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COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

SCHOOL OF BUSINESS

SUPPLY CHAIN IMPLICATIONS OF CARGO HANDLING AND TURNAROUND TIME OF BULK CARRIERS IN GHANA PORTS

By

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A thesis submitted to the Department of Supply Chain And Information Systems, in partial fulfillment of the requirements for the Master's Degree in Logistics and Supply Chain Management.

DECLARATION

I hereby declare that this research work is my own work and to the best of my knowledge does not contain any material previously written and published for the purpose of awarding a degree by another person at any university or institution, except where due acknowledgement has been made in the text.

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ABSTRACT

This research work investigates the relationship between cargo handling and turnaround time of bulk carriers in Ghana ports. The study analyzed the factors influencing cargo handling efficiency and its impact on the turnaround time of bulk carriers, with the objective of providing insights and

recommendations to optimize port operations. A mixed-methods approach was employed. Firstly, a comprehensive literature review was conducted to understand the existing knowledge on cargo handling practices, turnaround time, and associated factors in port operations. This formed the foundation for developing a conceptual framework to guide the research.

Quantitative data was collected through observations and analysis of cargo handling operations and turnaround times. Key performance indicators such as cargo handling speed, waiting times, berth utilization, and equipment availability were measured and analyzed. Additionally, qualitative data was obtained through interviews and surveys with port authorities, shipping agents, and other stakeholders involved in cargo handling processes. The qualitative data provided insights into the challenges and potential opportunities for improving cargo handling efficiency and reducing turnaround time.

The findings of the research highlight several key factors that influence cargo handling and turnaround time of bulk carriers in Ghana ports. These include berth availability, port infrastructure, equipment reliability, workforce skills, customs and documentation procedures, and coordination among stakeholders. The analysis revealed that inefficient cargo handling practices, delays in customs clearance, and inadequate equipment maintenance contribute to longer turnaround times.

Based on the findings, the research proposes a set of recommendations to optimize cargo handling and reduce turnaround time in Ghana ports. These include investments in modern cargo handling equipment, streamlining of customs and documentation processes, and training programs to enhance workforce skills. The conclusions drawn from this research emphasize the importance of efficient cargo handling practices in reducing turnaround time and improving port performance. The findings provide valuable insights for port authorities, shipping companies, and policymakers in Ghana to enhance cargo handling efficiency, reduce costs, and enhance competitiveness. By implementing the proposed recommendations, Ghana ports can improve their operational efficiency, attract more bulk carriers, and contribute to the economic growth of the country.

ACKNOWLEDGEMENT

First and foremost, praises and thanks to God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully, I would like to express my deep and sincere gratitude to my research supervisor, Dr. Listowel Owusu Appiah Department of

Supply Chain and Information Systems, for giving me the opportunity to do the research and providing invaluable guidance throughout this research. His dynamism, vision, sincerity and motivation have deeply inspired me. He has taught me the methodology to carry out the research and to present the research works as clearly as possible. It was a great privilege and honor to work and study under his guidance. I am extremely grateful for what he has offered me. I will also like to extend my Profound Gratitude to my Father for His love, prayers, caring and sacrifices for educating and preparing me for my future. I am very much thankful to my Siblings, Grandmother and Friends for their love, understanding, prayers and continuing support to complete this research work.

DEDICATION

This study is wholeheartedly dedicated to my beloved Father, Mr. Samuel Amatey Osabutey, who has been my source of inspiration and also gave me strength when I thought of giving up, who continually provided moral, spiritual, emotional, and financial support. To my siblings, relatives, mentor, friends, and classmates who shared their words of advice and encouragement to finish this

study. And lastly, I dedicated this book to the Almighty God, thank you for the guidance, strength, power of mind, protection and skills and for giving me a healthy life. All of these, I offer to you.

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LIST OF ABBREVIATIONS

AGV - Automated Guided Vehicle.

BPNN - Back-Propagation Neural Network.

CART - Classification and Regression Tree.

CFS - Container Freight Station.

CHE - Cargo Handling Equipment.

CNG - Compressed Natural Gas.

CPT - Cochin Port Trust.

DWT - Dead Weight Tons.

FMEA – Failure Mode and Effects Analysis.

GDP – Gross Domestic Product.

Gh-link - Ghana Link.

GPHA - Ghana Ports and Harbors Authority.

GRA - Ghana Revenue Authority.

ICS – Institute of Chartered Shipbrokers.

ICUMS - Integrated Customs Management System.

IMO - International Maritime Organization.

ISPS – International Ship and Port Facility Security Code.

ITF - International Transport Forum.

KPIs - Key Performance Indicators.

LNG - Liquefied Natural Gas.

LPG - Liquefied Petroleum Gas.

MPS - Meridian Ports Services Ltd.

OBO - Oil-Bulk-Ore cargo ship.

PPP - Public-Private Partnership.

PROBO - Product- Ore- Bulk- Oil Carrier.

RF - Random Forest.

SOLAS - Safety of Life at Sea TEU

- Twenty-foot Equivalent Unit.

TLSP - Total Logistics Service Providers.

TT - Turnaround Time.

UNCTAD - United Nations Conference on Trade and Development.

VTT - Vessel Turnaround Time.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Ports play a pivotal role in the global economy as critical nodes in international trade and transportation networks. They serve as essential gateways for the exchange of goods, facilitating the movement of raw materials, finished products, and energy resources across continents (UNCTAD, 2020). Efficient port operations are vital for enhancing supply chain efficiency, reducing transportation costs, and supporting economic growth.

Port efficiency is a key measure of performance that encompasses various aspects of port operations. It reflects the ability of ports to handle cargo efficiently, optimize the utilization of resources, and minimize delays (Notteboom & Pallis, 2008). Measures of port efficiency include turnaround time, berth productivity, vessel waiting time, cargo handling efficiency, and customer satisfaction (Zhang, Wan, & Yuen, 2017). These indicators provide insights into the effectiveness and competitiveness of ports in supporting global trade.

Port turnaround time, in particular, is a critical factor influencing overall port efficiency. Turnaround time refers to the duration required for a vessel to complete a round trip, including the time spent at the port for loading and unloading operations (Talley, 2006). Prolonged turnaround times can lead to congestion, delays, and increased costs along the entire supply chain.

Developing countries often face specific challenges related to port turnaround time. These challenges can have significant implications for their economies. Issues such as inadequate infrastructure, limited berth availability, inefficient customs and documentation procedures, and suboptimal cargo handling practices contribute to prolonged turnaround times (Nyame & Ramanathan, 2018). These delays affect trade flows, increase transportation costs, and hinder economic growth.

Among the determinants of turnaround time, cargo handling equipment plays a crucial role. Efficient and well-maintained equipment, including cranes, forklifts, conveyors, and other specialized machinery, enable smooth cargo operations and contribute to faster turnaround times (Zhang, Wan, & Yuen, 2017). Properly utilized handling equipment improves the productivity and effectiveness of cargo handling processes, reducing vessel waiting times and optimizing port operations.

Turning our attention to Ghana's ports, they serve as critical gateways for international trade and are essential for the country's economic development. Ghana's ports, including the Port of Tema and the Port of Takoradi, handle significant volumes of bulk cargo, such as oil, gas, and minerals. However, they also face challenges in terms of turnaround time and overall port efficiency.

Statistics indicate that Ghana's ports have experienced varying levels of turnaround time performance. Prolonged vessel waiting times, delays in cargo handling, and inefficient customs and documentation processes have been observed (GPHA, 2020). These issues not only impact the operations of the ports themselves but also have broader consequences for trade facilitation, supply chain efficiency, and economic growth in Ghana.

This research aims to investigate the relationship between cargo handling and turnaround time of bulk carriers in Ghana's ports. By focusing on the role of cargo handling equipment, the study seeks to identify the factors influencing turnaround time, assess current challenges, and propose strategies to optimize cargo handling processes. The findings of this research will provide valuable insights to port authorities, policymakers, and stakeholders, enabling them to enhance port efficiency, reduce turnaround time, and drive sustainable economic development in Ghana.

1.2 Problem Statement

The delays experienced by vessels at Ghana's ports, particularly in the context of bulk carriers, have emerged as a critical problem that significantly impacts port operations, supply chains, and the macro economy. These delays, resulting from various factors such as inefficient cargo handling processes, inadequate infrastructure, and suboptimal customs procedures, have severe implications for the overall efficiency and competitiveness of the ports, as well as Ghana's trade facilitation efforts and economic growth (UNCTAD, 2020). Addressing the specific issue of turnaround time for bulk carriers requires a deeper understanding of the role of cargo handling equipment and its impact on delays and operational performance.

While previous studies have contributed to the understanding of port delays and turnaround time, they have predominantly focused on general performance indicators and factors influencing overall efficiency (Notteboom & Pallis, 2008). However, there exists a research gap concerning the specific role of handling equipment in contributing to delays and turnaround time performance, particularly in the context of bulk carriers in Ghana's ports.

Cargo handling equipment, including cranes, forklifts, and conveyors, plays a critical role in facilitating efficient loading and unloading operations. Inadequate equipment capacity,

inefficient utilization, and inadequate maintenance practices can lead to delays and longer turnaround times (Talley, 2006). It is essential to conduct research focused on examining the relationship between handling equipment and turnaround time in Ghana's ports. Such research will shed light on the factors that contribute to delays, identify areas for improvement, and develop strategies to optimize the performance of handling equipment (Zhang, Wan, & Yuen, 2017).

Therefore, the overall focus of this study is to investigate the relationship between cargo handling and turnaround time of bulk carriers in Ghana's ports, with a specific emphasis on the role of handling equipment. By comprehensively examining the efficiency and effectiveness of handling equipment, the study aims to identify the key factors contributing to delays and longer turnaround times. It also seeks to develop strategies to improve equipment utilization, maintenance practices, and overall performance, with the ultimate goal of optimizing turnaround time, enhancing port efficiency, and bolstering the competitiveness of Ghana's ports in the global market.

1.3 Objectives of the Study

The dissertation aims to identify factors that affect turnaround time of bulk carriers The following objectives are expected to be achieved at the end of the research study:

i. To identify factors that directly and/or indirectly influence Vessel Turnaround Time
ii. To identify the nature of relationships those controllable factors are having with turnaround time. iii. To identify most critical factors that need to be given priority to achieve quicker turnaround time

1.4 Research questions

i. What are the factors that influence Vessel Turnaround Time directly or indirectly?
ii. What relationship does those controllable factors have with turnaround time?
iii. What are the critical factors that need to be given priority to achieve quicker turnaround time?

1.5 Significance of the study

The study on cargo handling and turnaround time of bulk carriers in Ghana's ports holds significant significance for multiple stakeholders in the industry, academia, and the economy.

This research has the potential to drive operational improvements, enhance competitiveness, contribute to academic knowledge, facilitate trade, stimulate economic growth, and generate positive outcomes for various stakeholders within the industry, academia, and the broader economy of Ghana.

In terms of industry significance, the findings and recommendations of this study will assist port authorities, shipping companies, and logistics providers in optimizing cargo handling processes and reducing turnaround time. By improving operational efficiency, ports can achieve cost savings, increase throughput, and enhance customer satisfaction. This study also offers a competitive advantage for Ghana's ports. By addressing the specific challenges related to cargo handling and turnaround time, these ports can establish themselves as reliable trade hubs within the region, attracting more shipping traffic and investments. The optimized operations resulting from this research will benefit not only the ports but also the entire supply chain. Faster turnaround times will lead to improved supply chain performance, reducing transportation costs, inventory holding costs, and minimizing disruptions, benefiting importers, exporters, and other stakeholders involved in the supply chain.

In the realm of academia, this study fills a research gap by providing comprehensive insights into the relationship between cargo handling and turnaround time, particularly focusing on bulk carriers in Ghana's ports. It contributes to the body of knowledge on port operations, especially in developing country contexts, and expands the understanding of factors influencing turnaround time. Researchers can build upon this study's insights and expand their investigations in related areas, benefiting academia and generating further knowledge.

From an economic perspective, this study holds significant implications for trade facilitation. Ghana's ports serve as crucial gateways for international trade, and reducing turnaround time is paramount for efficient trade flows. By improving cargo handling processes and decreasing delays, this research contributes to enhanced trade facilitation, attracting more importers, exporters, and multinational corporations to utilize the ports for their trade activities. Efficient port operations also have a direct positive impact on the broader economy. Reduced turnaround time increases the competitiveness of Ghana's ports, stimulating foreign direct investment, generating employment opportunities, and fostering economic growth. Moreover, improved port efficiency translates into increased revenue for the government through higher volumes of trade, improved customs processes, and reduced costs for importers and exporters. This revenue can be reinvested in infrastructure development, further enhancing the port's capacity and supporting economic expansion.

1.6 Research Methodology

The research will employ a purposive sampling technique to select ports in Ghana that handle bulk carriers, considering factors such as cargo throughput and representativeness. Data will be collected through direct observations, measurements, interviews, and surveys with port authorities, shipping agents, and cargo handlers. Quantitative data will be analyzed using descriptive statistics and correlation analysis, while qualitative data will be analyzed thematically. Ethical considerations will be prioritized, including informed consent, confidentiality, and adherence to ethical guidelines and regulations.

1.7 Scope of Study

The study examines the relationship between improved efficiency of bulk cargo handling equipment used in the seaports of Ghana (Tema) and the effects it has on the total turnaround time of bulk cargo carriers. The researcher examines time spent in the seaport over a period of 10years based on the efficiency of these handling equipment present in the port and how improving such efficiency can shorten time spent in the Ghanaian seaports.

1.8 Limitation of study

One limitation of this study on cargo handling and turnaround time of bulk carriers in Ghana's ports is the focus solely on handling equipment as a determinant of turnaround time. While handling equipment plays a significant role in port operations, there are other factors that contribute to delays and turnaround time, such as berth availability, customs procedures, infrastructure limitations, and coordination among stakeholders. Exploring these additional factors could have provided a more comprehensive understanding of the challenges and opportunities for improving turnaround time in Ghana's ports. Incorporating a broader scope of determinants would have enriched the study and offered a more holistic perspective on port efficiency. Future research could consider addressing these additional factors to further enhance the knowledge base in this area.

1.9 Organization of Study

This study follows a five-chapter approach. Chapter one introduces the study and presents the background of the study, research problem and related objectives and questions. The relevance of the study and the scope is also presented. Limitations faced and a brief methodology was touched on as well

The second chapter of the study presents the review of literature relevant to the study. Conceptual and theoretical literature reviews are presented which is followed by the conceptual framework of the study.

Chapter three explains the methodology used in the conduct of the study. A thorough explanation of the research design, data collection and analysis procedures are presented.

With Chapter four, the findings of the study are presented and analyzed with reference to previous studies and theories.

The final chapter summarizes the findings from the field study and its analysis. The section presents the researchers' concluding remarks and the implications of the study.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This chapter covers reviewed literature material relevant to the chosen topic. This chapter identifies factors that affect turnaround time of bulk carriers in the light of determining key influencers that can be controlled by terminal operators in the Tema port and to provide cost

effective and efficient services with high port productivity. It reviews the conceptual and theoretical framework of bulk cargo handling equipment and vessel turn-around time, it mentions some key concepts, history and prospects of the Tema port, it discusses bulk cargo handling equipment and terminal associated challenges and further discusses the performance of the Tema port. The sources of the literature are from text books, periodicals and magazines, articles, peer reviews, journals and the organization reports were also used to assist the study.

2.1 Definitions:

2.1.1 Cargo Handling Equipment (CHE):

Cargo handling equipment are used to transport goods and materials from one location to another. They vary according to cargo type. Cargo handling equipment are employed widely in marines and railways for the transportation of heavy goods, containers, and components. Cargo handling equipment Vehicle generally comprises cranes, container handlers, yard tractors, forklifts, reach stackers, top and side handlers, hopper and conveyor belts. (Sislian, Jaegler, & Cariou, 2016)

2.1.2 Cargo/Bulk Cargo:

Cargo just as freight refers to goods or produce carried in a truck, van, airplane, train, or ship. We can transport cargo by land, sea, or air. Bulk cargo is shipped loosely and unpackaged in large quantities as opposed to being shipped in packages or containers. They are typically dropped or poured directly into a railway car, tanker truck, or the hold of a ship. It can be classified as either liquid or dry. They include oil, grain and coal. (Market Business News, 2022).

2.1.3 Bulk Carrier:

SOLAS (Safety of Life at Sea) CHAPTER XI defines bulk carrier to be a ship which is generally constructed with a single deck, topside tanks and hopper-side tanks in cargo spaces. (Marine Insight, 2020).

2.1.4 Cargo Terminal:

A cargo terminal is a place where goods are transferred between any two or more freight transport modes. In this interface unit loads are collected, exchanged, stored and/or distributed. The

handling operations at the freight terminal may include the same transport mode or two different transport modes. (Wiegmans, Masurel, & Nijkamp, 1999).

2.1.5 Vessel Turn-around Time:

Vessel Turnaround Time (VTT) is defined as the length of time a vessel spends in port from arrival to departure. (Premathilaka, 2018). Although it is conveyed as a specific time measure, it is a summation of several sub activities including waiting time for a berth, maneuvering time, mooring/unmooring time, idle time, cargo handling time and other time components until the vessel leaves port limits (Moon, 2018).

2.1.6 Port Performance, Efficiency and Productivity:

Productivity in any system is that the output in relation to input and may be a measure of efficiency within the utilization of resources. In turn, efficiency is one amongst the 3 basic output dimensions of the structure performance ie. Performance = effectiveness, efficiency and participant satisfaction. Effectiveness cares with accomplishment of express goals, while efficiency refers to the ratio of output to input or profit to price. In case of port ratio of time, cost, capacity etc. Represent the overall efficiency. This efficiency has a considerable impact on the economy. (Begum, 2003)

2.2 Empirical Review of Issues on Port Efficiency, Turnaround Times, and Productivity:

Efficiency, turnaround times, and productivity are crucial aspects of port operations that directly impact global trade, supply chains, and economic growth. Numerous empirical studies have explored these issues, shedding light on challenges, determinants, and potential solutions in various ports across the world.

2.2.1 Determinants of Port Efficiency:

A study by Notteboom and Pallis (2008) examined factors influencing port efficiency, including infrastructure, technology, and regulatory frameworks. They found that well-maintained infrastructure, advanced technologies, streamlined procedures, and effective governance are pivotal for improving port efficiency.

2.2.2 Turnaround Times and Delays:

Talley (2006) investigated port efficiency as a function of geography and location. The study highlighted that geographical factor, such as proximity to markets and trade routes, significantly affect turnaround times. Ports located closer to major markets tend to have shorter turnaround times due to reduced transportation distances.

2.2.3 Cargo Handling Equipment and Productivity:

Zhang et al. (2017) conducted an empirical review of port efficiency evaluation methods. They emphasized the role of cargo handling equipment in enhancing productivity. Efficient cranes, forklifts, and conveyors were identified as crucial for speeding up cargo operations, reducing vessel waiting times, and ultimately improving port productivity.

2.2.4 Customs and Documentation Processes:

The role of customs procedures in port efficiency was explored by Rajeevan & Balasubramanian (2012). The study revealed that efficient customs clearance processes, supported by electronic data exchange systems, significantly reduce delays and enhance turnaround times.

2.2.5 Technological Advancements:

A comprehensive study by Monios and Bergqvist (2020) examined the impact of digital technologies on port efficiency. They highlighted how automation, data analytics, and real-time information sharing enhance cargo handling processes, minimize bottlenecks, and optimize vessel turnaround times.

2.2.6 Environmental Considerations:

Kim et al. (2019) investigated the relationship between environmental factors and port efficiency. They found that sustainable practices, such as energy-efficient technologies and reduced emissions, not only contribute to environmental preservation but also positively impact overall port operations, including turnaround times.

2.2.7 Comparative Analysis:

An empirical study by Thanopoulou et al. (2008) conducted a comparative analysis of port efficiency across Mediterranean countries. They identified variations in turnaround times and attributed them to differences in infrastructure, operational practices, and regulatory frameworks.

2.2.8 Case Study in Developing Countries:

Nyame and Ramanathan (2018) conducted a case study on factors influencing port performance in Ghana, a developing country. The study highlighted the challenges of inadequate infrastructure, inefficient customs processes, and limited equipment capacity, all of which contribute to extended turnaround times.

2.2.9 Impact of Infrastructure Investments:

An empirical study by Coto-Millán et al. (2013) explored the impact of infrastructure investments on port efficiency in Spain. The study concluded that well-planned investments in infrastructure, such as berths and handling equipment, have a positive influence on port productivity and turnaround times.

2.2.10 Port Types and Specialization:

A comparative analysis by Haralambides et al. (2018) examined the efficiency of container and bulk terminals. The study found that specialized terminals tend to have shorter turnaround times due to focused operations and optimized equipment allocation.

In conclusion, empirical studies on port efficiency, turnaround times, and productivity provide valuable insights into the multifaceted challenges and opportunities in port operations. These studies underline the importance of infrastructure, technology, customs processes, environmental considerations, and strategic investments in enhancing overall port performance. The findings underscore the need for collaborative efforts among port authorities, stakeholders, and policymakers to optimize efficiency, reduce turnaround times, and promote sustainable growth in the global maritime industry.

2.3 Theory on Cargo Handling Equipment:

Cargo Handling Equipment (CHE) is any equipment used in ports, rail yards, and warehouse distribution centers to either handle freight or carry out additional on-site tasks like maintenance or repairs. Liquid, bulk (both break bulk and dry bulk), and containers can all be included in the cargo that arrives and/or departs via ship, truck, or train. Kokila & Abijath (2017) conducted a thorough study on the vessel turnaround time at Cochin Port Trust (CPT) to investigate the contributing factors to the slow ship turnaround times. Anindita, Soma, and Jhumoor (2016) looked at 13 of India's largest ports' performance in terms of key operational performance indicators. Their study examined the status of each port in many performance categories by conducting a systematic analysis of various performance indicators over a tenyear period (2003 to 2013).

The work created an integrated composite performance index to analyze the relative overall performance of various ports. Padmasani (2016) found that seven of the thirteen major ports' performance appears to be improving but is still inefficient given their current infrastructure. Dinu, Rosca, Dragu, and Ilie (2018) found that a number of factors, including the current quayside capacity and the terminal productivity of the bulk handling equipment, can be identified as dominantly affecting the overall wharf operations efficiency. Researchers looked for ways to alter throughput to improve transmission function using ARENA software and other analytical models. Li, Hong, Geng, and Wang (2017) claimed that accurate forecasting of arrival vessels can improve terminal performance by knowing its whereabouts.

2.4 Conceptual Framework:

Kindly refer to figure 2.1 for a diagrammatical view.

The terminal operation is highly competitive and complex, employing a variety of performance measures to increase productivity. Vessel Turnaround Time (VTT) is a widely utilized parameter when it comes to cargo vessel operations globally. It is a function of independent variables (Xi) and an uncontainable constant (α).

$$VTAT(Y) = f(Independent\ variables\ (Xi\ )) + \alpha$$

A multivariate statistical method known as multiple regression is used to look at the relationship between a single dependent variable and a group of independent variables. Different input and outputs of vessel turnaround time at the port need to be taken into consideration, such as availability of tugs and pilot, custom clearance, vessel breakdown, availability of ship-loaders and unloaders, cargo availability, berth availability, equipment breakdowns, speed of the

conveyor belts, poor planning, cargo separation, cargo condition, weather condition, workmanship of both technical and operation employees, cargo spillages on transfer points, route readiness, shift change, cargo separation, availability of front-end loaders, and cross contamination.

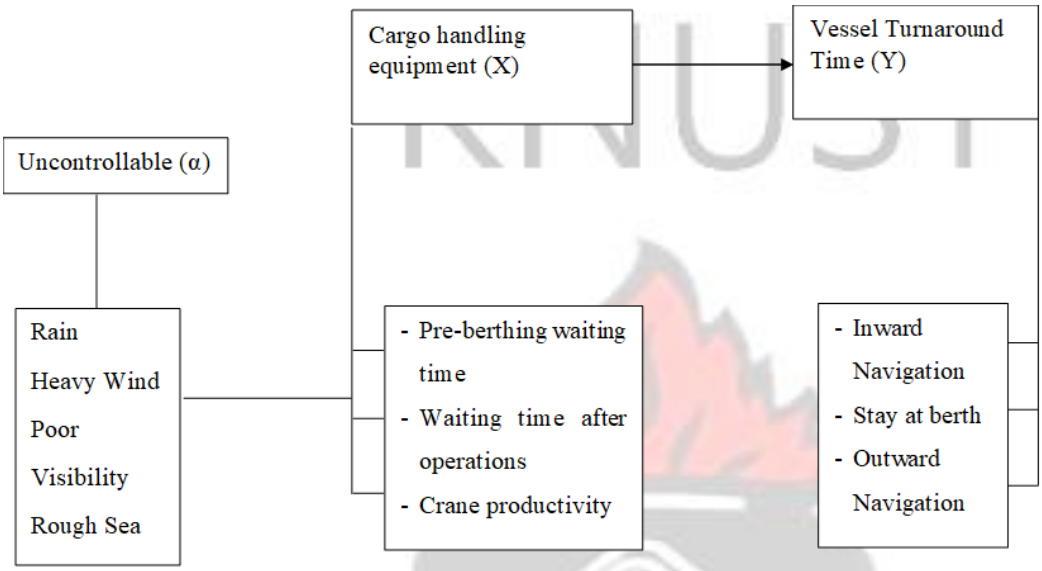

Figure 2. 1 – Conceptual framework

Source: Field work, 2023

2.5 Emergence of Bulk Cargo:

Unpackaged products that are transferred in huge numbers and transported in vehicles specially made for this use, such as bulk carriers or dry bulk ships, are referred to as bulk cargo. Bulk freight examples include fertilizers, cement, iron ore, grains, coal, and iron. (Inbound Logistics, 2023)

Many types of bulk cargo, including liquid and dry products, each have their own features and handling needs. When anything is shipped in its raw, unprocessed state, such as grains, minerals, ore, it is referred to as dry bulk cargo. Large, specialized bulk carrier ships are commonly used to transport and store solid bulk cargo. Solid bulk cargo handling and storage are both rather simple procedures. The load is kept in its unmodified state without any additional packing. On the other hand, liquid bulk cargo refers to goods transported in liquid forms, such as oil, chemicals, and liquefied gasses.

The majority of the time, tankers, or specialized ships, are used to transport and store liquid bulk cargo. Because liquid bulk cargo must be handled and stored under regulated circumstances in order to prevent spills, leaks, and other sorts of environmental contamination, it requires more

effort than handling and storing dry bulk cargo. Liquid and dry cargo each carry different kinds of risks when being transported. Physical harm or loss is one of the biggest risks for dry cargo. Inadequate handling, stacking, or securing of the cargo during loading and unloading operations might result in this risk, which could lead to the loss or damage of goods. Theft is another risk element because dry cargo can be targeted for hijacking while in transit.

Spills or leaks are one of the major risk issues for liquid cargo. The tanker or pipeline may sustain structural damage, there may be a human error during loading, unloading, or transit activities, or there may be leakage. The people in charge of shipping or storing the commodity may suffer financial losses in addition to negative environmental effects. Cargo contamination, which renders the cargo unsafe or unusable, is another risk element. The bulk cargo market is very huge and several industries rely on bulk cargo shipping to transport goods globally. (Inbound Logistics, 2023)

2.6 History and Types of Bulk Cargo Vessels/Bulkers:

When it comes to ancient ships, hauling bulk freight was the main focus of their basic designs, according to the history of commercial transportation. Bulk carriers have arguably existed since the first commercial ship set sail. Bulk carriers, sometimes referred to as bulkers in logistical jargon, are commercial ships that are employed for the bulk transportation of unpackaged goods like cereals, cement, grains, coal, ore, etc.

The concept of using a bulk carrier to move valuable minerals, ores, and food grains dates back to the 1850s. Yet, there have been a number of significant improvements in the design and application of the vessel type over time. A bulk carrier features top side and hopper-side tanks with corrugated transverse bulkheads and is designed to transport dry bulk goods. Specialized bulk carriers were produced as a result of the popularity of steam-powered vessels.

In the year 1852, a British coal carrier by the name of "SS John Bowes" served as the first bulk carrier. Bulk haulers of this era used water as ballast rather than sandbags. Conveyor belt loading and unloading of freight was also developed at this period. This reduced the loading and unloading times because it not only offered an effective technique to handle the cargo operation, but also increased its speed. Bulk carriers with diesel propulsion entered the market later in 1911. Few ships, such as "Liberty ships" and other war-built ships, such as Victory and

Fort class ships, were utilized to transport large cargoes during and after World War II. We can claim that the genuine bulk carrier idea first appeared in the 1850s when ships began carrying

heavy loads to save time and money. The double bottom structure was introduced for single deck ships in 1890, long before the idea of the bulk carrier.

Triangular-shaped topside tank structure was introduced for a cantilever-framed ship in 1905. The first specifically designed bulk carrier ship was constructed in the late 1950s and had crew quarters at the aft, an engine room layout at the aft, derricks for cargo movement, three to five cargo holds, and no tween decks. The Japanese-designed and -built Freedom Ships, which were widely used to transport bulk cargoes during that time, became quite popular. As time went on, other bulker classes were also constructed. Ships were equipped with cranes rather than derricks to increase cargo operations' versatility.

Handy size bulkers are still quite frequent since over time smaller ships entered service as a result of easier accessibility in smaller ports. However, during 1980s the ship-owners invested in bigger size bulk carrier ships as they gave them the scope to transport more amount of cargo in less time, making the trade more profitable.

Bulk carriers currently account for about 21% of the world's commerce fleet. More than 25% of all bulk carriers are only registered in Panama, whereas more than 50% of them have owners from Greece, Japan, or China. If we are solely discussing shipbuilding, South Korea is the most well-known shipbuilder, and 82% of all bulk carriers are constructed in Asia. These changes have made sure that bulk carrier ships will always be a crucial component of the maritime industry (Wankhede, 2019).

2.7 Some Types of Bulk Carriers as Per Size

2.7.1 Mini Bulk Carrier:

The dead weight tonnage of these vessels is less than 10000. They have less than 5 cargo holds and they typically carry minor or general cargo.

Figure 2. 2 - Mini Bulk Carrier

Source: (Kepler, 2020)

2.7.2 Handy Size Carriers:

The dead weight tonnage of these vessels is between 25000 to 40000 tonnes. They usually have 5 holds and they carry minor bulk or steel products in general (Wankhede, 2019).

2.7.3 Handymax Carriers:

The dead weight tonnage of these vessels is between 40,000 to 60,000 tonnes. They usually have 5 holds and in general, they carry minor bulk, steel products, coal and grains. (Wankhede, 2019)

Figure 2. 3 - Handymax Bulk Carrier

Source: (Natal, 2013)

2.7.4 Panamax Carriers:

These ships range in dead weight tonnage from 60,000 to 100,000 tonnes. Typically, they have seven cargo holds. It was designed to transit the Panama Canal. Bauxite, coal, grain, ore, phosphate, etc. are typically carried by them. The largest width of these vessels is 32.2 meters. 2019 Marine Insight (Wankhede, 2019)

2.7.5 Post-Panamax Bulk Carrier:

The dead weight tonnage of the Post-Panamax Bulk Carrier ranges from 80,000 to 120,000 tonnes. These ships were made to pass through the new locks of the Panama Canal and have more width than Panamax. Typically, they have five holds. (Wankhede, 2019)

2.7.6 Capesize Bulk Carrier:

These vessels have a dead weight tonnage of between 100,000 and 200,000 tonnes. Normally, they contain nine cargo holds. These ships bypass the Suez Canal and sail from Asia to Europe. They depend on onshore infrastructure for loading and unloading because they are entirely gearless and lack cranes or derricks.

Figure 2. 4 - Capesize Bulk Carrier

Source: (Almeida, 2014)

2.7.7 VLBC (Very Large Bulk Carriers):

Around 200,000 tonnes of dead weight tonnage are carried by these vessels. They depend on onshore infrastructure for loading and unloading because they are entirely gearless and lack cranes or derricks. Typically, they have nine cargo holds or more.

Figure 2. 5 - Tubarao Maru

Source: (Kantharia, 2022)

2.7.8 OBO- Oil Bulk Carrier

The acronym OBO stands for Oil-Bulk-Ore cargo ship. They are specifically made ships that can transport bulk goods in both liquid and dry form. They are among the most technologically advanced cargo ships operating today.

Figure 2. 6 - OBO Carrier

Source: (Aury, 2023)

They consist of the PROBO (Product- Ore- Bulk- Oil) carrier and the Combination carrier. OBO ships cost more to build, but because they can transport both wet and dry cargo at once, they offer a more cost-effective choice by lowering the frequency of empty or ballast excursions. A tanker can only transport liquid cargo, and a bulk carrier can only transport dry freight. Due to this, the two types of vessels can only go on fixed routes with the least amount of flexibility.

OBO vessels, on the other hand, are versatile, allowing them to operate on various voyages in accordance with market supply and demand in order to maximize profit. From 1955 through 1980, these vessels dominated the market. One of the largest OBO carriers at the time was the MV Derbyshire, which weighed about 180000 DWT. Unfortunately, after battling a terrible storm and transporting ore as cargo, it drowned in the Pacific Ocean (Marine Insight, 2020).

2.8 Overview of Bulk Cargo Handling Equipment

A key component of port operations is cargo handling equipment (CHE), and ports, which are crucial to trade and economic vitality, rely on a variety of equipment, including vehicles and machinery, to transport cargo from one place to another. The purpose of this cargo handling equipment is to make it easier to transfer the goods between the ship's side and any transit shed, warehouse, barge, railway wagon, or road vehicle (Burnham, 2022).

Early on, the majority of cargo handling equipment was powered by diesel or gasoline, and emissions from this equipment contributed to poor air quality that affected port employees as well as people who lived and worked in nearby communities. Equipment used in ports that is powered by diesel and gasoline emits greenhouse gases that add to climate change (Burnham,

2022). In order to lessen the negative effects that the previous fuels are having on people and the environment, cargo handling machinery is now powered by alternative fuels like electricity, hydrogen, compressed natural gas (CNG), liquefied natural gas (LNG), and liquefied petroleum gas (LPG).

2.8.1 Dry Bulk Cargo Handling Equipment

When it comes to handling dry bulk cargoes, options include magnetic grabs attached to a high capacity travelling crane/gantries, or power-propelled conveyor belts that are typically fed at the landward end by hoppers. These gantries do not only move parallel to the quay, but also run back for significant distances, and so cover a large stacking area, and are able to plumb the ship's hold. These two pieces of machinery are appropriate for managing ores and coal (Gandung, 2017).

In the scenario involving bulk sugar, the cargo would be released into a hopper beneath a railway wagon or road vehicle that is fed by gravity. Elevators (in the United States) or silos are commonly associated with grain and can be operated by pneumatic suction, sucking the grain from the ship's hold. The equipment used in handling dry bulk cargoes include ship unloaders, front loader, belt conveyor, hopper, silo / elevator, grab type unloaders loading boom. Below are some images (Gandung, 2017).

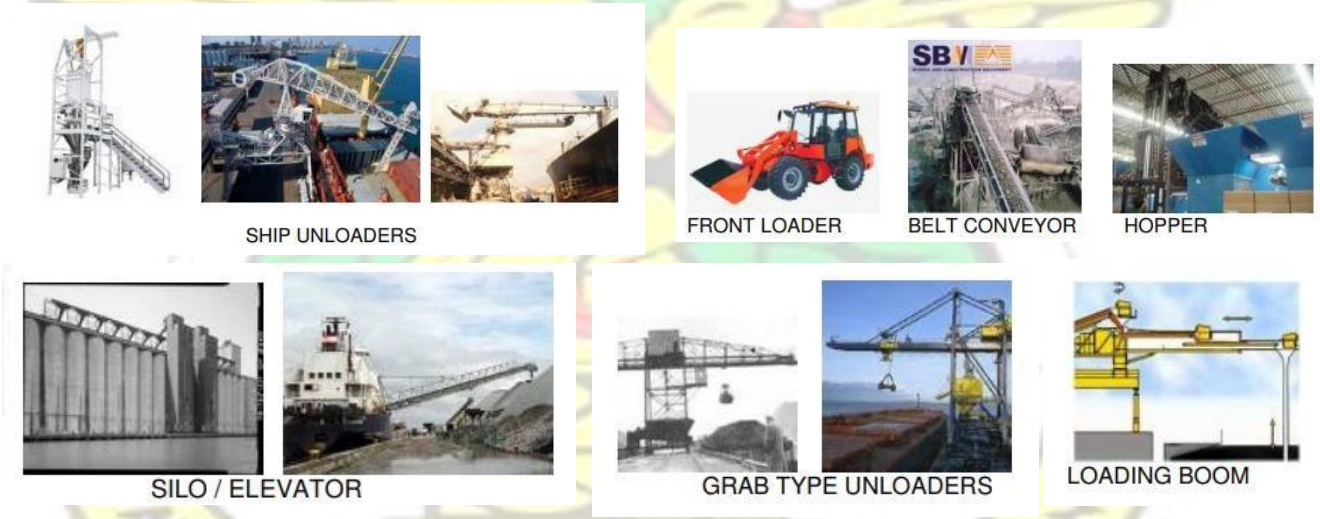

Figure 2. 7 - Dry Bulk Cargo Handling Equipment *Source: Gandung, 2017.*

2.8.2 Liquid Bulk Cargo Handling Equipment

Pipelines linked to shore-based storage containers are used to transport liquid bulk cargo from tankers, such as crude oil and derivatives. Pumping machinery is available in the refinery or tanker storage facility on land, but not at the quay. Due to the hazardous nature of this cargo, it

is customary to construct the special berths on the seaward side, a short distance from the main terminal.

The primary ship's manifold, typically located amidships on either the port or starboard side, receives the oil cargo that is discharged from the ship's tanks through the cargo piping system. Oil is distributed to shore-based storage tanks on the oil terminal from the shore manifold after being moved there using shore-based loading equipment. To prevent oil leaks, the loading arm hose needs to be oil-tight flanged to the ship's manifold. Below are images of liquid bulk cargo handling equipment.

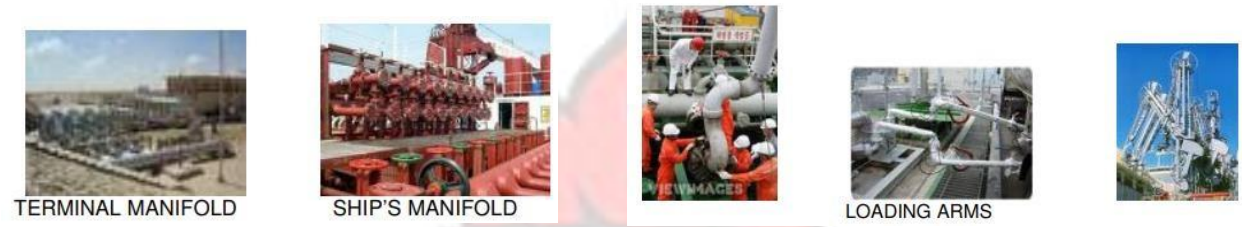

Figure 2. 8 - Liquid Bulk Cargo Handling Equipment Source: Gandung, 2017.

2.9 Challenges Faced by Tema Port

In accessing the challenges faced by the port of Tema, various articles touched on three areas where challenges are likely to rise from when it comes to the port of Tema. The areas considered included challenges faced by the administrative part of the port, challenges faced by stakeholders in the maritime industry and thirdly, challenges associated with the new incentive of clearing using the paperless system.

Speaking at a day-long Continuing Professional Development program for members of the Chartered Institute of Logistics and Transport in Tema, General Manager Wisdom Segbefia, who is responsible for corporate planning at the Ghana Ports and Harbours Authority, mentioned a few challenges relating to the administration of the port of Tema (Segbefia, 2011). Infrastructure capacity issues, a lack of funding for development, lengthy wait times, a lack of space for development, cumbersome cargo clearing procedures that almost always impede the free flow of cargo, which constitutes a major problem in the supply/logistics chain, and some shippers' tendency to use the port as a storage area were mentioned as challenges. This was attributed to a government regulation that only allowed a maximum of 60 days of free storage time in port prior to shipment, which was blamed on the government. Large amounts of uncleared cargo, truck congestion, and a lack of competition in the stevedoring industry as a result of cargo

allocation were among the additional difficulties faced by port officials, according to Mr. Segbefia (Segbefia, 2011).

Regarding the issues confronting stakeholders in the maritime industry, the researcher found out that despite the sincere efforts being made by the Ghana Revenue Authority and Ghana Link to address the difficulties that freight forwarders are encountering when using the Integrated Customs Management System (ICUMS) to clear goods at the Tema Port, the system is still riddled with issues that are dissatisfying the community of freight forwarders (Imirhe, 2020). At the Tema Port, it has come to light that many freight forwarders protested against what they described as delays in the processing of documents to clear their goods from the port. They blamed the situation on the full implementation of the Integrated Customs Management System (ICUMS), also known as Uni-Pass, which has assumed full responsibility for cargo clearance at the port (Ocloo, 2020).

A maritime programme dubbed “eye on the port” which was aired through-out 2016 on Metro TV highlighted pertinent issues that confront stakeholders in the Port. These include the presence of a multiplicity of state agencies with a physical presence in the port, extortion from importers in the name of taking goods for sampling by inspection agencies. Issues of confiscated items and different exchange rates for foreign currencies in the port were also raised. The charging of miscellaneous fees by clearing agents in spite of the paperless regime was another challenge raised by stakeholders in the port (GPHA, 2018).

2.10 Challenges Faced at the Bulk Terminal Operation

The handling and storage of bulk cargo like coal, iron ore, cereals, and petroleum products are referred to as bulk terminal operations at the port. These commodities are typically carried in bulk, necessitating specialized facilities and equipment for their handling (Dr. Theo Notteboom, 2021). Cranes, conveyor belts, and other large equipment are used in bulk terminal operations to load and unload cargo from trains, trucks, and ships. Then, the cargo is transported to its destination after being kept in silos or warehouses.

Making sure that hazardous items, such chemicals and petroleum products, are handled safely is one of the biggest concerns in bulk terminal operations. This calls for the employment of specialized tools, skilled staff, and careful attention to safety regulations. Also, the handling and storage of bulk cargo can have a big effect on the environment, especially if there are spills or

leaks. To reduce these hazards, effective environmental management methods are crucial ((UN), 2015).

Infrastructural constrains and labor shortages are other identified challenges that are associated with bulk terminal operation. Specialized equipment and facilities are needed for bulk terminal operations, and a lack of suitable infrastructure can cause delays and inefficiencies. The heavy machinery used in bulk terminal operations requires skilled labor, and a lack of competent workers may have an adverse effect on production and safety.

2.11 Ghana's Main Engine of Growth and Development - Tema Port.

Ports play a vital role in the development of various nations, especially where countries focus on trade as a source of growth and development. Facts have it that over 90% of world trade is carried by sea in terms of volume and by far the most effective way to move goods and raw materials in bulk. In landlocked countries, the efficiency or otherwise of transit ports has direct effects on international trade and competitiveness (Luguje M. A., 2007).

Ports serve as a medium through which countries receive and send goods and services that are imported and exported because sea transport is more affordable for bulk transport of goods as compared to other modes of transportation. Tema port handles more of Ghana's imports and exports and the port's efficiency in terms of operations have increased over the past decade and have contributed immensely towards the development of the country. In Ghana, the contribution of GPHA to country's development is tremendous where they are committed to following government policies on private sector-led growth. Records have it that before 2001 only two stevedoring private companies operated in the ports ((GPHA) G. P., Port News, 2002). The number increased to eleven stevedoring companies in 2008 and as of 2018 that number had increased to 22 private stevedoring companies which are in operations at the port of Tema. Some level of improvements has been made such as a higher level of professionalism and a greater degree of choice and attention to customer service due to increasing private sector involvement in the operations of the port.

The port of Tema serves as a vital part of the international transport chain of Ghana and a primeboost to industrial and agricultural development ((GPHA) G. P., Ghana Ports Handbook, 2008). The port has made it possible for the movement of capital goods from one country to another for the purpose of production. Most machines and equipment imported by hinterland countries around Ghana use the Tema port while importing such items. Again, according to Tema

Metropolitan Assembly, 2006 on the Guide to Development of Tema Metropolitan the Tema port has contributed to road networks, for instance, the construction of a 6km road from the port to the Tema Motorway to enhance transportation within the Tema Township and access to the port.

The Ghana Ports Handbook published in 2008 indicates the port of Tema has created employment opportunities for many citizens over the past years. The successful operations of Tema port would require labor to engineer operations in the ports. Despite the capital-intensive nature of seaports in the world, a significant proportion of people are employed by seaports.

Various governments have generated enough revenue from the operation of Tema which in return are used for nation-building. Revenue generated from the ports are mainly from customs duties from shippers and also charges levied for various services provided to ship and cargo as and when it is required. As the port tend to increase in revenue generation, it in the long run, affects the country's GDP and revenue generated by Tema port has increased over the past decades.

Regarding environmental protection, GPHA has been part and supported projects relating to pollution control and safety awareness creation. For example, GPHA supported the Marine Pollution Convention and ensures the protection of the port area and port environs. A week in each year has been set aside for the celebration of safety week during which seminars, symposia and lectures are organized for staff of Tema port for the creation of safety awareness.

The port of Tema again contributes to the health sector one way or the other, they have supported several health-related exercises and campaigns, for instance, the National HIV/AIDS awareness week which is to enhance public consciousness on health problems. GPHA Tema also operates hospitals which serve both workers in the authority and the general public at large.

The port of Tema is fast emerging as a regional hub for West Africa linking West African countries to various parts of the world. It is also recognized as the main driver for industrial growth and development in Ghana. The port of Tema has the capacity to handle all types of vessels and a range of commodities including dry and liquid bulk, containers, vehicles and breakbulk ((GPHA) G. P., 2018).

The participation of the private sector in port operations has significantly increased the performance of Tema port by pushing up labour productivity, improving service quality and reduced cost doing business in the port. The current port expansion project which was concluded under a Public-Private Partnership (PPP) is expected to allow Tema port to handle 3.5 million TEU making it the biggest container port in the region. This will boost port revenue, improve cargo handling and will lead to greater port utilization. In return, it will aid to make Tema even

more competitive with other ports in the sub-region. Port performance as measured in Tema port over the past decade can be described as undulating ((GPHA) G. P., 2018).

Various projects were undertaken by the port of Tema over the past decade which has led to improvements in the operations at the port of Tema and eventually has affected trade growth.

2.12 Port Performance

Port performance refers to the efficiency and effectiveness of a port in facilitating the movement of goods and passengers (Notteboom & Rodrigue, 2019). It is a critical aspect of the transportation and logistics industry as ports serve as gateways for global trade and commerce. Port performance is a crucial aspect of maritime trade since it plays a critical role in determining the efficiency and effectiveness of cargo handling, transport, and delivery. Effective port performance is vital in ensuring smooth international trade and economic growth. Poor port performance can negatively impact the economies of countries by increasing the cost of goods, delaying delivery, and damaging goods during transport.

The performance of a port is measured in terms of its capacity, productivity, reliability, and costeffectiveness (Ntoko & Olugbenga, 2020). Capacity refers to the ability of the port to handle high volumes of cargo and passengers without congestion or delay (Nguyen & Pham, 2020). Productivity measures the speed at which cargo and passengers are processed and handled (Notteboom & Rodrigue, 2019). Reliability refers to the port's ability to provide consistent and dependable services (Behdani & Farahani, 2020). Cost-effectiveness is the balance between the cost of port operations and the value of services provided (Kim & Cahoon, 2019).

Several factors affect port performance, including infrastructure, technology, labor productivity, regulatory environment, and security measures. A well-designed and maintained port infrastructure, including berths, quays, and warehouses, is essential for efficient and effective port operations (Kim & Cahoon, 2019). Advanced technologies, such as automated cargo handling systems and electronic data interchange, can significantly improve productivity and reduce processing times (Ntoko & Olugbenga, 2020). Effective port performance requires investment in these areas to improve the capabilities and infrastructure of ports.

Labor productivity is a critical factor in port performance as ports heavily rely on manual labor. Efficient labor practices, such as productive equipment utilization and work scheduling, can enhance port productivity. A favorable regulatory environment, such as streamlined customs

clearance and simplified cargo documentation requirements, can enhance efficiency and reduce processing time.

Infrastructure is a critical factor that influences port performance, and it includes the physical structures, equipment, and services essential for port operations. The quality of infrastructure such as pier capacity, berths, container yards, and cranes among others, play a critical role in the efficiency of the port operations.

Technology is another critical factor that influences port performance. Advancements in technology have led to the adoption of modern and automated systems that have improved port efficiency and effectiveness. These systems have improved cargo handling, tracking, and security, and they have facilitated seamless operations in the ports.

Security is an essential factor that influences port performance, particularly in current times characterized by increased terrorist activities and insecurity. Effective security measures have to be put in place to ensure the safety of personnel, cargo and, facilities. These include measures such as access control, surveillance systems, and detection of cargo containing hazardous materials.

Efficiency is another crucial factor in port performance, and it involves the ability of the port to handle cargo quickly and efficiently with minimal delays. Efficient cargo handling leads to reduced dwell time and faster turnaround times, resulting in increased capacity and cost savings.

Lastly, the regulatory environment significantly influences port performance, and it determines the level of adherence to international standards for maritime trade. Regulations governing port operations, including customs clearance and clearance of cargo, greatly impact port efficiency and effectiveness. Also, security measures are critical in ensuring safe and secure port operations. Ports need to be secured from potential threats such as piracy, terrorism, and cargo theft, which can significantly impact port operations and disrupt global trade.

2.13 Port Performance Indicators

The importance of ports in the transportation of goods cannot be overemphasized. Ports serve as a link between water transport and land transportation. The performance of ports is crucial to the overall efficiency of the transportation system. Port performance indicators are a set of measures that help to evaluate the efficiency and effectiveness of port operations (World Bank, 2018).

According to the International Association of Ports and Harbors (2019), Ports use a variety of performance indicators to evaluate their efficiency and effectiveness. UNCTAD (2018) noted the following are some of the common indicators used by ports:

Berth productivity: This measures the time taken to unload and load a ship. The productivity of a berth is determined by the number of containers or cargo moved per hour.

Turnaround time: This measures the time taken for a ship to depart after completing its operations. A shorter turnaround time indicates better port efficiency.

Dwell time: This measures the time taken for cargo to be cleared and released from the port. A shorter dwell time indicates better port efficiency.

Occupancy rate: This measures the number of berths occupied by ships at any given time. A higher occupancy rate indicates better port efficiency.

Throughput: This measures the amount of cargo that passes through the port within a specified timeframe. A higher throughput indicates better port efficiency.

2.14 Port Performance Analytics Theory

Port performance analytics theory is a model-based approach that seeks to optimize the efficiency and effectiveness of port operations. It integrates various data sources, statistical models, and artificial intelligence algorithms to provide real-time insights into port performance, identify bottlenecks, and recommend strategies for improvement. The theory is grounded in the principles of operations research, queuing theory, and risk analysis (Saeedi & Iranmanesh, 2017).

One key aspect of port performance analytics theory is the use of simulation models to predict and visualize the behavior of the port system under different scenarios. For example, a discreteevent simulation model can be used to predict the impact of changing vessel arrival patterns on berth capacity, crane utilization, and queuing times (Lee & Lee, 2016). These models can be calibrated using historical data or real-time monitoring to ensure accurate predictions.

Another aspect of port performance analytics theory is the use of data-driven techniques to identify key performance indicators (KPIs) and monitor their trends over time (Fawzi, Manteghian, & de Souza, 2019). Examples of KPIs in port operations include vessel turnaround time, crane productivity, container throughput, and berth availability. By analyzing these KPIs, port managers can pinpoint areas of the operation that require improvement and develop action plans to address them.

Port performance analytics theory also emphasizes the importance of risk management in port operations. By modeling and analyzing potential risks such as vessel collisions, berth congestion, or equipment failure, port managers can develop contingency plans to mitigate their impacts (Wang & Wang, 2020).

2.15 Factors Responsible for Vessel Turnaround Time

Vessel turnaround time is the duration between a ship's arrival at a port and departure from that port Jang et al. (2014). It is an important metric to measure a port's efficiency and productivity as it affects shipowners' and shippers' logistics plans. A shorter turnaround time translates to lower costs and faster cargo transit, which is essential for a competitive global market. However, many factors affect vessel turnaround time. This writeup discusses some of these factors, which includes infrastructure, equipment, processes, and communication, backed by references.

2.15.1 Infrastructure:

The availability of infrastructure is critical to port efficiency. Adequate infrastructure includes berths, terminals, and quay cranes. Insufficient infrastructure may cause congestion, delays, and longer turnaround times. A study done by Lazaridis et al. (2016) showed that inadequate infrastructure leads to longer turnaround times and high operational costs.

2.15.2 Equipment:

Equipment availability and reliability are also essential factors in port productivity. The execution of operations such as loading, unloading, and cargo storage require efficient and reliable equipment. The availability of equipment such as container-handling gantry cranes, rubber-tire gantry cranes, and straddle carriers is necessary for timely operations. For example, a study conducted by Li et al. (2019) revealed that equipment failure was a leading cause of reduced productivity and longer turnaround times.

2.15.3 Processes:

Efficient processes are critical for optimal vessel turnaround time. Processes include customs clearance procedures, cargo handling, inspections, and documentation. Shorter customs and inspection processes can allow cargo to move more quickly, reducing turnaround time. Integration of processes using digital technology and automation can also reduce turnaround

time. A study conducted by Jang et al. (2014) found that the implementation of an automated gate system reduced container truck queuing and turnaround time.

2.15.4 Communication:

Effective communication among all stakeholders, including shipping lines, terminal operators, and port authorities, is crucial in achieving optimal vessel turnaround time. A breakdown in communication often results in confusion, expensive mistakes, and delays affecting productivity. A report published by the International Transport Forum (ITF) identified communication among stakeholders as key in achieving efficient port operations (International Transport Forum, 2019).

2.16 History of Tema Port:

Between the 16th – 18th centuries, foreign trade in the then Gold Coast was undertaken from 40 landing points scattered around the Gold Coast. By the 1900s, these had converged to six main ports of trade. Transport witnessed its first revolution in the road and rail network from 1920 to the 1940s, culminating in the construction of the Takoradi Port. Further road expansion and shifts in the direction of trade in the post-independence era led to the construction of Ghana's second port, Tema Port. Sir William Halcrow and partners began building the Tema Port in 1954, consisting of two breakwaters covering 500 acres of water with twelve berths, four transit sheds, offices, two cocoa sheds and dry dock sites, a slipway and a workshop.

In 1963, a cocoa conveyor was commissioned to carry cocoa bags from sheds to ships at berths 6 and 7. On 18th June that same year, Tema Port had its first tanker vessel call by "M/V Avacus" berthing and discharging 17,500 tons of crude oil through pipelines to Ghana. The expansion of quay two began in 1997 with the dredging of the turning basin and the waters along the one (1) and two (2) berths. In 2003, the existing sheds were demolished to pave the way for the planned 250,000 sqm container terminal in the main port. In 2004, Meridian Ports Services Ltd (MPS) was formed to take over the running of the container terminal with Bollore and APM Groups owning 70% and the Port authority owning the remaining 30%. Parallel to these developments, reconstruction and restructuring activities were undertaken, including privatization of some major port services, ISPS Code implementation and compliance, and the cocoa sheds located at the western side of the port were pulled down and the adjacent car park was relocated to a privately owned and managed off- dock.

In 2007, the Golden Jubilee Terminal was completed, which covered a surface area of 140,000 m2. This off dock devanning area was aimed at decongesting the port and taking away all Container Freight Station (CFS) activities from the main port. (GPHA, G.P, 2016)

2.17 Summary:

Port performance is a critical aspect of the transportation and logistics industry, and it significantly impacts the global economy. Ports must continuously improve their performance through effective management strategies, investment in infrastructure and technology, and adaptability to changing market conditions. Improving port performance requires investment in infrastructure, technology, security, efficiency, and regulatory environment. Countries must, therefore, prioritize investment in these areas to improve their ports' overall capabilities and competitiveness.

In addition, several factors contribute to vessel turnaround time at ports. These include infrastructure, equipment, processes, and communication. The efficient management of these factors can optimize vessel turnaround time, reduce operating costs, and enhance port competitiveness. Port authorities and stakeholders must prioritize these factors to achieve a more productive and efficient port environment.

CHAPTER THREE

METHODOLOGY AND ORGANIZATIONAL PROFILE

3.0 Introduction to methodology

This chapter seeks to cover the various techniques, procedures and strategies used in the gathering of information and analysis of relevant data.

3.1 Research Design

According to Kabir (2016) research design refers to the overall strategy that one chooses to integrate the different components of the study in a coherent and logical way. This research will employ a mixed method (qualitative and quantitative methods to answer and address the research questions and objectives respectively.

Qualitative research is defined as a market research method that focuses on obtaining data through open-ended and conversational communication (Bhat, 2020). This method is used to know or identify what people think about a topic of interest and why they think that way. The qualitative method allows the researcher to present their findings through reflecting and analyzing opinions, experiences, and attitudes of the respondents. Access to quantitative data was viable with questionnaires and desktop researches, which provided relevant information in identifying various the various bulk cargo handling equipment used at the Port of Tema.

This study employs both qualitative and quantitative analysis this is because conclusions and recommendations will be drawn based on opinions and experiences of the respondents.

3.2 Source of data

In this research work, data was collected from two main sources and these are, primary and secondary.

3.2.1 Primary Data

Primary data deals with data collected at source. This type of data is obtained directly from first hand sources by means of experimentation, observations and survey and not subjected to any form of manipulation or processing. (Forplus Blog, 2020) This is a field data collected through questionnaire and interviews. Interviews were conducted with selected respondents and observations made around the terminal areas to ascertain the various phenomenon that occur at

berths when vessels berth. Questionnaires were administered to shipping lines to know their view and experience on using the port for import and export operations.

3.2.2 Secondary Data

This is an already existing literature important to the research study and was gathered from various books, scholarly articles, journals and thesis and other publications which have bearing to the study. These materials have been accessed through documents published on the GPHA website with details which ranges from annual tons of bulk cargo that passes through the port to the time spent by these bulk carriers at the port. Other materials including previous research studies were also visited to aid in completing the research.

3.3 Population

Ariola (2006) defined population as any group of individuals who have one or more characteristics in common that are of interest to the researcher. In other research, (Turkson, 2011) argues that in order to draw a sample there is the need to know the number of people in a population, and if this total number is made up of people you might be interested in and falls into different subgroups. The population of this study include Shipping Companies, Terminal Operators and Administrators of the Tema Port.

3.4 Sample Procedure and Sampling Size.

Regarding this project work, two familiar sampling strategies were used to collect valuable data from the field of study. The techniques used were Simple Random and Purposive Sampling techniques.

The study adopted the purposive sampling technique to select 6 administrative staff of Tema Port. 9 Terminal Operators and 25 Shipping Companies operating at Tema port. The total sample size is 40.

Table 1 Target population and Sample size

SAMPLE	**SAMPLE SIZE**	**LOCATION**	**METHOD**
Shipping Lines	25	Tema	Questionnaire
Bulk Cargo Terminal Operators	9	Tema	Interview

Tema Port Operation Officers	6	Tema	Interview/Desktop Research

Source; Field Data, 2022

3.5 Sampling Techniques

Simple random sampling technique which is a subset of the statistical population makes each member of the subset has an equal probability of being chosen for the purpose of preventing the unbiased representation of a group (Lauren, 2020). Data gathered from shipping companies was based on the simple random sample strategy. This is because their core business is to transport cargoes for importers and exporters respectively and by so doing engaging in handling bulk cargoes.

The purposive sampling is the second sampling strategy used and is a non-probability sampling technique, which is also known as judgement, selective or subjective sampling. (Rogers, 2018) This method was used to specifically select only respondents that by nature of their work interact with the port of Tema and engage in import and export of goods that are bulk in nature.

3.6 Data Collection Instrument

For the purposes of this research work, three instruments for the collection of data were used these are desktop information, questionnaires and interviews.

3.6.1 Desktop Research

Desktop research as used as an instrument for data collection aids in finding relevant data which already exists, as opposed to collecting data through questionnaires and interviews. While it may not be able to answer specific questions, desktop research provides you with useful information.

3.6.2 Questionnaires

A questionnaire is a form containing a set of questions addressed to a statistically significant number of a target population as a way of gathering information for a study or survey. Pertaining to my research work questionnaires were administered to sample population who do business in the port. These include stakeholders in the maritime industry which include: Shipping Companies, Terminal Operators and Administrators of the Tema Port.

3.7 Data Analysis Techniques

The data collected using quantitative and qualitative methods as well as various samples collected were analyzed and the results combined to complement each other. Qualitative data and quantitative data from the social survey were analyzed to present a holistic and

comprehensive clarification of the study where the data confirmed and complemented each other for understanding of the issues under study.

The data gathered from the field was used to generate and compute various statistical analysis using descriptive statistical tools. Pie charts, bar graphs, histograms, figures and tables were developed to enhance visual presentation of results by using Microsoft Excel.

The qualitative data on the other hand was analyzed manually using appropriate issues arising from the various interviews. Interviews were recorded with phones and the audios was transcribed before successive manual analysis was conducted to generate analysis for better understanding.

Data collected was also analyzed with Microsoft Excel and IBM SPSS Statistics 25.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION OF RESULTS

4.0 Introduction

In this chapter, the researcher made attempts to analyze data and interpret results based on the various research data instruments employed. The analyses were segmented into questionnaires

and structured interviews considering the objectives of the study. The targeted institutions and respondents have been contacted and essential information has been derived. Presentations were carried out in tabular and graphical representations for the purpose of simplicity and clarity. The participants include: Shipping Lines, Bulk Cargo Terminal Operators and Tema Port (GPHA) Operation Officers.

4.1 Analysis of Questionnaires and Interviews.

A total of 25 questionnaires were distributed to shipping lines for the purpose of this research work. All 25 questionnaires representing 100% response rate have been retrieved. The response rate is very high and as such enough data is gathered for the analysis of this research work. The high response rate also gives validity to the findings from the data. See table 4.1 below for questionnaire response rate. Also, interviews were conducted to retrieve relevant data from Bulk Cargo Terminal Operators and Tema Port (GPHA) Operation Officers for which analysis were also made accordingly.

4.2 Analysis of Respondents Identity

Table 4. 1 - Analysis of Respondents Identity.

VARIABLES	CATEGORY	NUMBER	PERCENTAGE (%)
Age	20-29	5	20%
	30-39	10	40%
	40-49	7	28%
	50-59	3	12%
Gender	Male	18	72%
	Female	7	28%
Level of Education	SHS	7	28%
	HND/Degree	14	56%
	MBA/Others	4	16%
Employment Status	Temporal	9	36%
	Permanent	16	64%
Years of Employment	0-5	3	12%
	6-10	7	28%
	11-15	9	36%

	16-20	3	12%
	21 and above	3	12%

Source: Field data, 2023

Table 4.2 above represents the classification of the identity of shipping line respondents. As shown, the age, gender, level of education, employment status and years of employment of respondents are clearly represented. The table represents that, 5 respondents which constitutes 20% are between 20-29, 10(40%) are between the age of 30-39, 7(28%) are between the age of 40-49 and 3(12%) are between 50-59. The gender of the respondents was also represented and shows that 18 respondents which constitute 72% were male while 7(28%) were female. Table 4.2 also presents a vivid description of the educational level of the 25 respondents, 4 which constitute 16 % have basic certificate, 7(28%) have SHS (WASSCE), 10(40%) have BSc. and HND and 4(16%) have MBA/other higher qualification. According to the survey, 9(36%) were temporal staff while 16(64%) were permanent staff. Finally, according to the years of employment of the respondents, 3 respondents representing 12% were employed between 0-5 years, 7(28%) represents 6-10 years of employment, 9(36%) represents 11-15 years, 3(12%) represents 16-20 years of employment and finally, 3(12%) represents 21 and above years of employment.

4.3. Analysis of Responses from Shipping Lines.

The researcher asked the respondents to state the number of years their company has been in business at the Tema port to make sure that selected shipping companies have been in existence for quite a few years in order to aid access to relevant information that will help to identify factors that affect turnaround time of bulk carriers, its adverse effects and determine rectifying measures.

Table 4. 2 - Years of existence of selected shipping Companies

Years of Operation	Frequency	Percentage
1-10 Years	10	40%
11-20Years	11	44%
21-30 Years	4	16%
31 Years and above	-	0%

Source: Field Data, 2023

The table above shows that a greater percentage of shipping companies selected for the purpose of this research work has been in operation between 11 and 20 years, representing 11 companies and accounting for 44%, 10 shipping companies have been in operation between 1 and 10 years which represents 40%, 4 shipping companies have been in operation between 21 and 30 years representing 16% and none of the companies operates beyond 31 years.

Furthermore, the researcher asked the respondents about the frequency at which their vessels call at the port. This question is purposed to help determine how often vessels encounter cargo handling or other related challenges and shall help the researcher to identify factors that influence Vessel Turnaround Time directly or indirectly.

Interpreting the figure below, it has been observed that, 68% (17) of the total shipping line respondents asserted that their vessels often call at the Tema Port, 8% (2) responded rarely while 24% (6) responded sometimes.

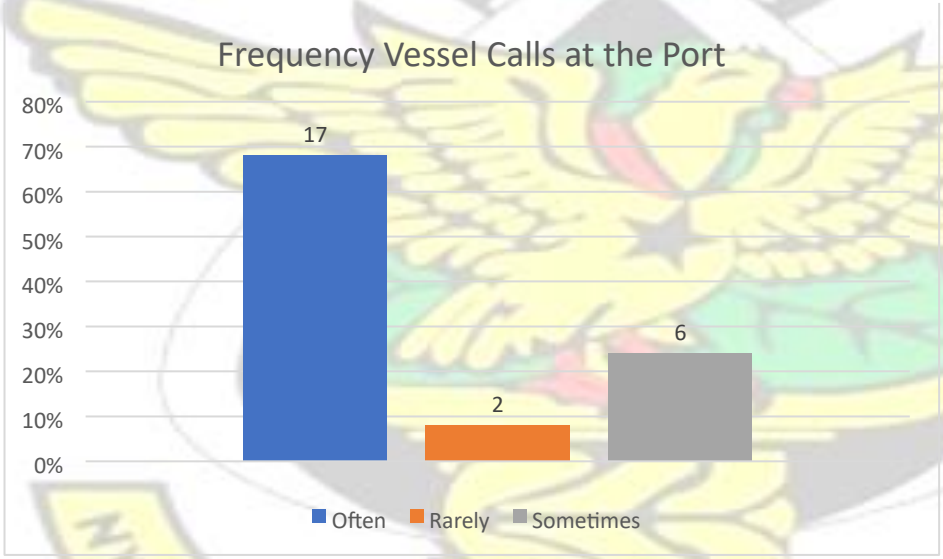

Figure 4. 1 Response from Shipping Lines
Source: Field data, 2023

Again, the researcher asked how the respondents would rate Prearrival, waiting time, berth allocation and service time with respect to bulk cargo handling performance from ship-shore at the port. This set of question to determine the effects cargo handling operations, have on vessel turnaround time of bulk carriers at the port of Tema. It shall also aid to identify whether administrative and natural phenomenon (tides) also accounts for vessel turnaround challenges.

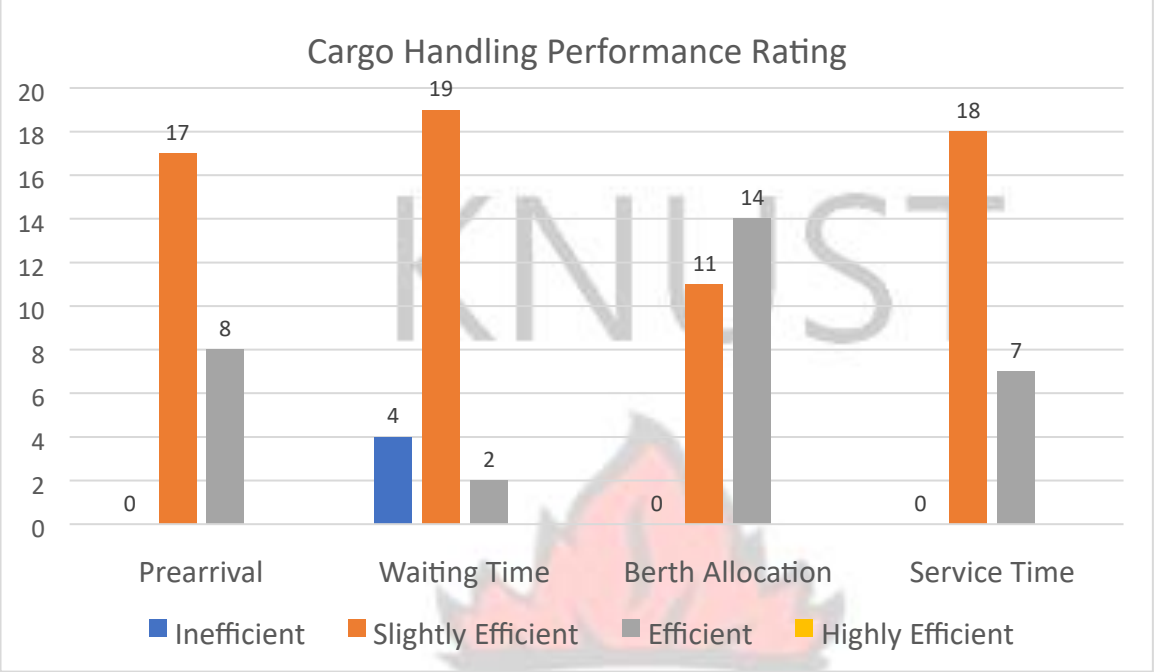

Figure 4. 2 - Response from Shipping Lines

Source: Field data, 2023

The figure above explains cargo handling performance rating by the shipping line respondents involved in this survey with respect to vessel prearrival, waiting time, berth allocation and service time. According to the responses, out of 25 respondents, 17 and 8 respondents representing 68% and 32% respectively responded that prearrival activities are slightly efficient and efficient while none responded inefficient or highly efficient. 4 (16%), 19(76%) and 2(8%) responded that waiting time activities are inefficient, slightly efficient and efficient respectively. Also, 11(44%) and 14(56%) respondents asserted that activities of berth allocation are slightly efficient and efficient respectively while 18(72%) and 7(28%) respondents respectively responded that service time to bulk cargo vessels are slightly efficient and efficient.

In addition, the respondents were asked to state some factors aside port operations that affect turnaround time of your vessel. The researcher asked this question with the intention to identify factors that influence Vessel Turnaround Time directly or indirectly.

According to the respondents, the following factors were identified.

- Delays caused by port authorities during boarding procedures.
- Breakdown of equipment, unexperienced labour force, mechanical failings.
- Congestion at previous port of call, tidal conditions (weather)

- Nature of cargo, cargo plan, readiness on port side.
- Daylight berthing and sailing.
- Difficult/complicated formalities for loading and sailing with numerous authority clearances.

According to your chief officers, some cargo handling challenges they face at the Tema port have been stated below. This question is geared towards determining the effects cargo handling operations have on vessel turnaround time of bulk carriers at the port of Tema.

- Harassment by port authorities, customs officials and the immigration.
- Frequent damage to ship and equipment.
- Delays in effecting corrections in relation to operations.
- Congestion, container management and workforce problems.
- Port and State authorities making things difficult for vessels when they call at the port; like Port State Control.

The researcher asked the respondents if they would rate the port's operations as efficient or not and also to explain their answer. The researcher by asking this question is interested to determine whether the shipping lines get satisfied about the operations of the Tema Port with respect to bulk cargo vessel handling.

From the findings, 18 respondents representing 72% asserted that yes, the bulk cargo operations at the Tema Port are efficient while 4 respondents representing 16% opposed without giving reasons. 3(12%) of the respondents are uncertain due to limited knowledge and experience. The findings from the 18 respondents explains the following; experience from the other ports in the sub region makes the Tema Port quite efficient even though there is room for improvement. The operations of the Tema Port are efficient as they are key to reducing trade cost, transport cost, connecting supply chains and supporting global trade. The Port's Performance is at an acceptable rate but can be improved with proper advancement of equipment and personnel.

4.4 Interview Session with GPHA Operations Officers

In a series of interview conducted with the operation officers of GPHA with regards vessel traffic management, it was revealed that vessels are allocated to come to the port to work when they come to the anchorage, these vessels are declared by agents which then go to the harbor master's

office for allocation. A committee is then set up to examine the vessel type, specifications (most especially the draught) and cargo on board. This information when gathered will help the committee allocate which berth is appropriate for the said vessel that calls at the port. According to the interviewees, the bulk cargoes that normally come to the port of Tema includes bulk clinker, wheat, maize and rice but these cargoes do not come often as opposed to the containerized goods.

After the committee setup by the Habour master decides which berth is appropriate for a vessel, a berth meeting is then induced to allocate vessels to the right stevedore for loading or unloading. The essence of this is to ensure cargoes are handled by the appropriate skilled personnel and the right equipment are used in handling it.

After the berths are allocated to the bulk cargo carriers, the port authorities serve the stevedores a notice and the cargo owner(s) as well. They are then allowed to discharge the cargoes. To ensure efficiency of the stevedores' operations, the port authorities monitor the unloading process. Prior to the start of the unloading process, it has been said that the expected number of days the discharge is to take place is being communicated to cargo owners and stevedores. More trucks and handling equipment are then deployed prior to berthing by the cargo owner in order to take cargoes from the port to their warehouse this is done in order to avoid demurrage charges. Should the discharge operation exceed the allocated number of days the port has given to the cargo owner for discharge, the cargo owner will be charged for demurrage. Should there be instances where the discharge of bulk cargo is not completed on the allocated time the port authorities reserve the right to halt operations and send the vessel back to the anchorage and allow another vessel that is in waiting at the anchorage to come in and use the berth, or start calculating demurrage for the extra time spent at the berth. That is a mechanism placed by the port to force cargo owners operate fast and efficiently when discharging cargoes. There are instances where natural circumstances like rain fall affects the smooth discharge operations, these are considered when calculating the time allocated to vessels for discharge operations. In times where cargo owners have challenges with the handling equipment, they need to serve an official notice to the port authorities indicating the issue and then requesting for an additional day in order not to face extra charges.

The interview also revealed that, when it comes to bulk carriage the port does not have its own equipment in handling bulk cargoes at the port but the cargo owners. It has come to light that every company has their cargo handling equipment in the port and ready to be used anytime their cargoes land in the port. Cargoes owners of *grains* have their hoppers, trucks and other necessary

equipment required for handling these bulk carriers. The equipment is being parked at an area known as the holding area in the port so as and when a cargo owner's goods are in and ready to be discharged the equipment are taken out of the holding area for usage at the appropriate time.

The average numbers of years the operations officers have been working in the bulk terminal is 10years and also, they have testified that almost all the time the cargo owners provide personnel that have the right knowledge about handling the equipment used in the handling the cargoes. Nevertheless, there are instances where accidents happen for examples the strings attached to the hoppers get thorn or the chains attached to the pneumatic dischargers get broken. In these regards investigations are made to ascertain the cause of the accident and possible recommendations are made to possibly prevent such occurrences in the future. One of the operation officers recalled a situation in the early 2000s where *a bulk rice was being discharged from the port, after the operator had lifted the grains from the hatch the strings attached to the hopper got thorn and caused delay in discharge but no injuries were recorded. Upon investigations it was realized that periodic maintenance was not carried out by the Ghana Maritime Authorities.* Over the years, this incident has not occurred again.

The port organization has an association that licenses the stevedores to operate within the port. Now before a license is given to a stevedore to operate there are systems and requirements you need to meet in terms having the right qualified personnel that can handle the necessary equipment. The port has a pool of stevedores each specialized in the type of cargo they handle, in managing all these it is necessary of the port to allocate tasks to each of the stevedores as and when there is aa discharge operations so as not to over work one party. For instance, if a stevedore works today and exhausts the maximum tonnage he is to handle, the next day will be allocated to a different person so as not to over use a stevedore. The committee responsible for issuing out workload makes it possible enough to distribute the same tonnage handling for all stevedores. According to the interviewees, cargo owners from time to time are advised to always provide handling equipment that are an upgrade of what they already have, this is to help reduce the time spent in port when discharging their cargoes.

It was evident from the interview session that vessel turnaround time depends one a few factors which include firstly the availability of berths from the time the vessels begin waiting at the anchorage, another factor is the availability of the necessary equipment by the cargo owners which will enable stevedores operate at their full capacity. Again, it is necessary for the stevedores to possess the technical knowledge about the equipment used in handling. Not

forgetting natural circumstances that affect the smooth discharging of cargoes. These factors tend to affect the turnaround time of vessels at the port.

4.5 Analysis of Berths (Bulk Cargo)

The table below shows a total of all 21 berths available in Tema Port, having draughts ranging from 8.2 to 16 meters. In exception of Valco and Oil Berth, Terminals 1 and 2 contain 16 multipurpose berths. A dedicated container terminal known as Terminal 3 currently has three berths and can accommodate ships with a 16-meter draft and a length of 366 meters.

As the main aim of this research seeks to identify factors that affect the turnaround time of bulk carriers, the berths in focus for this analysis includes berths that handle bulk cargoes (liquid and dry). A total of 10 berths out of the 21 handles bulk cargo, these berths are highlighted in the table below. It is important to note that some of the berths serve as a multipurpose berth which handles a wide array of cargoes and not necessary bulk cargo carriers only.

Table 4. 3 - Number of berths at the port of Tema

Berth No	Berths	Length (m)	Draught (m)
1	Container terminal	299	11.2
2	Container terminal	275	11.4
Max draft of V/LS to berths =11.2 m	Spaces between bollards at Quay 1 are approx. 30m. Spaces between bollards at Quay 2 extension are generally variable.		210
3	Deeper Draft Vessels including containers and dry bulk and general cargo vessels	228	10.0
4	Container Ships	181	9.2
5	Fishing Vessel	183	8.5

6	Reefer & General Cargo Vessels	183	8.2
7	Bulk cargo	183	7.5
8	Tankers vessel carrying alcohol and Oil palm	183	8.2
9	Fruit terminal (banana, pineapple, orange)	183	8.2
10	Containers, bulk and bagged and the cargos.	183	8.2
11	Mineral berth (Clinker, bulk carrier)	183	8
12	Multipurpose berth (Navy & Refer)	220	8.2
13	Multipurpose berth (RoRo Vessels)	220	8.2
14	Bulk Cargo, Bagged cargo (Bulk Cement)	220	8
15	Multipurpose berth (Reefer, small tanker, multipurpose vessel	220	8
16	Multipurpose berth (small vessel)	75	8
Valco Berth	Private Berth (Aluminum Products)	175	9.6
Oil Berth	Tankers	Max 244	9.6
BERTHS OUTSIDE THE PORT - OFFSHORE TERMINAL			
	Description	**LOA (m)**	**Draft (m)**

CALM (SPM) For Crude	Approximately 3.2 n.m. offshore Position; connected to the Tema Oil Refinery (TOR) tank farm.	204 – 274	20.0
CBM (ABB) For Products	Approximately 2.7 n.m. offshore with the PLEM, connected to the tank farm by a 2.1 n.m. × 18 in. diameter subsea pipeline.	1 55 – 203	12.2

Source: Field Data, 2023

4.6 Analysis on Pre Berth and Waiting Time - Bulk Cargo Carriers

Data gathered from the monitoring and surveillance department of the GPHA dated October 27th to November 6th 2022, it was made known to the research that data after the stated date were cleared from the port's management yet for research purposes. This has left the researcher with no other choice than to use the available data at the time the research is being conducted.

The table below shows data on the name of bulk carriers, arrival (date and time), berth (date and time) and waiting period of these vessels at the port of Tema.

Table 4. 4 - Bulk Carrier Names, Arrival Date & Time, Berth Date & Time and Waiting time of vessels

Vessel	Arrival (Date& Time)	Berth (Date & Time)	Waiting Time (hrs)
Majestic Noor	27/10/22 || 17:00	29/10/22 || 18:54	49.54
Breb Courtesy	24/10/22 || 05:00	30/10/22 || 18:00	157
Agia Fotini	30/10/22 || 10:45	30/10/22 || 13:20	2.35
Alexia	03/10/22 || 11:00	19/10/22 || 19:18	392.18
British Captain	18/10/22 || 00:30	03/11/22 || 14:48	398.18
Thor Independence	02/11/22 || 23:00	04/11/22 || 03:36	28.36

Darya Chand	31/10/22 || 20:20	02/11/22 || 11:12	38.52
Diddi	27/10/22 || 03:30	02/11/22 || 16:10	156.40
Honmon	02/11/22 || 11:30	05/11/22 || 07:24	67.54
Papayiannis III	01/11/22 || 17:00	04/11/22 || 07:12	62.12
		Total Waiting Time	**1,352.19**
		Average Waiting Time	**135.22**
			5 Days 38 Mins

Source: Field Data, 2023

The analysis above shows that the average waiting time for bulk carriers withing the stated time for this analysis is approximately 5days 48mins after vessels have arrived at the port of Tema.

4.7 Analysis on Service Time - Bulk Cargo Carriers

Service time refers to the hours taken to either unload or load a bulk carrier at the port, the table below gives a data and analysis on the time spent in offloading bulk cargoes of the stated vessels. As it was revealed in an interview with personnels from GPHA, when it comes to bulk cargoes discharge at the port, prior to vessel berthing the agencies responsible for offloading such vessels are given prior notice. In this regard the offloading equipment and trucks are already in place which makes offloading procedures to begin as soon as the vessels berth their designated berths. The variables for analyzing the service time of the bulk carriers will be the time between berth and departure from the port.

Table 4. 5 - Table indicating the Service Time from Berth and Departure Date and Time

Vessel	Berth (Date & Time)	Departure (Date & Time)	Service Time(hrs)
Majestic Noor	29/10/22 || 18:54	03/11/22 || 16:56	118.2
Breb Courtesy	30/10/22 || 18:00	05/11/22 || 00:35	126.35

Agia Fotini	30/10/22 || 13:20	05/11/22 || 01:25	131.5
Alexia	19/10/22 || 19:18	05/11/22 || 14:45	403.27
British Captain	03/11/22 || 14:48	06/11/22 || 07:48	64
Thor Independence	04/11/22 || 03:36	06/11/22 || 09:36	30
Darya Chand	02/11/22 || 11:12	06/11/22 || 12:56	97.44
Diddi	02/11/22 || 16:10	06/11/22 || 16:24	96.14
Honmon	05/11/22 || 07:24	07/11/22 || 18:24	59
Papayiannis III	04/11/22 || 07:12	08/11/22 || 05:12	94
		Total Service Time	**1219.9**
		Average Service Time	**121.99**
			5 Days 5mins

Source: Field Data, 2023

The analysis above shows that the average service time for bulk carriers within the stated time for this analysis is approximately 5days 5mins after vessels are berth at the port of Tema.

4.8 Interview Session from Stevedoring companies / Terminal Operators

In an interview session with Stevedoring personnel, the researcher tried to get responses on the perception from the stevedores on quay- equipment performance in relations to crane moves, crane service time, forklift, slings, derricks etc.

The researcher needed information on effect of available equipment on the workflow of terminal operators (Stevedores) to know the results produced by this available equipment.

For the purposes of loading and unloading cargo at the port, cranes and other equipment must be available. Large bulk carriers and container ships, among other highly specialized and larger vessels, rely on shore side equipment. Smaller ships frequently have cargo handling gear that is

fixed inside the ship, or they are "geared." Pumps on the shipboard and at the dock are used by oil tankers to load and discharge their cargo.

Majority of the respondents stated that, the current equipment used are slow and quite old. While working, they frequently develop faults. Operations are generally slowed down by this. Although the government and businesses can purchase sophisticated equipment for the work, nothing has been done so far. A sufficient and appropriate equipment list must always be present to ensure efficient cargo handling operations. But in recent years, management has been unable to accomplish this due to a number of factors and limitations, including their inability to timely secure government consent, political factors, and interference from the government, lengthy bureaucratic procedures, their failure to estimate future traffic, etc. As a result, port has regularly experienced congestion.

The researcher enquired if the terminal operators (stevedores) are assigned to task reasonably enough to make them operate more effectively and timely.

The participants noted that, there are several ways to work effectively and most of the time this done. The issue faced is that, most people do not understand the work principles and processes so they are unable to work efficiently. Other do not also have good knowledge on the machines they are operating so when there is a small fault which they can fix to help continue operations, they are unable to do that because they don't know. This usually delays the work since we would have to wait for the technicians to come. The shift system being employed at the port is a good system which makes operations continues. There is no halt in work due to closing time. The port operates a 24 hour and 7 days operations weekly. Most task assigned are to be performed in accordance to safety operations and according to the laid down procedures so no one is cheated. There is a roaster for every shift and duties to be performed. This improves efficiency during work operations and if there were good equipment, work would have been very easy and less time spent operating on a particular vessel, hence reducing turnaround time.

The respondents were asked of their opinion what the operational challenges hindering efficient turnaround times.

The participants noted that, the major challenge hindering efficient turnaround time is insufficient inventory. This is due to the high frequency of breakdowns, rising operating costs of outdated equipment, equipment unavailability, lack of financing and available space for maintaining an abundance of outdated equipment, technicians' reluctance to often attend breakdown jobs, and other factors. Additionally, the anticipated disposal of the equipment takes

a lengthy time. Similar to this, a large portion of the equipment has reached the end of its useful life and is still in use, but with higher running costs and dangers. Forklifts, for instance, should be disposed of after seven years of use because their cost starts to climb after year seven. The equipment should be replaced after year 7 as the real yearly running cost surpasses the average annual total cost after that point. But we have some forklift which are about 15 years and above. This is very bad and would continue to give problems.

If operations aren't done within the time frame and there is a delay, there won't be quick turnaround time since a lot of time would be spent on one vessel.

Governmental policies or interferences causing turnaround challenge(s) in their operations and how it's done.

Majority of the respondents admonished that Political interference and decisions is hindering the progress of their operations. Due to political influence, a lot of people are being employed to work without prior training and education. Hence, they misuse this equipment and do not follow the right safety procedures. Because of a lack of knowledge, inadequate training, and a reckless attitude, the majority of operators do not adhere to the correct driving practices. This involves handling overloaded containers, driving too quickly, braking suddenly, running into obstacles, colliding with other cars and buildings, and using the wrong operational procedures. Most of the breakdowns are due to operator abuse and negligence. But because there're politicians backing them, remedy actions cannot be taking against them.

The participants were asked if they encounter operational complexity as a result of ship size. If yes, they should explain how the ship size influence the complexity of operations?

The respondents noted that, most of the big vessels are containerized vessels and they go to MPS, Terminal 3. Those that come to terminal 1 and 2 are vessels the terminal is able to handle. Most of the small vessels also usually have their own cargo handling equipment so we usually don't have challenges. We use our own equipment for the larger vessels that call at terminal 1 and 2 that do not have their own handling equipment. The major issue faced is with regards to delays where there is equipment break down which needs repairs.

The respondents were further asked if they can recommend an improvement in the existing equipment to help improve on the current service quality.

Some stated that, there should be adequate equipment to handle the demand. There should be modern equipment at the port for operations. There should also be routine maintenance, consistent checks and proper disposal of the equipment.

In addition, Lack of training is seen to have an impact on every aspect of equipment maintenance and operation. To maintain and enhance equipment performance, all technicians and operators require continuous training. For the implementation of new systems, oversight, and control over staff actions, supervisory staff urgently needs training. Additionally, management professionals struggle to oversee all maintenance and operational tasks. The most important factor in developing expertise in all facets of maintenance and operation is training.

CHAPTER FIVE
SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter of the research consists of a summary of the findings, the conclusion and recommendations made by the researchers according to the research findings.

5.2 Summary of findings

The summary of the findings obtained from this research work are as follows

5.2.1 Regulated Pre-Berthing Procedures

When ships land at the anchorage, the port master organizes a committee to inspect the draft and sort of cargo on board the ship before berthing. This aids in providing the proper berth that can hold the said and vessel along with its goods. This is done to stop vessels from berthing in the incorrect place.

5.2.2 Measures for Efficient Cargo Operation

It is essential for the port to implement procedures that will guarantee that cargoes are discharged/loaded effectively and within the designated time limit. The introduction of demurrage charges, where ships/cargoes are charged an additional amount for exceeding the given number of days to be used for discharge, is an effective measure used to ensure that cargoes are discharged within the specified time period.

5.2.3 Factors Affecting Vessel Turnaround time

According to the circumstances surrounding the vessel operations, the study has identified a number of factors that either result in a shorter or prolonged turnaround time for vessels. These variables include the availability of berths and suitable handling gear, the stevedores' proficiency with handling gear, breakdown of equipment, mechanical failings, congestion at previous port of call, nature of cargo, cargo plan, readiness on port side, daylight berthing and sailing, difficult/complicated formalities for loading and sailing with numerous authority clearances and acts of God, such as natural events like rain and tides.

5.2.4 Cargo Handling Performance

The study has revealed that pre-arrival cargo handling performance is slightly efficient. Concerning waiting time, vessels spend relatively longer waiting time before finally been allocated berths, this implies that, berth allocation is also slightly efficient as asserted by the average majority. Concerning service time, it was discovered that it is slightly efficient meaning there is the need to improve the service time of cargo handling when vessels berth in port.

5.2.5 Cargo Handling Challenges Faced by the Tema Port.

The shipping lines within the researcher's sample, mentioned the following as some of the cargo handling challenges, they face at the Tema port. These include; harassment by port authorities, customs officials and the immigration, frequent damage to ship and equipment, delays in effecting corrections in relation to operations, congestion, container management and workforce problems and Port and State authorities making things difficult for vessels when they call at the port; like Port State Control.

5.2.6 Efficiency of Bulk Cargo Operations at the Tema Port.

Although the bulk cargo operations are not up to par, it was determined from the study findings that there is still room for improvement. The Tema port's bulk cargo activities are effective because they are crucial to cutting trade and transportation costs, tying supply chains together, and promoting international trade. Although the port's performance is at an acceptable level, it could be raised with the right people and equipment upgrades.

5.3 Conclusion

Regarding the research's objective of identifying factors that affect turnaround time of bulk carriers in Tema port and determining key influencers that can be controlled by terminal operators to help provide cost effective and efficient services with high port productivity. Bulk cargo handling is an important aspect in the maritime industry and the Tema port is of no exception. Handling bulk cargo effectively and efficiently necessitates the use of specific equipment intended to handle these cargoes. To facilitate the handling of bulk cargo, the port of Tema has been outfitted with a variety of equipment such as cranes, conveyors, forklifts, etc.

Despite the availability of equipment, there are still challenges that influence the turn-around time of bulk carriers in Tema port. Some of these challenges include lack of qualified personnel to run the equipment as well as inadequate and poor equipment maintenance. Additionally, there are logistical difficulties like traffic jams and delays with customs processing and rains falls and tidal waves as described as *acts of God.*

In order to improve the turn-around time of bulk carriers, various measures can be considered. Such as the need to invest in modern equipment that is specifically designed for the handling of

bulk cargo. This will not only improve efficiency but also reduce the risk of damage to cargo and equipment. Also, there should be a comprehensive maintenance program for handling equipment to ensure that it is in good working condition. This will reduce downtime and the risk of equipment failure, which can cause delays.

5.4 Recommendations

The following recommendations are made based on the research findings and conclusions.

One significant recommendation is for the port authority to establish a streamlined communication channel with vessels en-route to the port. By obtaining complete information about vessels' arrival schedules, the port can adequately prepare for their arrival. This preparation encompasses tasks such as berth allocation, documentation processing, berthing arrangements, and cargo servicing. These pre-emptive actions will help reduce waiting times, minimize vessel congestion, and ensure a more synchronized and efficient cargo handling process. It is vital that the port authority takes the lead in this endeavor, fostering effective communication with shipping lines and vessel operators.

To maintain smooth operations, the port of Tema should consider implementing routine equipment maintenance and optimizing labor force management. Regular maintenance of cargo handling equipment, such as cranes and forklifts, is essential to prevent unexpected breakdowns and delays. Additionally, hiring experienced laborers who can pass on their expertise to new recruits will facilitate a seamless transition in the workforce. This approach will mitigate the loss of experience and skills due to workforce turnover. The port administration should take the initiative to ensure the implementation of these maintenance and labor management strategies.

It is recommended that the port authorities collaborate closely with cargo owners to ensure that the provided stevedores are adequately trained and equipped. This measure will enable them to address minor technical issues during the vessel's service time without needing to wait for external technicians. By empowering stevedores to handle minor faults independently, the port can significantly reduce vessel downtime and enhance the overall efficiency of cargo operations. The responsibility to enforce these training and equipment standards lies with the port management, supported by effective partnerships with cargo owners.

To further expedite the service time of bulk carriers, continuous monitoring of stevedores during loading and offloading operations is crucial. Port authorities should actively oversee the activities of stevedores to ensure the optimal utilization of equipment and adherence to operational protocols. By ensuring that all required equipment is effectively employed and

operations are streamlined, the port can minimize idle time and optimize vessel turnaround time. This proactive oversight should be carried out by the port administration, reinforcing the port's commitment to efficiency and performance improvement.

Addressing congestion and delays in handling bulk carriers at the Tema port necessitates enhanced coordination among all stakeholders involved. This includes stevedores, customs officials, and shipping companies. Improved collaboration and synchronized efforts among these entities are essential to eliminate bottlenecks in the cargo handling process. The port authority should take the lead in fostering communication and collaboration platforms that facilitate realtime information sharing and coordination among stakeholders. This collaborative approach will mitigate delays, reduce congestion, and enhance the overall effectiveness of bulk carrier operations at the port.

In summary, these recommendations collectively aim to optimize cargo handling, reduce delays, and enhance the overall efficiency of bulk carrier operations at the Tema port. Each recommendation comes with a clear call to action for the relevant stakeholders. The Tema port authority, in particular, holds a central role in initiating and overseeing the implementation of these measures, collaborating with cargo owners, labor management, stevedores, customs officials, and shipping companies to create a harmonious and streamlined cargo handling process.

5.5 Proposed Further Research

A further study in the area of Analysis of current equipment and facilities: A detailed analysis of the current equipment and facilities used in Ghana's seaports for handling bulk cargo would provide a better understanding of the challenges facing the industry. This would help identify areas that require improvement and guide the development of solutions.

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APPENDICES

APPENDIX 1 PART A (RESPONDENTS IDENTITY)

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

STUDENTS PROJECT QUESTIONNAIRES AND INTERVIEW GUIDE.

INTRODUCTION

I am a student of the Kwame Nkrumah University Of Science And Technology, pursuing MSc. Logistics and Supply Chain Management in the department of Supply Chain and Information Systems. I am researching on **"SUPPLY CHAIN IMPLICATIONS OF CARGO HANDLING AND TURNAROUND TIME OF BULK CARRIERS IN GHANA PORTS"** as a requirement for the award of a Master's Degree in the above-stated program. This study

aims to identify factors that affect turnaround time of bulk carriers in the light of determining key influencers that can be controlled by terminal operators in the Tema port and to provide cost effective and efficient services with high port productivity.

I shall be grateful if you can find time to respond to these questionnaires to enable me successfully complete this research. This study is intended for academic purpose only and not for any commercial purposes.

I hereby assure you that all the information given will be treated as confidential and shall only be used strictly for its intended academic purposes. Please tick the appropriate box for your answers and write briefly when needed.

NB: In case of limited space for answers, please continue behind your paper and state the question number.

PART A (RESPONDENTS IDENTITY)

1. AGE

1. 20-29 years [ ] 2. 30-39 years [ ] 3. 40-49 years [ ] 4. 50-59 years [ ]

2. **GENDER**

1. Male [ ] 2. Female [ ]

3. LEVEL OF EDUCATION

1. Basic Education [ ] 2. SHS [ ] 3. HND/Degree [ ] 4. MBA/others [ ]

4. EMPLOYMENT STATUS

1. Temporal employment [ ] 2. Permanent employment [ ]

5. YEARS OF EMPLOYMENT

1. 0-5 [ ] 2. 6-10 [ ] 3. 11-15 [ ] 4. 16-20 [ ] 5. 21 and above[ ]

APPENDIX 2 - QUESTIONNAIRES TO SHIPPING LINES

1. Years your company has been in business at the Tema port.

   1-10 [ ] 11-20 [ ] 21-30 [ ] 31 and above [ ]

2. Frequency your vessel calls at the port.

   Often [ ] Rarely [ ] Sometimes [ ]

3. How would you rate the following with respect to bulk cargo handling performance from ship-shore at the port?

NB: Inefficient (1) Slightly Efficient (2) Efficient (3) Highly Efficient (4)

Activities/Performance	**1**	**2**	**3**	**4**
Prearrival				
Waiting Time				
Berth Allocation				
Service Time				

4. State some factors aside port operations that affect turnaround time of your vessel.

……
……
……
……

5. According to your chief officers, what are some cargo handling challenges they face at the Tema port?

……
…..……
……..

6. Would you rate the port's operations efficient or not? Yes [ ] No [ ] Either ways, explain your answer:

……
……

APPENDIX 3 – INTERVIEW GUIDE TO BULK CARGO TERMINAL OPERATORS

1. How does the available equipment affect your workflow?
2. Are you assigned to task reasonably enough to make you operate more efficiently and timely?
3. In your opinion, what are the operational challenges which are hindering efficient turnaround times?
4. Which government policy is/are causing turnaround challenge/s in your operations and how?

5. Do you encounter operational complexity as a result of ship size? Please share with me or better; does ship size influence the complexity of operations?
6. Would you recommend an improvement in the existing equipment to help improve on the current service quality?

APPENDIX 4 – INTERVIEW GUIDE TO G.P.H.A OPERATIONS OFFICERS

1. How is your vessel traffic management system's performance, abilities or challenges?
2. How does management of port equipment affect bulk carrier turnaround?
3. How does management of marine services affect bulk carrier turnaround?
4. What control mechanisms is the port having to ensure efficient turnaround time of bulk carriers?

5. Would you describe your current workforce at the port as up to standard? (Have the required skills and knowledge)
6. Does the management of the port have any plans of improving the current bulk carrier handling equipment?
7. What do you think about vessel turnaround time at the port and what factors affect turnaround times?