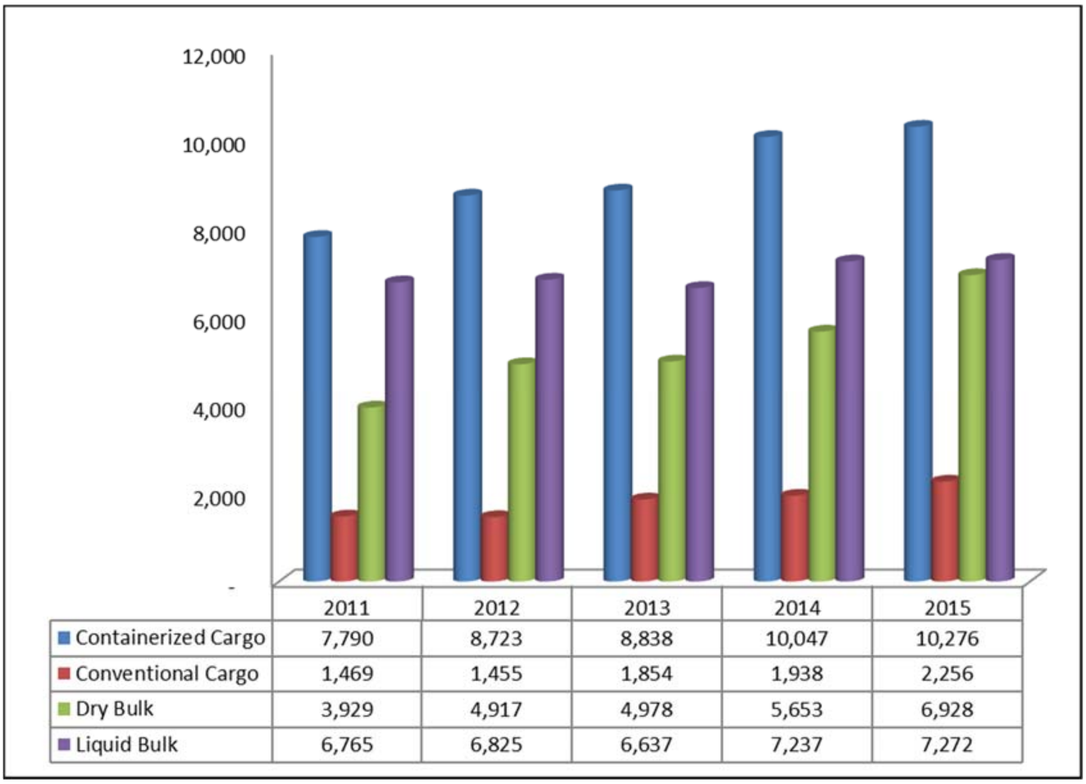
Figure 11:Average Vessel Port stays

Source: Adopted from KPA Annual Bulletin Statistics 2015

From figure 12, it can be noted that bulk carriers took the most amount of time at the port at 5.3, followed by barges at 4.3 and tankers at 4.2 average number of days respectively. Car carriers and passenger ships spent the least time in the port at 1.1 and 1 days respectively.

5.3.4.3. Cargo Throughput

Figure 13 indicates cargo throughput at the port of Mombasa for the year 2015 in deadweight tonnage (DWT) for four categories of cargo from 2011 to 2015. Figure 13 indicates a growing trend in cargo throughput from 2011 to 2015. This is mainly attributed to increasing dry bulk and containerized cargo shipments, improvement of the port infrastructure, increased efficiency in terms of port operations and removal of non-tariff barriers in the East Africa Region, thus enhancement of regional integration.



	2011	2012	2013	2014	2015
Containerized Cargo	7,790	8,723	8,838	10,047	10,276
Conventional Cargo	1,469	1,455	1,854	1,938	2,256
Dry Bulk	3,929	4,917	4,978	5,653	6,928
Liquid Bulk	6,765	6,825	6,637	7,237	7,272

Figure 12;KPA Cargo throughput from 2011 to 2015.
Source: Adopted from KPA Annual Bulletin Statistics 2015

From Figure 13, containerized cargo recorded the highest DWT handled at 7,790 in 2011 and 10,276 in 2015. This is followed by liquid bulk at 6,765 in 2011 and 7,272 in 2015. Dry bulk followed at 3,929 in 2011 and 6,928 in 2015. Conventional cargo was the least handled at 1,460 in 2011 and 2,256 in 2015. It is also observed that the amount of dry bulk handled by 2015 almost doubled the quantity handled in 2011. The steady increase in cargo throughput has contributed to port congestion over the last 5 years. However, the recent construction of the first phase of the second container terminal which was expected to increase the annual port capacity by 450,000 TEUs (KPA, 2017). The completion of the first phase of the construction of the Standard Gauge Railway (SGR) has also greatly contributed to ease the port congestion as goods are transferred to the Inland Container Depot (ICD) in Nairobi and to the environments.

Figure 13:Vessel Performance at the Port of Mombasa
Source: Adopted from KPA Annual Bulletin Statistics 2015

From Figure 11, container ships recorded the highest number of calls at 28% while bulk cargo and general cargo recorded 16% and 14% respectively. From the information given in Figure 11, the researchers deducted that container vessels make the most calls at the port of Mombasa, more than any other type of vessel; therefore, it is highly likely that they represent the greatest share of the use of fuel and consequently emissions.

It is also noted that the three aforementioned categories of vessel calls recorded 58% of the total calls at the port during 2016 whereas 42% of the vessel calls were vessels carrying other types of cargo. However, out of the remaining 42%, tankers constituted 12%

5.3.4.4. Berth Occupancy at the port of Mombasa

The researcher undertook an analysis of the berth occupancy to investigate the time occupied by different types of vessels at berth as compared to the total time. This is in recognition of the fact that 75% of the time spent by ocean-going vessels at the port is at the berth area where most of the marine fuel is consumed (ANL,2003). The berth is also characterized by the highest fuel consumption resulting in emissions of Greenhouse Gases (GHG). The expansion of the port of Mombasa through the construction of the first phase of the second container terminal which became operational in 2016 along with other areas, such as expansion of the capacities of the yards, development of berth 11-14, establishment of the cruise ship terminal among others have an impact on the emissions at the berthing areas. Figure 14 shows the average berth occupancy at the Mombasa Container Terminal.

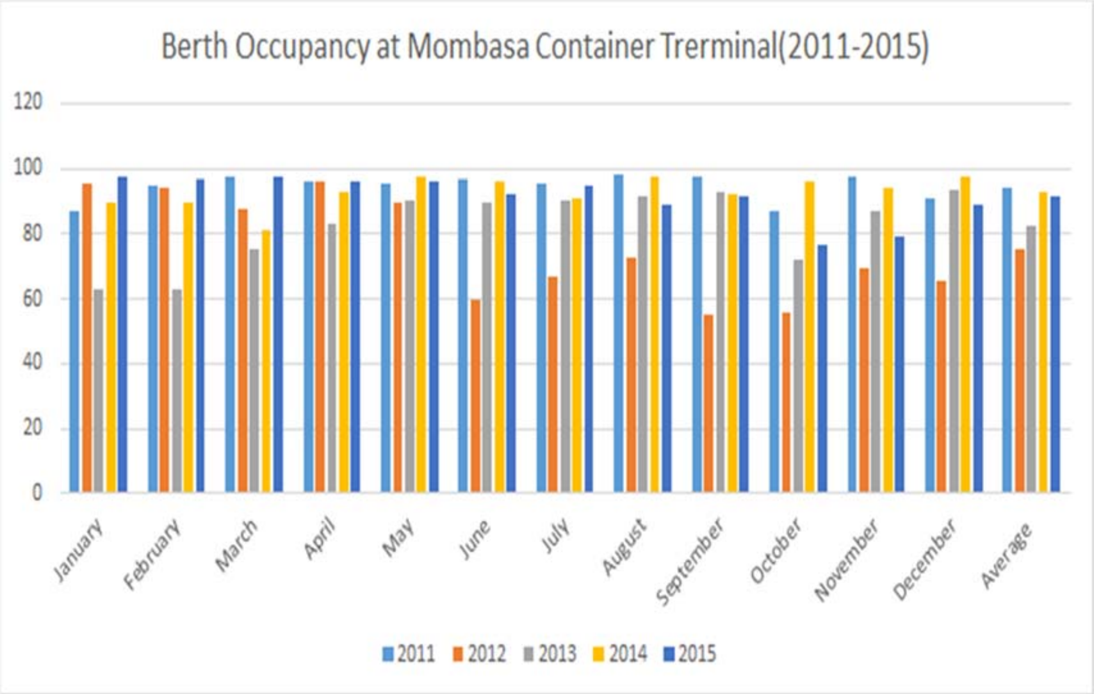


Figure 14:Berth Occupancy at Mombasa Container Terminal
Source: Adopted from KPA Annual Bulletin Statistics 2015

NOTE: Container Terminal Berth Occupancy Covers Berths 16, 17 and 18 only

Mombasa terminal recorded the highest berth occupancy during the period 2011-2015. It indicates that container ships made the most calls to the port during the period 2011 to 2017 in comparison to other ship types. This indicates congestion in the terminal and emissions as well. The port of Mombasa undertook the construction of the second container terminal which came into operation in 2016.

According to KPA Annual Report 2018, the total cargo traffic at the port has increased by 7.1% per year over the last decade from 14,419 ('000 DWT) in 2006 to 28,963 ('000 DWT) in 2017. This is attributed to the growth of the Kenyan economy as well as the neighboring landlocked countries (KPA, 2014). Over the past decade, this trend has remained steady. As a result of the increase of cargo traffic in the port over the last decade, the government of Kenya has streamlined certain development projects which are aimed at increasing the port capacity.

These include the enhancement of the second phase of the Mombasa Port Development Project (MPDP), converting berths 11 to 14 into container berths and relocation of the oil terminal at Kipevu (KOT) among others.

5.3.5. Emission Sources at the Port of Mombasa

According to the Northern Corridor, Transport Observatory Report 2017, a Baseline Emissions Inventory (BEI) was conducted on the port of Mombasa. The research focused on the various sources of emissions at the port. The research investigated pollutants which are associated with fuel combustion like sulphur dioxide (SO2), oxides of nitrogen (NOx), and particulate matter (PM). The total emissions at the port of Mombasa were also estimated by analysis of the following emission factors:

I. Emissions from ships during maneuvering.
II. Emission produced by ships while at anchorage at the port.
III. Equipment related emission whose sources include trucks, vehicles, rail locomotives that access the port on a regular basis.
IV. Electricity use at the port of Mombasa

The IMO Port Emissions toolkit 2018 also recognizes that port emissions considerations must also extend beyond ships to also include port-related emissions sources emanating from equipment for cargo handling, trucks, locomotives, domestic ships and electrical grids.

The Emissions Inventory Baseline Report 2017 indicates the magnitude of emission causes in the following order:

I. Port entrances
II. Auxiliary engines as well as auxiliary boilers while at berth

The report also indicated that while emissions at berth are less than the emissions by cruise vessels, the closer the berths are to the population at the port cities the magnitude of health impacts increases.

5.3.5.1. Emissions from Port Operations

The researcher analyzed the emissions from port operations in the port of Mombasa from operations by cranes, operations vehicles, mooring boats, engineering stations at the port terminals and fueling stations among other types of equipment in the port according to the KPA monthly average fuel utilization data for the months of February, March and April 2017 for baseline purposes as shown in Table 5.

Table 5:Average Monthly Fuel Utilization Data

Month	**Diesel**	**Petrol**	**Lubricants**	
			Liquid	**Molten(Kg)**
February	467,648	5,527	13,430	540
March	470,317	7,120	15,117	610
April	485,723	5,130	14,880	572
Average	**474,563**	**5,926**	**14,476**	**574**

Source: Adopted from KPA Annual Bulletin Statistics 2015

The Baseline Survey Report conducted in 2017 by UNEP, estimated the emissions for ships that call at the port of Mombasa while anchoring and maneuvering.

Table 6: Emissions at the Port while anchoring

Main Pollutants(Tons)				**Particulate Matter(Tons)**		**GHG Pollutants(Tons)**		
NOx	CO	SOx	NH3	PM10	PM2.5	CO2	CH4	N2O
9,544.92	595.08	6,579.96	1.996	328.865	328.865	479,302.32	2.898	20.634

Source: Emissions baseline survey 2017

According to Table6, sulphur oxides fall in the category of main pollutants whose quantity of emission exceeds all other compounds.

Table 7: Emission during Maneuvering

Main Pollutants(Tons)				**Particulate Matter(Tons)**		**GHG Pollutants(Tons)**		
NOx	CO	SOx	NH3	PM10	PM2.5	CO2	CH4	N2O
774.36	97.56	617.76	0.181	107.221	107.221	43,396.08	0.603	1.084

Source: Emissions baseline survey 2017

Note: It is important to note that ferry movements and fishing vessels were not included in the analysis

From Table7, it can be seen that the intensity of ship pollution from oxides of sulphur fall third after carbon and nitrogen oxide emissions.

Other emission compounds by sources as obtained from NCTTCA Baseline Report 2017 are summarized in Table 8.

Table 8:Summary of Port Emissions by Sources

Source	CO2	NOX	PM2.5
Rail	288,262.36	4,379.70	117.88
Electricity use	7,876,095.00	-	-
Tug and mooring boats	400,205.28	8,473.61	-
Heavy Machinery	12,402,729.65	44,257.62	-
Trucks	4,178,958.00	14,903.68	-
Employees Personal cars	4,230,000.00	-	-
Commuter Buses	117,500.00	-	-

Source: NCTTCA Emissions Baseline Survey 2017

The port emissions by sulphur compounds were not included in the report. Additionally, the members of staff interviewed by the researcher through telephone conversations did not provide such information. Emissions emanating from port expansion infrastructural projects have not been included in the analysis.

Nevertheless, these realized developments have implications in the future in terms of emissions which could have health impacts on the port city and the surroundings. According to the Emissions Inventory Baseline Report, it is projected that GHG emissions will increase by 125% by 2032 as shown in Figure 15.

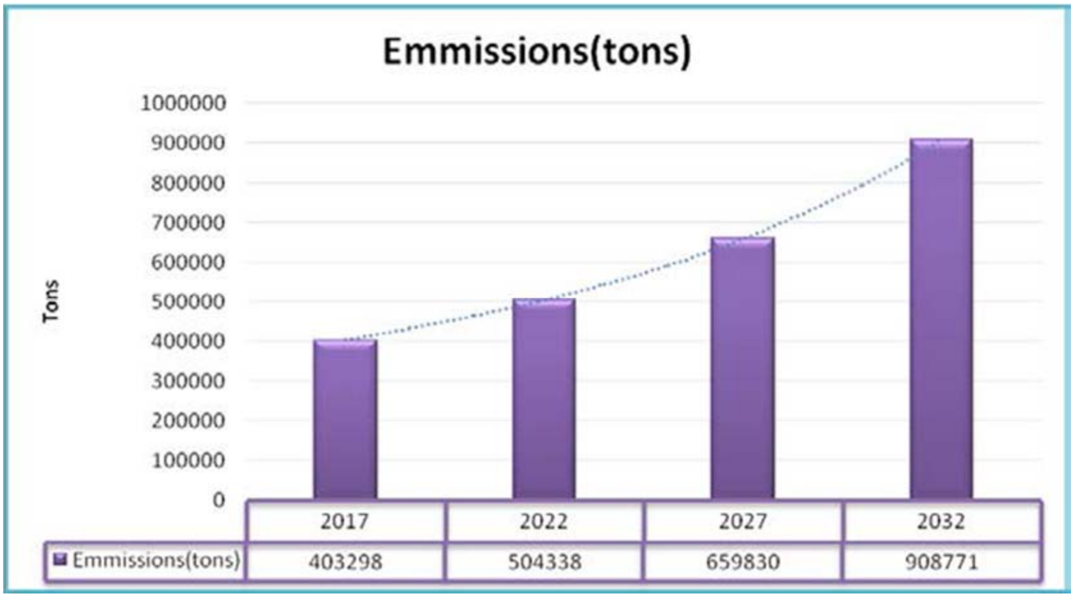


Figure 15:Emissions projection at the port of Mombasa

Source: KPA/NCTTCA 2017

The Emissions Inventory Baseline Report suggests that reducing the emissions at the port of Mombasa will need a focus on emissions from ships. The report recommends various critical interventions for emissions reduction which include the ratification of MARPOL Convention Annex VI regulations for the prevention of marine pollution from vessels a development of national regulations in line with the IMO Sulphur directive. Global practices for emissions reduction at the ports were further recommended as follows:

I. The mandatory use of low sulphur marine fuel for ships while at berth or alternatively the equivalent reduction of sulphur emission by the use of exhaust gas scrubbers

II. Establishment of incentives for sulphur reduction whereby the port of Mombasa is recommended to use differentiated port charges according to sulphur content emitted by ships while at berth by using the World Ports Climate Initiative (WPCI) model involving certain port charges in accordance with environmental performance as measured by the International Environmental Ship Index (ESI).

III. Establish mandatory use of cold ironing whereby the facilities are provided by the ports.

IV. Installation of liquefied natural gas bunkering facilities in order to make available fuel to the LNG powered ships especially the new vessels.

V. Strengthening the monitoring and evaluation framework for monitoring ship emissions at the port by requiring all vessels calling at the port to declare the capacity and type of fuel utilized by auxiliary engines at berth, monitoring the maneuvering activities of vessels while at the port,

VI. Establish awareness programs to stakeholders in the Mombasa Port Community.

5.3.6. Environmental Policy Affecting Port of Mombasa

The ISO 14000 is a framework comprising standards on Environment Management systems, life cycle analysis, performance evaluation of the environment and greenhouse gases. The purpose of these standards are to assist organizations minimize the way in which their operations negatively impact the environment. These standards also manage environmental responsibilities in a systematic manner. The environmental performance management system is meant to fulfill compliance obligations, achieve numerous environmental objectives and enhance environmental performance.

The national constitution of Kenya describes Kenya’s commitment to sustainable and ecological development. It also requires strict adherence to international regulations and agreements for which Kenya is a party to. The Bill of Rights in Kenya provides for the right of a clean environment for every citizen. The policy on climate change in Kenya is influenced by Kenya’s global and national commitments to the UNFCCC, the policy on climate change in East Africa and climate change policy in Africa as a whole. The legislature in Kenya established a Climate Change Act and a National Climate Response Strategy aimed at controlling emissions in the country. However, sulphur compounds are not included in these initiatives.

Kenya has a national strategy to limit pollutant compounds such as carbon dioxide (CO2), nitrous oxides (N20), methane (CH4) among others.

However, sulphur compounds are not included in these initiatives. The Green Port Policy is an environmental policy adopted by Kenya Ports Authority. However, it is not compliant entirely with IS0 14001 requirements.

The port of Mombasa has adopted the Green Port Policy (GPP), a policy aimed at enhancing the conservation of the environment in countries along the coastal region. The policy recommends the reduction of emissions by adopting renewable energy. It requires that all ships docking at the port of Mombasa should use electricity instead of diesel upon docking at the port of Mombasa (Kalmar, 2016).

5.4. PESTLE Analysis of the Port of Mombasa application

The researchers evaluated the external environment to ascertain the threats and opportunities for the port of Mombasa in adopting the four indicators as identified by the researchers. These were considered from a political, economic, social, technological, environmental and legal aspects using PESTEL analysis. This was conducted in order to identify the opportunities and the threats of the four identified indicators implemented in the port of Gothenburg and whose experience is replicable to the port of Mombasa. Table 9summarizes the PESTEL analysis for the port of Mombasa.

Table 9: PESTEL Analysis for Port of Mombasa

Aspect	Issue
Political	**Positive** ● Existence of an enabling political environment that supports the developments in the port of Mombasa ● Political support from the Kenyan Government as well as goodwill for the infrastructural developments ● Parliamentary passage of proposed bills regarding sustainable development goals. The constitution of Kenya recognizes and supports ecological development. In addition, Management and Coordination Act No 8 in the Kenya Constitution commits to implement the policies regarding protection of the environment from all forms of air pollution as well as to

	instill harmony in managing the environment of Kenya ● Regional Integration by establishing infrastructural developments of the port in line with the East African Community(EAC) Infrastructure master plan. ● Kenya is part of the NCTTCA treaty aimed to facilitate trade between member states. ● The Government of Kenya support of the IMOs Resolution A 979/24 calling upon governments to adopt a regional security approach against piracy by adopting an action plan to initiate negotiations with Somalia Government and other interested parties. **Negatives** ● Changes in the Government administrations leading to change in funding priorities for the port and consequently developments. ● Political interference and long tendering processes to implementation of infrastructure projects ● National and county governments competing agendas. ● Threats to of insecurity due to political instability
Economic	**Positives** ● Strategic position of the port of Mombasa in the East Africa Region attracting major shipping lines among other numerous investors ● Both global and national economic growth likely to stabilize maritime business in the future ● Increased industrial growth demand **Negatives** ● Import dependence on the port of Mombasa exposes the port and the country at large to volatility of freight rates ● Slowdown of the global economy is likely to affect the growth of Mombasa
Social	**Positives** ● Collaborations of the port of Mombasa and other Partner Government agencies to enhance trade facilitation ● The numerous infrastructural developments and the expected implementation of the four KPIs in light of the sulphur directive is expected to create employment opportunities for the growing population. **Negatives** ● High risk of accidents due to poor road network which may interfere with truck transportation of the compliant fuel as well as the sabotage of pipelines connection. ● Stakeholder participation in the port community meetings

	needs to be sustained and properly structured ● Insecurities likely to hamper movement of cargoes to the hinterland.
Technological	**Positives** ● Major technological improvements in the Port of Mombasa presents a high chance towards high efficiency and productivity ● High technology advances have enhanced reduced security threats in the port ● Advances in terms of technology for equipment at the port has increased its operational and energy efficiency and cost effectiveness. ● Enhanced tools for data analysis in the port have enabled effective methodologies for port planning and improvement in terms of capacity. **Negatives** ● Systems hacking and Cybercrime remains as threats to the port ● Continuous investments in the port to increase its competitiveness globally are demanding and require huge sums of money forcing the government of Kenya to borrow funds externally.
Legislative	**Positives** ● The KPA Act is under review. The outcome of the review will have a positive impact on the operations of the port. ● The regional legislative developments such in which Kenya is party to will positively impact on the port performance. **Negatives** ● Non-Compliance to existing policies among maritime service providers involved in the cargo clearing process. ● Conflict between national and county government regulations may hamper the development of the port. ● Increased participation in the private sector and the new developments experienced in the port of Mombasa may lead to long compliance requirements in terms of regulation
Environmental	**Positives** ● Implementation of The Green Port Policy will boost the recognition of the Port of Mombasa and enhance its attractiveness. ● The efforts of the government and the port administration is making towards energy conservation will have a positive

	impact on cost savings. ● Utilization of health compliance regulations **Negatives** ● Emissions in the port area may jeopardize the port image if appropriate action is not taken ● Carbon emissions from port users, if unchecked, negatively affect port image

After this process, the current condition of the port of Mombasa was described, showing potential opportunities and barriers to apply the results of the analysis of the previous sections. In this sense, Kenya is a very attractive country due to its geographical location and maritime orientation, and also being a friendly environment for investors. In other words, private companies may be interested in participating in the development of the port facilities to get a revenue creating added value to the current services offered in Mombasa, improving as a side effect the quality of the air in the city, and at the same time, Kenya's organizational culture is traditionally cooperative with regional and international organizations, hence the third party participation is viable. As it has been described in the previous chapters, figure 16 best describes the roadmap adopted by the researchers in describing an effective approach that can be implemented at the Port of Mombasa in preparation for the implementation of the IMO 2020 Sulphur directive.

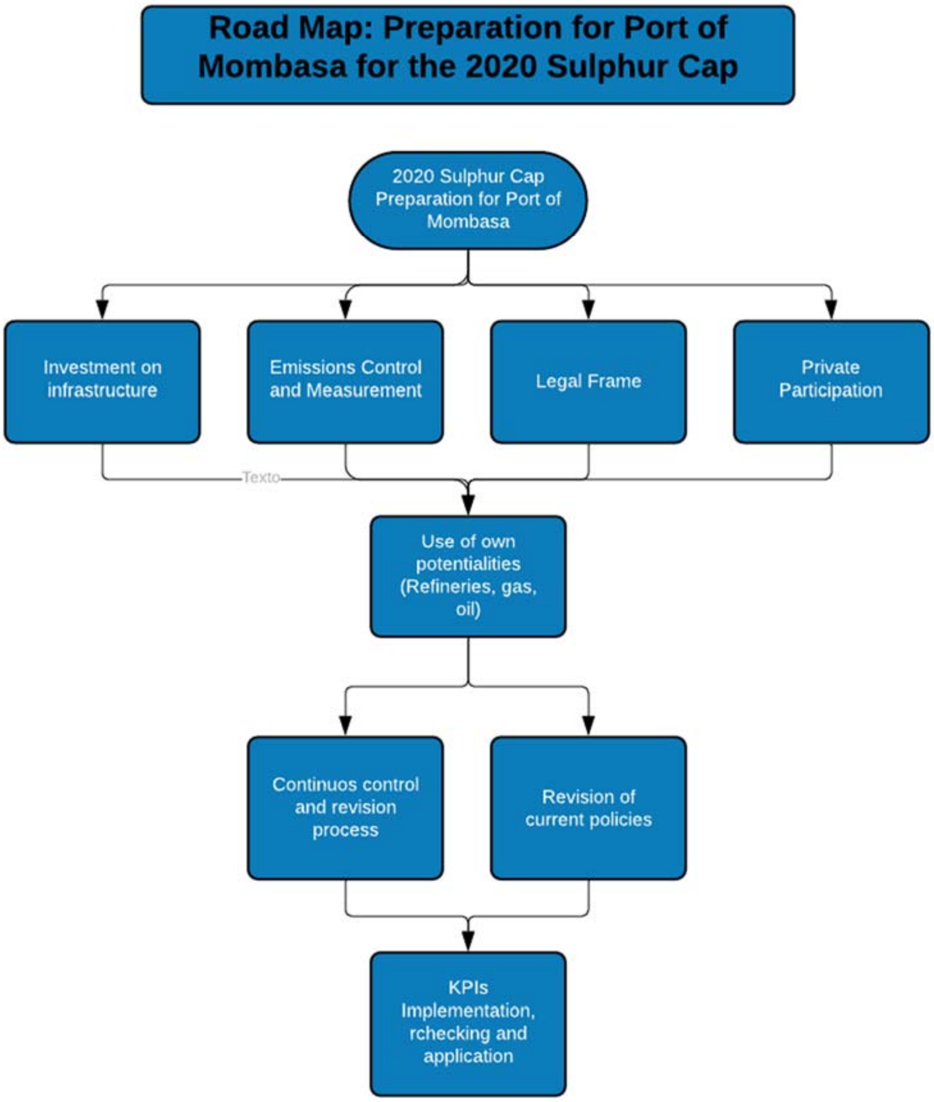


Figure 16:Roadmap for Sulphur Cap Implementation at The Port of Mombasa

6.0. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

The 2020 Sulphur Cap has already arrived, in less than 4 months (from August 2019) the whole world will be obliged to perform in the shipping business scenario under the same framework but not with the same level of preparation. The gap between developed and developing countries is still broad, and hence the technical preparation and the resources required to face the same kind of challenges are still the main reason to have delays in the efforts to reach the same level of readiness.

In this sense, the port of Gothenburg, as the biggest port in Sweden and with a history trackable to the XVI century, has been exposed to the dynamic changes in the shipping industry for over 400 years so far. In other words, it has suffered important transformations and hence massive investments through time in order to catch up with the trends and common practices in the ports around the World, but also to stay competitive in the market.

Moreover, ports are a common good of the nations as they are used to develop the economy, society and welfare of the countries. Therefore, a more proactive approach should be implemented in order to adapt them to market demands, ergo it becomes clearer that port States (as Public Sector), must not work alone in the task of keeping up-to-date port facilities but follow the trend as a good practice model, employing the private sector as a stakeholder in the port operations party.

This is the case of the port of Gothenburg, which is one facility where during the last two centuries (1900-2000), the participation of private companies in the modernization of the port has kept it always on the vanguard of the maritime trends. For instance, in 1989 Stena Line started to use cold ironing as the first company in the port aiming to reduce the consumption of fuel during cargo operations of RO-RO vessels.

In the same way, as the SECA regulation in the Baltic and North Seas were about to be enforced, the Port Authority of Gothenburg employed private companies

(Swedegas and Skånegas) to build LNG facilities to provide bunkering from ship-to-ship and from onshore-to-ship and to store the fuel at a high levels of inventory.

On the other hand, the four key indicators, namely LNG infrastructure, Onshore Power Supply (Cold Ironing), incentives to shipping companies, and Monitoring and Control Mechanisms were identified as the measures to comply with at the port of Mombasa in lieu of the IMO Sulphur regulation implementation in the Non-SECA areas. These as from January 2020 have been implemented in the port of Gothenburg among other various ports along the Baltic and North Sea region. The Kenyan Port Authority has adopted the Green Port Policy requiring that ships calling at the port of Mombasa to switch to electric power. The policy is meant to enhance the conservation of the environment by limiting emissions.

Similarly, once the data collected from Stena was analyzed, the researchers found not only numbers and explicit details, but also additional knowledge inferred once the process of combining information was obtained through secondary sources. Then, the proactive policy of this company became notorious to go one or several steps ahead of the current status of the industry at some point of time, but also the interest in participating actively in the application of regional and local policies emanated either from the Swedish Government or the EU.

As part of the findings of this research, Stena´s internal policies proved that it is not only desirable but also recommended to allow private operators to get involved actively in the procedures and operations of the ports. When they make profits from exploiting the facilities without affecting public funds, technologies are developed to contribute to the improvement of the quality of services offered at the port. However, the innovation resulting from applying ideas were not considered from the public sector perspective.

Finally, the objectives of this study were aimed to create a benchmarking analysis of the port of Gothenburg implementation of the four identified four key performance indicators implemented by the port of Gothenburg and Stena Line as a private port operator as a replicable experience for the port of Mombasa.

The research led to finding that Gothenburg's success is based on cooperation between the public sector (Government and Port Authority) and private entities (companies). Even when the investment of considerable amounts of money is required, the implementation of policies related to taxes and incentives added to the control and monitoring of emissions required by the IMO. The use of countries' potentialities (resources like gas and oil) are elements to be considered and developed in order to comply with the 2020 Sulphur Cap, hence the results of the research led to the following recommendations for the Kenyan ports.

6.2 Recommendations

According to the objectives set at the beginning of this work and the conclusions drawn *ut supra*, the researchers listed a number of recommendations aimed to satisfy what has been discussed before as the core of this paper. In concordance to the first objective, to describe the Investment Policy in the port of Gothenburg in Sweden by Stena Line related to Emissions Control for the 2020 Sulphur Cap, the recommendations are:

1. To study the port of Gothenburg as a model to develop the required KPIs, procedures and financing mechanisms to fund projects related to improve the capacities of the port of Mombasa in terms of environmental regulations and compliance.
2. To develop a network with other regional ports to increase and improve communication and common policies, and even to build infrastructure through common negotiation with different stakeholders.
3. To create communication channels with the Port Authority of Gothenburg in order to coordinate cooperation between it and the port of Mombasa, regarding technical assistance.

For the second objective, to analyze the structure and application of the Investment Policy in the port of Gothenburg in Sweden by Stena Line related to Emissions Control for the 2020 Sulphur Cap, the recommendations offered are somehow similar to the previous one but at a different level:

1. To evaluate the participation of a wider variety of private companies in the development of the port of Mombasa. When there are more options, better results can be achieved, not only in terms of offers but also in projects and improvements to be implemented in terms of procedures and infrastructure.
2. To build workshops and work teams to evaluate in real time the impact of the participation of private port operators like Stena Line in Sweden (Gothenburg), to understand and evaluate the convenience of allowing this kind of companies to be part of the improvement strategies of the port.
3. To create permanent combined commissions (Mombasa-Stena) to share information and training of human resources in order to increase the capacities of the parties to react to changes in the shipping market from different perspectives and geographical locations in the world, i.e. the wider the understanding, the better the results.

Finally, for the third objective, to propose to the Kenyan Government effective control mechanisms and necessary actions to ensure compliance and consistency in the implementation of IMO 2020 Sulphur Cap to the port of Mombasa based on the experience of Stena Line as port operator in Sweden. The researchers found that the Kenyan Government has currently taken measures to limit the intensity of emissions at the port of Mombasa. However, a lot of challenges are still being experienced. The researchers recommend the following measures:

1. Kenya Ports Authority and the Maritime administration in Kenya should work hand in hand to create awareness to the port community stakeholders and all the maritime service providers in Kenya.
2. Kenya Port Authority should consider documenting the movement of vessels in the port area to track and determine emissions
3. All vessels calling at the port of Mombasa at any time should declare the type and capacity of fuel utilized by auxiliary engines at berth. Furthermore, requirements for use of low sulphur marine fuel in engines should be made according to distance of the vessel from the coast. Additionally, regulations

should be enforced to reduce idling of vessels during movement within the port area.

4. The port of Mombasa should install relevant facilities for cold ironing and furthermore make it mandatory for vessels to switch to electricity while at berth.
5. That vessels docking at the port of Mombasa should utilize low sulphur fuel or alternatively make use of exhaust gas scrubbers.
6. The speed of the vessels when nearing the coast of Mombasa should be tracked to reduce the emissions.
7. Incentives should be initiated to shipping companies for vessels that comply with the low sulphur requirements
8. Mechanisms should be established to shift the excessive usage of heavy duty diesel machines to reduce emissions during port operations
9. Port community stakeholders in the maritime sector in Kenya should effectively established a clear path for tracking emissions at the port and coordinate to seek projects that will reduce emissions at the port as well as seek donor funding.
10. The Emissions reduction due to the Sulphur directive by the IMO should be included in the Mombasa Port Community charter and relevant companies should be given targets for emissions reductions with strict timelines for monitoring and control.

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