DISCRETE EVENT SIMULATION BASED OPERATIONAL PERFORMANCE ANAYLSIS OF MODJO DRY PORT, OROMIA, ETHIOPIA

M.Sc. THESIS

BY

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HAWASSA UNIVERSITY-IOT

DEPARTMENT OF INDUSTRIAL ENGINEERING

ADVISORS' APPROVAL SHEET

Submission Sheet-1

This is to certify that the thesis entitled "Discrete Event Simulation based operational performance analysis of Modjo Dry Port" submitted in partial fulfillment of the requirements for the degree of *Master of Science in Industrial Engineering and Logistics Management* under the Graduate Program studies, has been carried out by Mahmud Abdurahman Id. No IELM-R/007/09, under our supervision. Therefore we recommend that the student has fulfilled the requirements and hence, hereby can submit the thesis to the department.

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We, the undersigned, members of the Board of Examiners of the final open defense by Mahmud Abdurahman have read and evaluated his thesis entitled *"*Discrete Event Simulation based operational performance analysis of Modjo Dry Port*"*, and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of *Masters of Science in Industrial Engineering and Logistics Management*.

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STATEMENT OF THE AUTHOR

I, Mahmud Abdurahman declare that the thesis entitled *"Discrete Event Simulation based* Operational performance analysis of Modjo Dry Port*"* submitted in partial fulfillment of the requirements for the degree of *Masters of Science in Industrial Engineering and Logistics Management* is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references at the end of the main text. I also declare that this thesis is not submitted to other institution anywhere for the award of any academic degree, diploma or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of source is made.

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ABBREVAITION

ACO	Ant Colony Optimization
CT	Container Terminal
CDT	Container Dwell Time
DEA	Data Envelopment Analysis
DES	Discrete Event Simulation
DPOS	Dry Port Operating system
ESLSE	Ethiopian Shipping and Logistics Services Enterprise.
FEU	Fourth foot Equivalent Unit
GA	Genetic Algorithm
HIT	Hong Kong International Terminal
IBM	Industry Bench Mark
ITs	Internal Trucks
IT	Information Technology.
MDP	Modjo Dry Port
TTT	Truck Turn Time
TAS	Truck Appointment System
TEU	Twenty foot Equivalent Unit
TOS	Terminal Operating System
YCs	Yard cranes.
UNCTAD	United Nations Conference on Trade and Development
UNECA	United Nations Economic Commission for Africa
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific

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ABSTRACT

Container terminal operation consists of gate, container yard, and train and berth operation. The facilities used in the container terminal are reach stacker cranes, empty container handler, and yard tractors. The loading sequence of containers does not follow a FIFO (first in-first out) policy, and hence, the arrival order of containers does not define the sequence in which they are loaded. The purpose of this study was operational performance analysis of container terminals for the case of Modjo Dry Port. The study determined key port performance indicators (KPIs) of container terminal, factors affecting operational performance at container terminals and productivity level for container terminal. The researcher proposed a Desecrate Event Simulation (DES) model and a heuristic procedure for container's sacking plan and for gate operations. The main objective of formulating different scenarios was to find possible sets of input parameters, structural assumptions or model specifications that could lead to best performance. The data was collected using questionnaire, interview, conversation and observation the data was analyzed using descriptive statistics**.** The result of the analysis indicated that the numbers of gate operations, truck visit time, container dwell time (equipment, labor and land) productivity, container traffic are among the key performance indicator (KPIs). The study found the factors that affect the efficiency of operational performance are gate capacity, gate working hours, and resources within the terminal and truck arrival patterns container stacking system, custom clearance, container dwell time, operator experience, yard layout and maintenance problem. Current container terminal productivity level is poor comparing with industry bench mark of labor, equipment, and land. Based on the findings of the study, it is recommended that performance improvement strategy is changing current stacking strategies to dwell time segregated container stacking strategies. In addition, specific recommendations were made to address the issues identified which, if implemented, could significantly address the current inefficiencies observed in the Modjo Dry Port's operations

CHAPTER ONE

INTRODUCTION

1. Background of the study.

Containerization of ship cargo was first introduced in 1956, aiming to cut down the costs of maritime transport by reducing cargo handling costs (Levinson, 2006). Instead of loading/unloading each piece of transport item to or from a ship in a labor-intensive manner, containerization increases the efficiency and speed of transport by reducing the packing requirements and handling processes at all transfer points among port, rail and road. At the end of 2005, the world container fleet was expected to have increased to 21.6 million TEUs (Twenty-foot equivalent units) (UNCTAD, 2006). Thus, countries without adequate utilized transport facilities can be affected in their international trade (Castro, 1999).

Containerization has lowered shipping costs and significantly increased productivity of operations related to, international trades. Port terminals play a crucial role as intermodal interfaces and act as a linking node with other inland transport modes. International trade has been increasing over recent years, and with the increasing number of container shipments competition between port terminals has also increased. This means that there has been a greater demand for better service levels. Efficient logistics systems become necessary as an economy expands, becomes more diversified and globalized.

Ports are well known as playing an important role in multimodal transport systems and international supply chains, apart from their traditional role as clusters of economic activities. Ports engage in various activities: loading/discharging cargo on to/from truck or train; providing value-added services such as stuffing, packaging, maintaining, and others; and acting as warehouse and distribution centers (World Bank, 2007). Handling large volumes at a minimum unit cost and shortest time is paramount in positively impacting on the supply chain network. Establishment and explosion in global supply chains in the 1990s, coupled with export oriented growth strategies adopted by developing countries resulted into a paradigm shift in freight distribution systems. World Bank, (1993) defined the study of the Port productivity index that was divided into three types: by operational productivity, assets (equipment) productivity and financial productivity indicators. With the development of global multimodal supply chains, dry ports have been assumed increasing importance to suit the need for market development, smooth integration and closer collaboration between the different participants of the supply chain and transport network. Thus, it is a natural outcome for the ports to extend the services to locations situated further hinterland by either patronizing, forming strategic alliances or buying out existing dry ports so as to optimize the supply chain (Lee & Kim, 2003).

Multi modal transport and dry ports turned out to be the focal point in the new supply chain and logistics strategy formulation, first with the implementation in USA and developed in Europe, followed by East Asian countries and then more recently in Africa. This was mainly due to impossible focus to satisfy on trade which resulted into diminishing returns, congestion, and a significant fall in efficiency (Regasa, 2016).

As international trade volumes, freight transport and containerization rise rapidly, the East African region has not been left behind. The "Dry Port" concept is a step stone towards such development and can if managed correctly, lead to benefits on multiple levels within the transport industry (Laugesen, 2011). The competitiveness of a container dry port strongly relies on the service time of the container and, hence, the minimization of the time a container in the port is an overall objective with respect to terminal operations. In order to guarantee reduced service times for the truck, efficient cargo handling is required, especially considering that a higher number of containers are received by the terminal due to the tendency of increasing container throughput.

Many landlocked developing countries continuously face the challenge of physical isolation, supply chain related barriers from the sea and the high costs of trading with the rest of the world (UNECA, 2011). It is the most common at many container terminals that the retrieval containers are not properly stacked in the yard and we cannot avoid the containers' reshuffles. Hossein et.al, (2014) stated that a reshuffle is the removal of a container stacked on top of the desired container.

In inland logistics centers, dry ports are playing an increasingly pivotal role in the multimodal transport network that sustains economic activity by delivering key inputs to local enterprises and facilitating their exports of raw materials, semi-manufactured products, and finished goods, (Notteboom et.al 2005). For landlocked countries that normally suffer less connectivity with the rest of the world, innovations must be generated and applied to increase speed and reduce costs within the supply chain.

Ethiopia, as a landlocked country, has established its trade route along the Ethio-Djibouti corridor. The Ethio-Djibouti corridor is a main outlet to the sea and 925 Kilometers from Addis Ababa. It is the main route for Ethiopia's import and export trade which is dominated by freight transport. Due to economic deregulation that has been enacted in many sectors including freight transit and a program of privatization, state assets in combination with a rapidly growing economy powered by the Ethio - Djibouti corridor resulted in the growth of the transport industry. In an ever increasing volume of import-export volume in a coordinated way, the government of Ethiopia has taken a strategic measure by merging the former three public enterprises that have until recently been operating separately in a rather similar and interdependent maritime sub-sector; namely, Ethiopian Shipping Lines S.C, Maritime and Transit Services Enterprise and Dry Port Enterprise to form The Ethiopian Shipping and Logistics Services Enterprise. According to ESLSE, (Ethiopian Shipping and Logistics Service Enterprise) in response to the steadily growing volume of cross boundary trade, as a result, Ethiopia has moved to establish various inland dry ports. By 2013, four dry ports had been permanently established throughout Ethiopia in the city of Modjo, Semera, Mekele and Dire Dawa. There is also one temporary dry port in city of Kombolch and three freight stations centres around local area of Kality, Gelan and Adama. Modjo Dry Port was the first Dry Port in Ethiopia started operations in the first half of 2009. It is located at Modjo city, nearly 75 km East of Addis Ababa. The major dry port operations which consist of more than 78% imported goods are currently undertaken in this Port, (Modjo Dry Port annual report, 2017).

Currently ESLSE is administering seven dry ports including Modjo Dry Port and it was found out that the main operation at Port terminal are: loading and unloading import-export goods, stacking or storing goods and unpacking containerized goods, serving as a temporary storage place, custom clearance service, which in general can be divided in to gate control and planning operation, yard operation and Custom Freight Station (CFS).

Despite the obvious accelerating investments and increased service trade, the scientific research in the field of the dry port, operational performance analysis of container terminal are still lacking in Ethiopia. Since a public sector is aware of impact of the growing world container traffics and delays at container ports facilities, the port industry is under pressure to deal with the ever increasing freight volumes. Among these service operation the proposed study is concerned with the company's container terminals operational performance analysis.

Recently, container ports have experienced a number of challenges and restructures to survive in certain logistics environment (Faouzi, 2013). Consequently, modern container ports are part of complex systems operating in certain logistics environment. In order to minimize these challenges associated with landlockedness, the dry port concept evolved. Dry ports also evolved out of the challenges that faced existing sea ports i.e., due to the increase in size and capacity of container vessels, sea ports increasingly faced the challenge of inability to handle import and export cargo in a regular manner. This resulted into congestion at different sea ports due to long waiting time of trucks. Rodriguez (2009), observed that the evolution of dry ports was looked at as the cycle in the continuous development of containerization and intermodal transport, the country save foreign currency by mitigating demurrage charge that are paid at Djibouti port. The holding capacity of the Modjo Port has also improved from 950 to 14,900 containers and annual container service of the port is 133,070 TEU (Modjo Dry Port report, 2017).

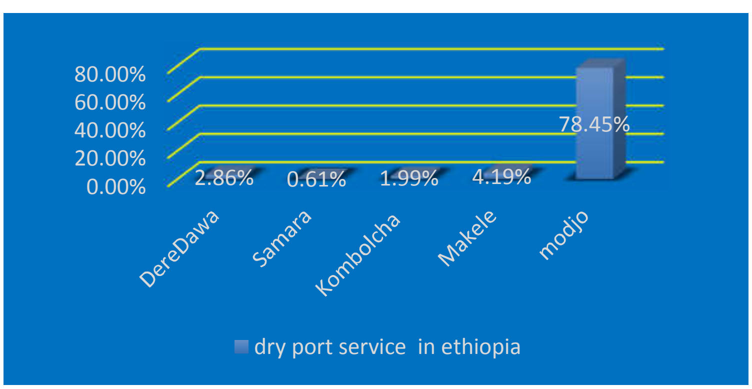


Figure 1.1: Dry port service in Ethiopia (Source: Modjo dry port annual report, 2017)

1.1. Statement of the problem

This thesis focused on dry port container terminal operation in the yard to save the issue of unproductive moves or reshuffling during stacking of inbound containers and to determine the most effective and best possible solution to maximize the efficiency of stacking system. There are two types of container handling operation, one is stacking and another is retrieval. If the containers are stacked on best possible location then the retrieval time of container, waiting time, and cost of the delivery truck will also be reduced. There were some constraints to stack the container in efficient way

Modjo Dry Port is undertaking the expansion and construction of ports and new terminals, under massive expansion work on total 144 hectares of land to meet international standard. On the other hand, they have customers complained of poor services and inefficient operation system, port serving imports of containerized cargo. It introduces long delays at the gate due to single in and out gate, in addition some containers are cleared within few days, while others are held for long months and perhaps should be considered abandoned at that time. These long held containers take up space at the container yard, increase the number of containers per stack, and increase the number of moves to get to a container, the major problem in the underlined company is container stacking system which is yard operation (container's reshuffling/unproductive moves) which occur due to not properly arranged stacking system. The additional movement which assigns the position of a blocking container is called a reshuffle or unproductive move. The containers' reshuffles at a container terminal is time consuming and increases container dwell time. This is the main reason of other problems which occur like delay in operational time at the terminal, cost increases and late container's delivery etc. Here what the researcher identify as a problem is container stacking system resulting in inefficiency of operational performance to the modjo dry port of container terminal.

1.2. Objective of the Study

1.2.1. General objective

The main research objective was to analyze the operational performance of container terminals for the case of modjo dry port.

1.2.2. Specific objective

The specific objectives of this research are to: -

- Assess key port performance indicators of container terminal.
- Determine factors affecting operational performance at container terminals
- Assess the productivity level for container terminal.
- Prioritize and select container operational performance improvement strategies

1.3. Research question

To achieve the specific objectives, the researcher wants answers to the following question.

1. What are the key performance indicators (KPIs) of container terminal operation?
2. What are the factors affecting efficiency of operational performance for container terminals at the port?
3. How does the productivity level of container terminal?
4. What are the performance improvement strategies and how can the poor performing continuation is improved and controlled?

1.4. Significance of the Study

Following the independency of Eritrea in 1991, Ethiopia became landlocked. Despite the obvious significance of port efficiency and as dry port is a new phenomenon to the country there are no studies conducted in the area especially on container terminal operation. Hence, in view of the important role those dry ports have to the whole supply chain and to entire economy of the country it is suitable to study the operational performance analysis on container terminal of the modjo dry ports. Therefore, this study is to identify the major factors that influence the efficiency of container terminal of the modjo dry port on operation perception. These findings will have importance to the researcher, academic, governments, port authorities and other Stakeholders by providing information and guidelines for the implementation of port policies and organizational reforms which enhance the efficiency of the dry ports. Moreover, it will narrow the existing knowledge gap in this area and could also serve as a reference for future studies in the area.

1.5. Scope and limitation of the study

The scope of the study covers the operational performance of container terminal case study of Modjo Dry Port. Specifically it covers cargo waiting line (gate operation), berth and train operation, Yard operation, (container stacking/storage, container loading/unloading) in container terminal of the port. Besides the study assessed the effects of the operational efficiency of container terminal systems practices from the stand point of the focal company, it was not involved the other companies of the container terminal systems. Finally the limitation of the research was, unavailability of related published work on dry port container terminal operation.

1.6. Organization of the thesis.

The research report consist six chapters and it was organized as follows. Chapter two present review of Container terminal concept and different definitions of the dry port. Container terminal performance measures, types of dry port, related works on operational performance. Subsequently, methods of the study were presented in chapter 3. Then, chapter 4 summarizes the result and discuss of the study and chapter five was about model development. Finally, on chapter six, the main findings of the study was summarized and conclusions was drawn based on the results of the study and at last, the paper forwarded appropriate recommendations and policy implications.

CHAPTER TWO
LITERATURE REVIEW.

Port refers to a location for the consolidation and distribution of goods. The Port can be a sea or dry ports. Dry port refers to the distribution of goods that has functions similar to those of a seaport, and which includes customs clearance services. Seaport functions that could be expected to be typically present at these dry ports. Sea ports is the place of contact between land and maritime space, and it provides services to both hinterland and maritime organization, Its primary function is to transfer goods (and people) from ocean vessels to land or to inland carriers, and vice versa. Ports have always had an important role in the development of national and international trade of countries, currently challenged by globalization, with implications for sustained economic development of their regions (Gaur, 2005). Globalization, emerged from trade growth between continents, regions and countries, has led to an expansion of global sea trade with huge impacts for ports. Increasing competition between transport modes and growing capacity per unit of transport demand for higher performance level in ports, which largely depend on their characteristics, such as infrastructure, equipment, governance structure and integration in logistic networks (Caldeirinha et al. 2011).

2.1. Definition of dry port

Dry ports were introduced as a way of accessing the hinterland and also reduce the pressure on the bottle necked, congested and inefficient sea ports. The adoption of dry port concept began in Europe and North America, followed by Asia, South America and then Africa. The dry port is a new concept, therefore this name is rarely known even in the logistics industry. Moreover, sometimes different definitions are used to describe the concept. There is no official dry port definition registered. Transport terminals having different functions than the ones named in the literature are sometimes containing the term dry port in their official name. Tsilingiris & Laguardia (2007) describe the dry port concept as an inland intermodal terminal that is directly connected via rail and/or truck to one or more water ports, and which can substitute certain port services in certain areas. They stress that the main aim of establishing a dry port is to perform certain container handling operations that have undesirable temporal and financial implications when done at a congested seaport.

In a dry port container handling costs should be lower in as much as the land and the labor cost is lower. The spacious facilities together with the intermodal centric design of the inland port accelerate the operations which are leading to positive monetary implications. From a network design point of view, the utilization of dry ports can decrease the generalized cost of dispatching containers (Aalborg 2009). Tsilingiris & Laguardia (2007) notice that because of the certain services that a dry port provides, it may appear to be similar to the distribution center.

However there is a main feature that separates the mentioned terms, a dry port is linked to the water port and can therefore substitute certain water port services, while a distribution center does not necessarily link to a port, for example the goods can be moved from the port directly to a dry port and only then the goods are cleared under customs). Moreover, an inland distribution center is not necessarily linked to and dependent on sea ports, while a dry port is linked to and dependent on sea port (Tsilingiris & Laguardia, 2007).

"A dry ort is an inland intermodal terminal directly connected to a seaport, with high capacity traffic modes, where customers can leave/collect their goods in intermodal loading units, as if directly to the seaport" (Roso, et al. 2006). Additionally to the basic services, transshipment, that a conventional inland terminal provides, such services as freight storage, consolidation, storage of empty containers, maintenance and repair of containers, customs clearance, and other services should be available at full-service dry ports (Roso, et al. 2006).

The definition suggested by United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP, 2006) describes a similar yet more detailed concept. Dry port refers to a defined inland location for the consolidation and distribution of goods that has functions similar to those of a seaport, and which includes customs clearance services. Seaport functions that could be expected to be typically present at these dry ports include container and possibly bulk handling facilities; intermodal infrastructure connections; a geographical grouping of independent companies and bodies dealing with freight transport (including, for example, freight forwarders, shippers and transport operators); and the provision of accompanying services such as customs inspections, tax payment, storage, maintenance and repair, banking and information communication technology connections.

Furthermore, it is necessary to highlight that dry ports are existing as the mean for organizational and business strategies in a logistics chain: dry ports might be considered as extended gates for seaports, through which transport flows can be better controlled and adjusted to match conditions in the port itself. Thus the terminals can help to improve land access to ports in both physical and psychological terms. This means that a dry port is more related to the organization and the service and business needs of the transport system, than related to a physical plant (Baltic, 2008). The given definitions are similar, especially that they all stress the similarity of port's and dry port's functions and transshipment function. Additionally, a Dry Port is described usually as container-oriented terminal.

2.2. Location of dry ports

While establishing a dry port, the choice of location makes an important impact on future performance, especially, considering that it is an intermodal terminal, having rail connection with the port. The intermodal transportation can be attractive for the shippers when the overall expenses are the same or smaller than the ones of road transport. Significant research on dry port distances have been made by Woxenius et al. (2004) and Rosa, et al. (2006). According to these researches, dry ports can be divided into close, midrange and distant dry ports.

The location of a dry port should be chosen according to the existing problems in the certain area, possible volumes of freight flows and potential to bring benefits to the selected area. Establishing midrange (distance is from around 70 km to 500 km) and close dry port (around 50 km or less distant from a port) is chosen when the port is lacking the storage area and its capacity cannot be increased, especially when there are no possibilities for the port to expand due to inhabited areas around or environmental aspects. It is useful to establish a dry port at a large distance (over 500 km) from a port when this place is near large areas of consumption and many manufacturers. Then the distant dry port has a potential to receive large volumes of goods as it can function as distribution center for further areas or the consolidation node for shippers located around. The illustrations of such dry ports are shown below.

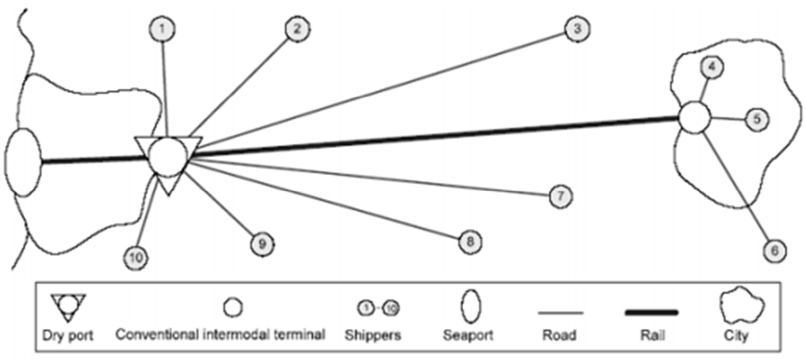


Figure 2.1: Close dry port connected to port, (Source: Roso et.al 2006)

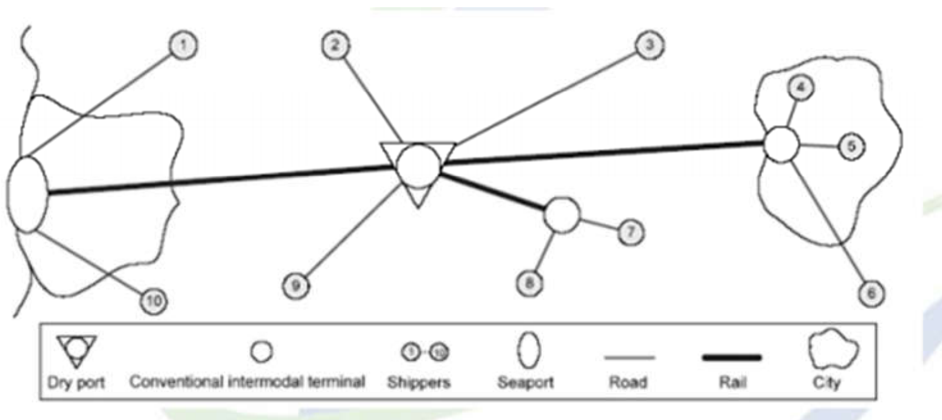


Figure 2.2: Midrange dry port connected to port, (Source: Roso et.al 2006)

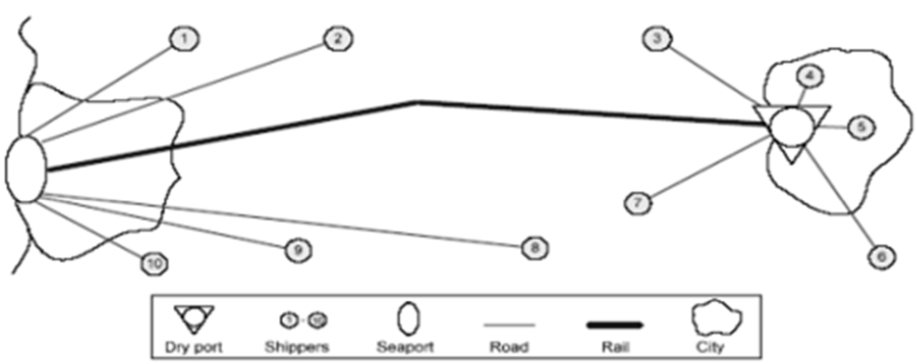


Figure 2. 3: Distance dry port connected to port. (Source: Roso et.al 2006)

It helps to reduce congestion on the access routes to the port and in the area around the port.

2.3. Functions of the Dry Port

Dry ports can be built from scratch or it may be developed from an inland terminal including some additional facilities that are characteristic for dry ports. If an inland terminal fulfils the following conditions it can be theoretically counted to be a dry port: The terminal should have direct connection to a seaport either by rail or by road; the terminal should have a high capacity traffic mode (i.e. rail or truck); the terminal should offer the same types of facilities as can be found in a seaport.

The realization of such conditions would mean that the customs services would be available at the terminal. That would allow making the goods ready for overseas travel already in a dry port, thus, the cargo could be transported through the port without long waiting time and loaded directly onto the train. The same idea would be relevant for the imported cargo. When the port is facing capacity problems, goods do not have to wait for the services at the port, after unloading from the ship they can be transported directly to a dry port. In that way ports are provided with extra available areas and their capacity is increased. UNESCAP, 2006 suggests that a terminal, having the status of a dry port, should be oriented to the expansion of its functions in order to be able to attract more enterprises and get more benefits from growing economics and increasing transportation volumes, as well as giving benefits for the area where it is located. As the very basis, it is enough for a dry port to provide services for handling and temporary storage of imported/exported loaded and empty containers and customs control. Afterwards it may expand the functions while including extra services. Moreover, even larger advancement can be reached while providing full import/export processes, broadening the functions towards industrial parks or special economic zones of assembly, manufacturing and agricultural processing (UNESCAP, 2006). The cardinal aim here is to make outward and inward movement of goods and services quicker and cheaper in terms of financial and operational costs (Wandera, 2001). Dry ports are therefore a very key component of intermodal freight transport system with vast advantages not only for landlocked countries but also for non-landlocked countries. Containerized trade has penetrated further inland and volumes have risen substantially with the consequence that cargo traffic through seaports has created congestion in the vicinity of these ports.

Dry ports have thus become an integral part of logistics by extending seaport functions inland (Garnwa al.et, 2009). In contrast with Europe and elsewhere in the world, where dry ports have been long established (Beresford & Dobson, 1989; Beresford & Dubey, 1990; Roso & Lumsden, 2010), East Africa's, dry port sector is still at primary level, with a few dry ports, that are yet to serve their significant logistical role in transport and logistics sector (Dry ports development in East Africa, 2016). The main objectives of a dry port are: to function as an extra hinterland space for the port/ports and a terminal, where the port can outsource its functions; to act as a high quality terminal while improving the efficiency and effectiveness of the logistics chain; to promote a modal shift. In order to implement the latter objectives, the following functions should be performed in a terminal:

2.4. Container terminal operations of dry port

In a terminal, containers enter and leave by different means of transport, such as trucks, trains. Container terminals provide the interface between rail roads and trucks and thus represent the critical link in the intermodal transportation chain. The main activities that make up the whole container terminal operation can be broken up into the following.

Berth Operations: The schedules of arriving train and the allocation of rubber gantry crane or reach stacker resources to service the train, the key concerns is the turnaround time of train.

Train Operation: Train operation involves the discharging and loading of containers on the train. This is handled by rubber gantry cranes or reach stacker to achieve high crane rates (number of containers moved per hour)

Yard Operation: is operation the busiest of all activities in the terminal, involves discharging containers from the truck, loading containers onto truck, shuffling containers that are out of sequence in the yard block, redistribution of containers to other blocks, known also as yard shifting, for more efficient loading into the second truck and inter terminal haulage where containers are moved to other yards in another terminal.

Gate operation: Deals with external freight forwarders, two activities are involved, namely export delivery where the freight forwarders bring in export containers to the yard to be loaded onto truck, and import receiving where freight forwarders receive containers from the yard to bring into the country (Sayi, 2008).

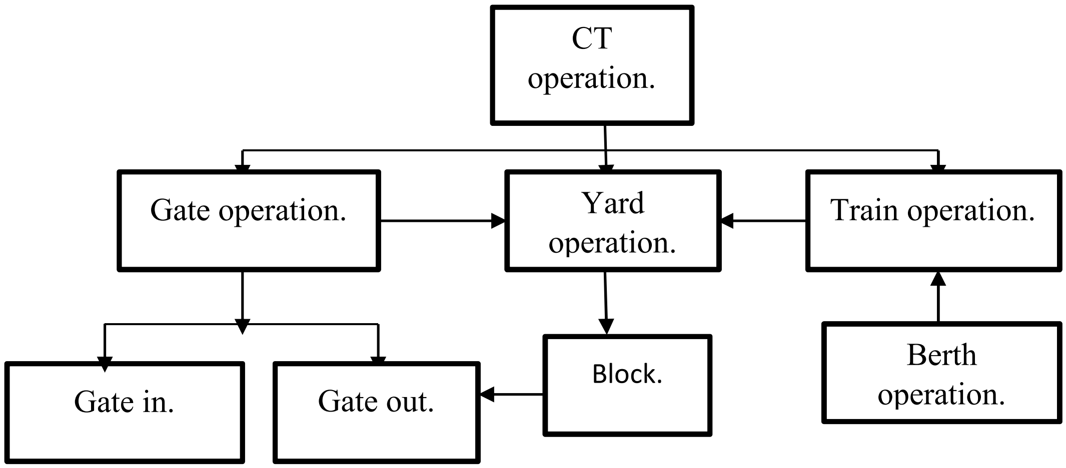


Figure 2.4. Systematic hierarchy of container terminal operation.

2.5. Dry port container terminal

A container terminal is a facility where cargo containers are moved between different transport vehicles, for the allowing the exchange of every kind of goods. The transshipment may be between container ship and land vehicles, usually trains or trucks, or, alternatively, can be between land vehicles: in the former case the terminal is described as a maritime container terminal; in the latter the terminal is described as an inland container terminal. Maritime container terminals often are a part of a larger port, and the biggest maritime container terminals can be located around major harbors. Inland container terminals tend to be located in or near major cities, with good rail connections to maritime container terminals. Containers are normally stacked for storage, and the resulting stores are known as container stacks (Pietrobon, 2014).

Container terminal operations, are activities for transferring containers between modes of transport and provide a package of activities/services to handle and control container flows from train/truck to land and vice versa. Container terminals are designated for the handling, storage, and possibly loading or unloading of cargo into or out of containers, and where containers can be picked up, dropped off, maintained, stored, or loaded or unloaded from one mode of transport to another (that is, vessel, truck, barge, or rail). World container terminals are classified into five categories by their ownerships: public terminals, carrier-leased dedicated terminals, terminal-operator built and operation terminals, carrier built and operation terminals, and joint venture of carriers and terminal operators. The operation characteristics of the five patterns are specified as bellow. (Eric Ting, 2011)

2.6. World container terminals categories

2.6.1. Public terminals

All the shipping lines share with each other the facilities of public terminals in loading and discharging and are charged at tariff rates, generally with first come first served principle and without any priority in berth usage except paying priority tolls. Container handling and other charges are calculated at common tariff rates, or paid at quantity discount rates in case container volume is over the fixed quantity agreed upon in contracts. Singapore, Busan, Keelung are categorized into this operation pattern.

2.6.2. Carrier-leased dedicated terminals

Carriers sign long-term lease contracts with the port authorities for their own exclusive use. Carriers pay rents and facility charges and the port authorities entitle contract carriers to right and priority in berth usage. Carrier could be entitled to purchase or install container handling facilities at his own account to compensate for rents and facility charges.

Kaohsiung, Keelung (some parts of the port), Kobe, Yokohama, Tokyo are categorized into this operation pattern.

2.6.3. Carrier built and operation terminals

By making a deposit and allocating to the port authorities in proportion to the total handling charges as agreed in the contract, a carrier or several carriers lease container terminals or invest directly in the construction, operation of container terminals and handling facilities. Malaysia, Taipei Port (invested by Yang Ming Line, Evergreen, Wan-Hai), Qingdao (Zhunguang, Kuaikuei, Tiasing) are categorized into this operation pattern.

2.6.4. Joint venture of carriers and terminal operators

By making a deposit and allocating to the port authorities in proportion to the total handling charges as agreed in the contract, a joint venture of shipping lines and terminal operators establishes a company, or makes a joint investment in leasing container terminals or invest directly in the construction, operation of container terminals and handling facilities. Shanghai (Yangshan terminals, Zhunghai terminals), Shenzhen, Shekou are categorized into this operation pattern.

2.6.5. Terminal-operator built and operation terminals

By making a deposit and allocating to the port authorities in proportion to the total handling charges as agreed in the contract, a terminal operator leases container terminals or invests directly in the construction, operation of container terminals and handling facilities. Hong Kong, Shanghai, Tianjin, Singapore are categorized into this operation pattern.

Large numbers of cargos are moved in containers through ports. Therefore, effective and efficient management of port container terminals is quite important in marine transportation development (YANG et.al. 2013). Thousands of containers are handled in a container terminal everyday by different types of material handling equipment. Managing activities of such high intensity level in a container terminal is a challenging task. In a container terminal, the allocation of resources is typically triggered by time, and all resources have to be considered simultaneously in the terminal's resource allocation process (Steenken et.al. 2004). In container terminals, different types of material handling equipment are used; quay cranes, yard cranes and trucks. Such equipment's are used in different parts of a container terminal to transfer containers from one location to another. There are many different decisions involved in operating container terminals and all these decisions affect each other. For example, decisions about the storage of containers in the yard directly affect the workloads of the yard cranes in the blocks and the traveling distances of the Internal Trucks (Its) and indirectly affect the efficiency of Yard cranes (Ycs). All these decisions are also related to the berth allocation of vessels (Murty.et.al. 2003).

2.7. Container terminal performance measures

Container terminal productivity/performance measures deals with the efficiency use of Labor, Equipment, and Land. Terminal performance measurement is a means to quantify the efficiency of the use of these three resources (Dowd & Leschine, 2001).

Tongzon & lingam (2009) identified several indicators of terminal efficiency and categorized them into two broad groups, namely: operational efficiency measures and customer oriented measures. The first set of measure deals with capital and labor productivity as well as asset utilization rates. The second set includes direct charges, truck waiting time, minimization of delays in inland transport and reliability (Tongzon & lingam, 2009) operational efficiency, which evaluate ports 'operational results, or input/output ratio, or productivity and effectiveness measures. Among the operational indicators there are such measures as arrival time, waiting time, service time, turnaround time, It is clear that the majority of all operational port performance indicators reflect time efficiency (UNCTAD, 1976), from that time this list is recognized as a reference point for researchers.

2.7.1. Key performance indicators

In regard to single output criteria, the throughput of container terminals in TEU is a popular indicator to display maritime business rankings, (World Shipping Council, 2011), KPIs measuring operational effectiveness and efficiency are (reach stacker productivity, container throughput, rail mounted or rubber gantry crane productivity, number of container moves, terminal and storage area productivity, container dwell time, number of gate, average number of reach stacker touch/hr. container traffic, truck visit time or truck turnaround time and so on) Container without a delivery date is known as the dwell container (Container Port Conference Rotterdam, 2003).

Type	Description
Yard measurements	Average truck turnaround time
	No. lifts / reach stacker /operating hour
	Mean storage dwell time
Gate measurements	Entry gate delay per arriving truck
	Exit gate delay per departing truck
	Trucks per gate per operating hour
Train measurements	Number of lifts per crane operating hour
	Average delay per train departure

Table 2.1 performance measurement indicators (Source: Container Port Conference Rotterdam, 2003).

Container Dwell Time: Merckx, (2005) defines the container dwell time as the average time a container remains stacked on the terminal and during which it waits for some activity to occur. According to this definition, dwell time also refers to the efficiency of terminal operations. The shorter the dwell time the more efficient the performed operation and vice versa. Container dwell time is one of the many performance indicators to assess the efficiency of terminal operation. As compared to standard indicators such as truck turnaround time or productivity indicators it is however not yet widely used for global benchmarking purposes. It is therefore challenging to define standard limits above which dwell time would be considered too long in any given port. Maritime industry sector experts tend to agree however on a 3 to 4 days representative mean value (Goardon, 2003).In practice typical averages of between 5 and 7 days are usually considered reasonable.

For containerized imports, cargo dwell time is defined as the time between truck arrival and container exit from the port facilities exceeds 20 days in average for most seaport in developing countries which makes them the most time-inefficient seaport in the world (UNCTAD, 2003).

Truck visit time: Truck visit time refers to the amount of time truckers are spending at the terminal when they come to pick up and drop off containers. This is an important KPI because it greatly affects a customer's bottom-line. As a key player in the supply-chain and important customer of the port terminal, container terminal want to help them succeed and provide the best service possible to them. If they can make more trips per week to the port because you've reduced the time it takes for them to visit, they will love working with your terminal instead of the competitors'. For an efficient port the average should lie between about 20-30 minutes.

Number of gate operation: The other KPI port terminal should monitor closely is the number of gate moves completed per day (in and out). This is an incredibly valuable metric because it not only helps port terminals understand their volume in real-time, but it also helps control overall operations.

2.7.2. Benchmarking container terminal performance

"Benchmarking is a continuous systematic process for evaluating the products, services and work processes of organizations that are recognized as representing best practices for the purpose of organizational improvement." (Spendolini, 1992). Benchmarking is a performance measurement tool used in conjunction with improvement initiatives; it measures comparative operating performance of companies and identifies the 'best practices. (Container Port Conference Rotterdam, 2003). Starting from an analysis of existing processes or activities and then to identify an external point of reference or standard, by which each activity can be measured or judged. A benchmark can be established at any level of the organization in any functional area. The ultimate goal is to be better than the best to attain a competitive advantage. Handling of containers has very much become a numbers game with all important throughput figures often featuring as benchmarks. However there is not, and there cannot be, a single holistic benchmark which can be applied to a whole container terminal.

2.7.3. Productivity benchmarks.

2.7.3.1. Workforce Productivity

This can be measured as the number of TEU per annum divided by the total number of staff employed in the terminal. Drewry (2013) indicates figures for a medium sized terminal (210,000 TEU) of 900 TEU/man rising to 1,100 TEU/man in a large terminal (over 500,000 TEU).

2.7.3.2. Yard Productivity.

This is broadly the number of TEU's of container handled divided by the total area of the terminal. The industry benchmark standard is generally taken as 20,000 TEU/ hectare/ year. For larger terminals an increase of up to 50% could be considered (Container Port Conference Rotterdam, 2003). Sate again strongly some of the observed trends, most effective operations seem to be concentrated in Asia, followed by Northern Europe. According to Drewry (2013) Maritime Research, the average crane productivity in 2009 was 136,531 TEUs per crane per year in Western Asia, 124,581 TEUs in Eastern Asia and 119,276 TEUs in South-East Asia; the lowest scores were reached in Eastern Europe (56,063 TEUs) and North America (71,741 TEUs) (Drewry Maritime Research, 2013). Crane productivity is typically an average of 20 moves per crane per hour in Western Africa, 25 to 30 in South Africa and 35 to 40 in Asia. Figure 2.5 provides examples of cargo dwell times in sub-Saharan Africa, which are unusually long, compared with performances in other regions such as Asia and Europe, where cargo dwell times in large ports are usually under one week. Not including Durban and Mombasa, the average cargo dwell time in most ports in sub-Saharan Africa is estimated at 20 days (Raballand et al., 2012).

2.8. Dry port in the East African Country

The East African Community composed of Uganda, Kenya, Tanzania, Rwanda, and Burundi, as well as Ethiopia, South Sudan, and Democratic Republic of Congo. A part from Kenya and Tanzania that enjoy a coastline along the Indian Ocean, the rest are landlocked hence suffering shipping and logistical bottlenecks that come with landlocked ness. High economic potential of this region, it currently relies almost 100% on Mombasa Sea port (Kenya) and Dares salaam Sea port (Tanzania) for shipping needs. Although Somalia Ports of Mogadishu and Kismaayo could serve Ethiopia ease of access due to distance and weak connectivity create variation in the level of utilization of available alternative ports and their significance in handling the Ethiopian trade, due to proximity reasons, political instability and terrorism have made it unviable. The port of Djibouti is the main gateway for Ethiopian export and import cargoes. It is the base port for ESLSE operations and also serves as a home port for own ships.

Table 2.2, ports share of Ethiopian cargo handled, Source: (Shewangizaw, 2016)

Port of discharge	Share (%)
Port of Sudan	1.2
Berbera	0.2
Djibouti	98.6

To meet its logistics needs, the region's hinterland relies on three major transport corridors, namely; the northern corridor, Central corridor and Southern Corridor with origin from Mombasa and Dares Salaam ports. The northern corridor is connected by rail and road, from Mombasa port in Kenya through the cities of Nairobi, Eldoret, Kampala in Uganda, to Democratic Republic of Congo and Southern Sudan. Along this corridor are dry ports in Mombasa, four kilometers from Kenya's port of Mombasa, Malaba in

Eastern Uganda and two inland ports on the shores of Lake Victoria in Kisumu-Kenya and Port bell in Uganda. The Central corridor linked by rail stretches from the Port of Dares salaam through the City of Dodoma to Rwanda, Burundi, and Uganda. Along this route, there is one dry port in Isaak Tanzania and an inland port on Lake Victoria city Mwanza. The Southern Corridor linked by Rail and road also originates from Dares salaam all the way to the border with Zambia. Below is the map of East Africa showing transport and logistics corridors.

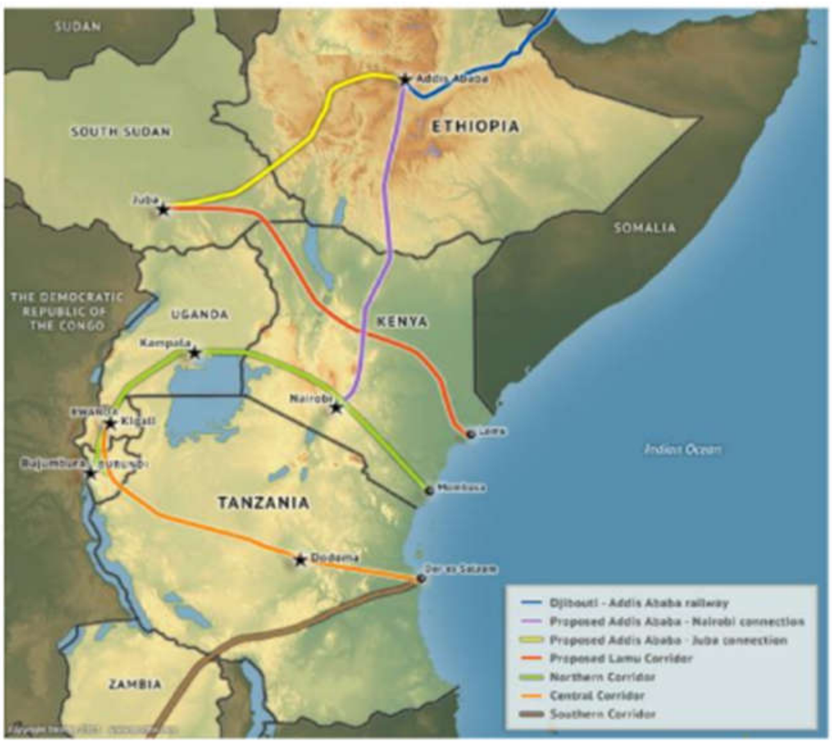
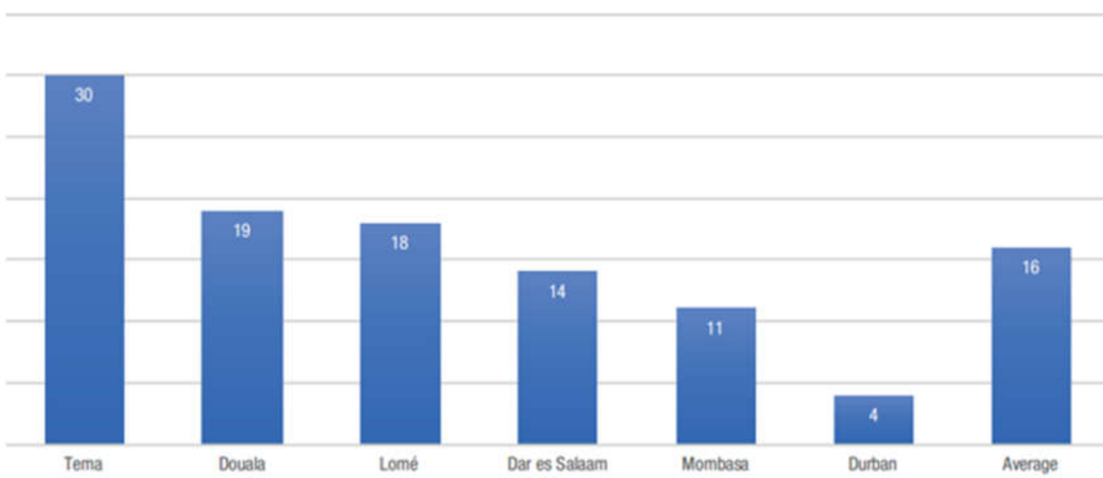


Figure. 2.5: Transport corridors of East Africa. (Source: Wanzala.et.al, 2016)

The single most important factor, according to recent studies on dwell time in sub-Saharan African ports, is the use of the port as storage warehouse by importers or their agents. It seems that importers are taking advantage of the opportunity of free storage given and only consider taking their cargo when the free storage nears expiry (Refas & Cantens, 2011). The dwell time for containers between delivery and dispatch in the terminal presents us with a good means of identifying poor clearance procedures. This can be due either to terminal or regulatory authority requirements and generally affects import cargoes. The average industry benchmark, time aspired to in most terminals is 3 or 4 days with most terminals allowing importers this time until storage charges are triggered. In practice typical averages of between 5 and 7 days are usually considered reasonable (Container Port Conference Rotterdam, 2003).

Figure 2.6. Average Cargo dwell time in sub-Saharan Africa 2011 (number of days)

Source: (Review of Maritime Transport 2017).



Note: Average does not include Durban

2.9. Related works

A container terminal works under multiple operational objectives. Container terminal operations comprise of a very complicated set of container handling processes. Many approaches have been developed to solve container terminal problems. Silva et al. (2008) presents a comparative study on Genetic algorithm (GA) and Ant Colony Optimization (ACO), in order to decide which of the algorithms should be used on the optimization and rescheduling of a logistic system. The study is based on two different analyses, a literature survey, where the performances of GA and ACO are compared for different well known benchmark problems, and on a detailed comparison for a logistic optimization problem. Both analyses led to the same general conclusions, GA and ACO have good and similar performances for different instances of different optimization problems, but the GA have in general a lower computational burden. However, the extra-time required by the ACO is used to record information about the optimization procedure that can be used to reschedule the logistic system in dynamic environments. Cordeau et al. (2007) studied the Service Allocation Problem, the objective is the minimization of container handling operations in the yard and it is formulated as a Quadratic Assignment Problem. Jinxin et al. (2008) considered the problem of scheduling of trucks in a container terminal to minimize amount of space covered. An integer programming model for truck scheduling and storage allocation problem is formulated (CAO Jinxin 2008). Huang et al. (2008) presents a simulation model that can be used to simulate the container terminal operations for the purpose of terminal design, capacity planning and operations planning, it was found to be effective in replicating real world operations as well as in evaluating the handling capacities (Huang, 2008).

Nyema (2014) assess factors influencing container terminals efficiency with a case study of the Mombasa Entry Port using a descriptive survey design. This study revealed that factors such as inadequate cargo handling equipment, reducing berth times and delays of container ships, dwell time, container cargo and truck turnaround time, custom clearance, limited storage capacity, poor multimodal connections to hinterland and infrastructure directly influencing container terminal efficiency.

Ries et, al. (2015) proposed a mathematical model to support the pre-assignment of block positions to segregations. Huynh (2009) provided a mathematical model to examine the effect of limiting truck arrivals on truck turn time and crane utilization. As an extension for their work, Huynh & Walton (2011) produced DES model to simulate various appointment rules. They examined the individual appointments vs the block appointment and studied its effect on truck turn time and crane utilization.

A comprehensive study by Morays & Lord (2006) developed the appointment system implemented in terminals across North America. They adopted various strategies to reduce the idling of truck, congestion at gates and emissions related to CT drayage operations.

Li et al. (2016) proposed some response strategies that help in solving the problem of truck arrivals' deviation from its appointments. Results showed that the greenness of operations is significantly affected by the use of truck appointments. Chen & Jiang

(2016) introduced some strategies to manage the truck arrivals within the time windows based on truck service relationship to reduce the terminal congestion.

To sum up, an increasing attention is paid to the Truck Appointment System (TAS). However, only two studies Phan & Kim (2015) and Phan & Kim (2016)) investigated the Truck Appointment System (TAS) with considering the collaboration among trucking companies and the container terminal. Chen & Yang (2010) studied the export container's drayage operations in Chinese CT. They proposed an integer programming model in order to reduce the transportation cost through time window management. They indicated that the peak arrivals are smoothed by solving the problem using a genetic algorithm (GA).

Simulation can be defined as creating a computer model of a real or proposed system and conducting experiments with the model to describe the observed behavior and/or predict the future behavior before investing any time or money. Simulation is a tool to evaluate the performance of a system, under different configurations of interest and over long periods of real time, because of experimenting with a real system could be costly and/or impractical, simulation has become an extremely important tool for designing and analyzing complex systems.

Simulation modeling techniques are being applied to a wide range of container terminal planning processes and operational analysis of container handling systems. The purpose of simulation is to generate data that can be used in decision making. It is a cost effective way of pre-testing proposed systems, plans, or policies before incurring the expense of prototypes, field tests, or actual implementations. Discrete Event Simulation has long been a useful tool for evaluating the performance of complex systems. Discrete-Event Simulation exploited to support container terminal decisions in a complex and stochastic environment. Simulation was used in many studies for developing and testing truck appointment systems. Sharif et al., (2011) developed an agent-based simulation model to achieve a steady arrival of external trucks at container terminals. The results showed that the congestion at CTs can be minimized by using gate congestion information and estimating the truck idling times. (Karafa, 2012) conducted a case study using a dynamic traffic simulation model to investigate the congestions and related emissions. Simulation based approaches have been widely used to model various planning problems arising in container terminals (Huang 2008). Jinxin et al. (2008) considered the problem of scheduling of trucks in a container terminal to minimize make span. An integer programming model for truck scheduling is formulated, the problem was solved with a genetic algorithm (Lee. et.al 2008)

Huang et al. (2008) presents a simulation model that can be used to simulate the container terminal operations for the purpose of terminal design, capacity planning and operations planning, it was found to be effective in replicating real world operations as well as in evaluating the handling capacities (Chen et.al, 2008)

Huynh and Walton (2008) and Huynh (2009) investigated limiting the arrivals and individual appointments versus the block appointments. In addition, they introduced combined mathematical model and Discrete Event simulation (DES) model. Guan &Liu (2009) stated that the Truck Appointment System (TAS) is one of the most viable strategies to avoid the terminal congestion and improve the system efficiency. To achieve that, authors formulated a nonlinear optimization model and applied a multi-server queuing model.

Based on a previous work Speren et al. (2013) used a DES model to investigate yard operations performance, and a significant reduction in yard crane move. Various performance analysis and objective are examined such as transportation cost, fuel consumption, shifted arrivals, and truck waiting times. A new concept of chassis exchange introduced by Dekker et al. (2013) to reduce the CT congestion using simulation as a calculation tool. Zhao & Goodchild, (2013) used a hybrid approach of simulation and queuing models to examine the impact of the TAS on the performance of yard crane operations. The results showed a significant improvement in system performance and efficiency. Zehendner & Feillet, (2014) formulated a mixed integer programming model to get the optimum number of appointments considering the CT workload. Results are validated using DES to ensure the improvements of service quality for both the trucks and also for all terminal resources.

2.10. Research gap identified

Due to changes in port industry, most countries are making great efforts to secure their ports by investing more funds on port facilities and by improving efficiency in port operations and management, to advance their competitiveness and performance. The port authorities have implemented various strategies, such as building logistics centers, expanding container port areas, cooperation between port authorities in the same areas and advancing IT systems (POGOLO, 2013).

In recent years from Addis Ababa University Mussema, (2016) had focused mainly on determinants of port performance for the underlined case company. The result of the analysis indicated that, cargo handling equipment, customs operations, port infrastructure, size of dry port, port staff, and reliability of port operations and quality of logistics service are found to be important factors in determining the performance of modjo dry port, without studying on the utilization of the three resource land, manpower and equipment, as well on key port performance indicators, port productivity and the factors that influence efficiency of container terminals in the port.

Most of previous research was based on efficiency and performance of the seaport interface leaving a room for a dry port interface. By careful investigation of the approaches proposed in the literature the researcher identify the gap for this paper approaches, there are two gaps that are needed to be covered to improve the existing approaches. The first gap is estimation of the truck turn times of dry port (TTT), this simple procedure lacks aspects such as the waiting times of trucks at gate, at the Yard, service rate of truck at the gate at the yard and arrival patterns of the truck. The second gap is that the existing literature did not considered the randomness of the dry port yard terminal stacking operations, this is the gap identified in this study.This paper propose modjo dry port to fill the gap by analyzing container terminal performance and resource utilization.

CHAPTER THREE

RESEARCH METHODOLOGY

Container handling problems at container terminal are too complex to be modeled analytically; discrete event simulation has been a useful tool for evaluating the performance of systems. Container terminal operations can best be analyzed using queueing models, it is believed that analytical queueing models are valid only if the probability distribution of the mean arrival rates of the truck (λ) is equal to or less than mean service rates (μ) of the truck ($\lambda \leq \mu$). However, the container terminal operation is difficult to check analytically with queuing models. Therefore simulation is an effective alternative for container terminal system analysis. Design and case study appraisal of container terminals may be carried out through two main approaches: optimization or simulation. Although the approaches based on optimization models allow a more elegant and compact formulation of the problem, Simulation is perhaps the best tool used for any non-trivial, real world system. For analysis of complex systems, simulation is often used prior to the operation of the real world system as a mediator for a dynamic situation (Kelton, 1991). Therefore, simulation methodology was recommended and chosen to analyze container terminal operation systems.

The container stacking problem in a container terminal is an important part of port management. Thus, container terminal operations have been of increasing interest to researchers. This paper studies the most important process at a container terminal that can be optimized by means of operations research. Relocation is most important to storage and pickup operation in block stacking because it affects the handling cost. A heuristics approach was proposed to show the relationship between the number of unproductive moves and container handling cost. The methodology used in this thesis was a Discrete-Event Simulation that consist of a simulation method for modeling to stack the containers in the yard and to avoid the further reshuffles.

The special nature of inland terminals and the complexity of its operations, arising from the complex operational interactions between the different service processes, are the most challenging aspects when analyzing and evaluating the performance. Analyzing efficiency is extremely important to terminal operation and helps terminal operators to ensure that they are getting optimal use from their equipment, time, and land.

Discrete Event Simulation (DES) had long been a useful tool for evaluating the performance of complex systems. In discrete event simulation the central assumption of the system changes instantaneously in response to certain discrete events and help to achieve several aims: overcome mathematical limitations of optimization approaches, support and make computer-generated strategies/policies more understandable, and support decision makers in daily decision processes through a "what if" approach.

In order to make the employee aware on performance of container terminal of the port questionnaire was for data collection with selection of a sampling frame for gathering information on current status of container terminal, discrete event simulation model was implemented to analyze the data.

Researcher decided to concentrate purposely on this port because it is the major port which import a big volume of containerized cargo's providing port services contributing to international trade to countries economy, only on this company which covers more than 78% of import and logistics service in the Ethiopia. Researcher took field survey to understand the operation and current status of container terminal and to assess the key port performance indicators and collected data on the utilization, availability and performance of each machine. In this context it was important to work out standard processes to get an idea of dry port terminal operations and to locate the sources of performance indicators. During terminal visits, the researcher applied questionnaire to check the availability of generic data and collect available information on the performance of the terminals to define the gap between needed indicators and availability of data for further modeling and analysis.

3.1. Research Design

The study employed an exploratory approach using a descriptive survey design to describe the current status of operational performance of container terminals. A descriptive research design presents and reports the way things are (Mugenda & Mugenda, 2003). Also, descriptive research design is used when data are collected to describe persons, organizations, settings or phenomena (Creswell, 2003). A case study was considered an appropriate method on the operational performance analysis of container terminals because it provides an opportunity to study in depth and provide well-ordered information concerning the area of the study. Furthermore, case study strategy was considered appropriate as it allows direct observations of the events at the port terminals being studied and interviews of the persons involved in the events. Physical working conditions, and facilities and through interviewing terminals administrators and users enabled to get picture of terminal operational performance. A case study strategy has a unique strength that enables the researcher to use a variety of methods of data collections. The approach was not limited to a single source of evidence since it relies on a variety of sources, in this study interviews, direct observations and conversation as well a survey, was used as methods of collecting data.

3.2. Study Population

Sekaran (2010) refers to population as the entire group of people or things of interest that the researcher aims to assess. Population as defined by Mugenda & Mugenda (2003) is an entire group of individual or objects having common observable characteristic. The study therefore took all person involved in the operations of container terminal in the underlined dry port as well as stakeholders who make use of the facility in port operations.

The target population mainly consisted of Container terminal operation flow team, Customer service and documentation team, gate plan and control team Terminal operators freight forwarders (clearing and forwarding agents),With regard to demographic details (i.e., age, gender, and level of education) as the main source of information in relation for analyzing operational performance of container terminal at the port. The number of these people when put together is approximately 404. Therefore the study targeted 404 people.

3.3. Demographic profile of respondents. The study analyzed the background information of the respondents by using the following parameters: gender, level of education, type of organization, name of department section/unit, position held by the respondents.

Table 3.1 Demographic Profile of Respondents

		Frequency	Percent
Gender	Male	24	75%
	Female	8	25%
	Total	32	100%
Education level	Master's degree	6	18.75%
	First degree	20	62.5%
	Diploma	6	18.75%
	Total	32	100%
Types of organization	Container terminal operation	14	43.75%
	Custom clearing operation	8	25%
	Gate controller operation	6	18.75%
	Other	4	12.5%
	Total	32	100%
Position	Senior Level Manage	6	18.75%
	Middle Level Manager	3	9.4%
	Junior level manager	8	25%
	Operators	7	21.88%
	Others	6	18.75%
	Total	32	100%
Work experience	6-7 years	7	21.88%
	3-5 years	9	28.125%

	< years	16	50%
	Total	32	100%

As Table 3.1 indicated 75 % of the respondents were male and the remaining 25 % were female. Regarding the education level, 62.5 % of the respondents have first degree, 18.75 % have diploma and the remaining 18.75 % respondents have Master's Degree. Furthermore, Table 3.1 indicated the types of organizations where customers were working, accordingly 43.75 % of respondents work in container terminal operation, 25 % on custom clearing and 18.75 % of respondents work gate controller. With regard to position of the respondents 18.75 % of the respondents were senior level managers while the 9.4% middle manager, 25% of the respondents were junior and 21.88% operator while others 18.75% working experience of respondents 6-7 years (21.88%) and 3-5 years also 28.125% and less than two years work experience was 50 % of respondents.

3.4. Area of the study

The study was conducted in Modjo city, at container terminals of dry port. Purposely because it is the major port in Ethiopia which import a big volume of containerized cargo's providing port services contributing to international trade to countries economy.

The choice of these research centers as a case study was because of the following reasons: First the company has large number of staffs that most data could be collected and be compiled easily. Secondly, most of the information needed by the research are available at these units and it was easier to attach targeted interviews of different categories since their daily activities are dealt at this centers. Lastly the company have long experience than other dry port in the country.

3.5. Sampling design and sample size procedures

In conducting the study the researcher selected representative samples from the entire population. It was not possible to cover the whole population due to time and resources constraints. Identifying survey respondents involved going through lists of people who were thought to share certain characteristics or concerns. Calculated sample size was also done to the locations that the researcher collected data. This population sample was drawn from the number of people currently working on the container terminals, the respondents composed of container terminal operation, freight forwarders, miss-location container flow team and Gate controller operation.

Keller (2009) indicates that a sample is a set drawn from the entire population. As Kothari (2004) expresses, a sample size between 10% and 20% is considered adequate for in depth studies. Therefore, the sample size for this study was 10% of 404.

Collecting information from every individual port user was very difficult thus; the researcher planned to interview respondents through skipping methods. Total number 40 respondents was assumed to be representative of the entire population.

Table 3.2: Sampling Frame

Department-Section/Unit	Frequency	Percentage
Container terminal operation	14	43.75%
Custom clearing operation	8	25%
Gate controller operation	6	18.75%
Other	4	12.5%
Total	32	100

3.6. Methods of data collection

Suanders et.al (2009) suggest the following data collection techniques: sampling, secondary data, observation, Interviews, and Questionnaires and that is what the researcher have used in this study, for primary data collection purpose, survey questionnaire is used. Employee of the dry port was approached personally and asked to fill the questionnaire. The questionnaire has six sections. First section is about general information of the participant and the company. In the second section participants were asked to evaluate the overall container terminal efficiency of the dry port based on the productivity of single crane. In the third section respondents were requested to inform the key port performance which has an impact on the efficiency of container terminal port. In the fourth and fifth section participants were asked to evaluate the overall crane productivity and container dwell time respectively and in the last section participants were asked to evaluate the overall custom clearance. Due to time constraints the sample size was based on the availability and willingness of customers when the data was collected physically at the dry port premise. Accordingly, questionnaire was distributed to 40 dry port workers who are willing to participate on the survey. Out of the 40 questionnaires 32 of it was filled completely and returned which means there were 80% response rate. Furthermore, secondary data from different publications was used

3.7. Conceptual framework

The research was guided by a Conceptual Framework that is indicated by the independent and dependent variables.

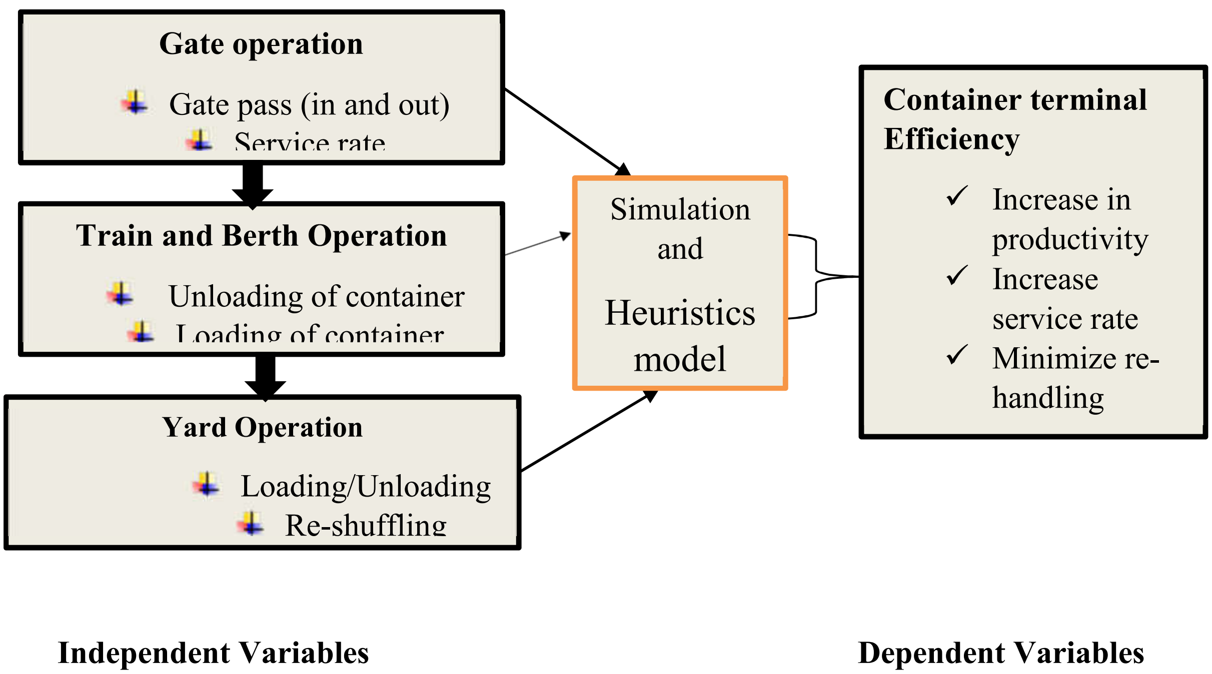


Figure 3.1: Conceptual Approach Framework

The above diagram shows the whole process of container terminal operation. This Conceptual approach express that Company's port competitiveness can be affected by how its operation activities are undertaken. Thus, this is the foundation on which the study was conducted or established. Truck inter arrivals and service rate may affect the gate operation and manner of berthing and train operation as well affected crane productivity and yard operation, yard operation is the busiest of all operation in container terminal and manner of stacking system could affect the terminal performance. By integrating each and every operation of the container starting from gate to yard using simulation model methodology and heuristic approach could improve and increase in the container terminal efficiency to depending on increased productivity, increased service rate and minimizing re-handling of container.

CHAPTER FOUR

RESULT AND DISCUSSIONS

4.1. Questionnaire results and descriptive analysis

This chapter presents the result of the research and analysis of the data and discussions of the findings in order to interpret according to the stated research questions and objectives.

4.2. Results on container terminal efficiency

This was the question responsible for the objective of the research, the perceptions was as follows; From the Graff respondents, (50 %) shows that operational performance of container terminals of Company is inefficient ,only 31.25% said yes, the big number who responded positive to the question are the staff of the terminals.

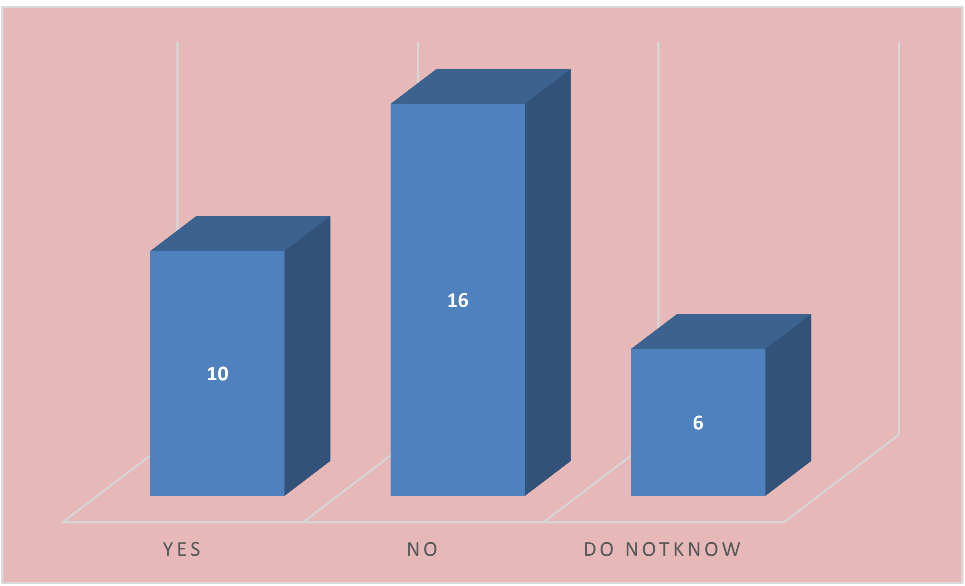


Figure 4.1: response on container terminal efficiency. (Source: survey respondents)

4.3. Assessment on key performance indicators

Even though there are so many KPIs to analyze operational effectiveness and efficiency like Crane productivity, container throughput, number of container moves, terminal and total area productivity, container dwell time, number of gate, average number of reach stacker touch/hr. average number of manpower productivity, container traffic, truck turnaround time, the researcher assessed on four key performance indicators, namely container dwell time, container traffic, and truck visit time and number of gate of container at the dry port because this is very important KPI for each and every container terminal. Respondents were asked to evaluate the significance level of the container dwell time, container traffic, truck visit time and number of gate in determining performance of the port.

4.3.1. Assessment on container dwell time

For the terminal operations at the Modjo Dry Port the average container Dwell time is 56 days (modjo dry port, 2018) and there is a direct relationship between distribution of dwell times and terminal occupancy. The total time the container remains stacked in the yard is a very important performance indicator in the container terminal. The longer the dwell time the worse the performance or productivity of the container terminal.

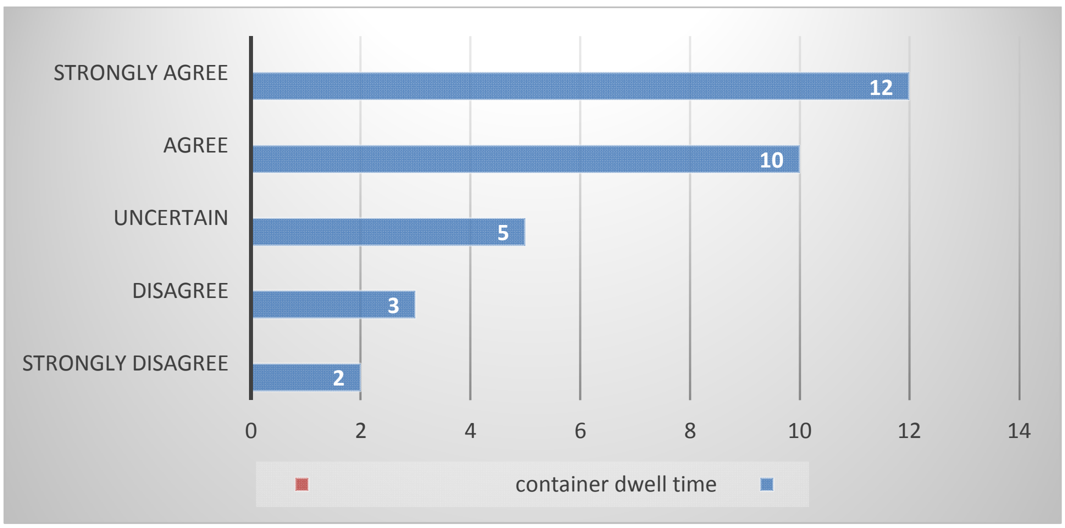


Figure 4.2: container dwell time as key performance indicators (Source: respondents)

From the Figure 4.2 significant number of customers was believed container dwell time is the key performance indicators the company dry port by 37.5% which is high response on strongly agree 31.25 % of the respondents say agree, 15.625 % of the respondents uncertain and 9.375% of the respondents dis agree and only 6.25% of the respondents dis agree from these what the researcher conclude that container dwell time for the company as key performance indictors is strongly agree.

4.3.2. Assessment on truck visit time

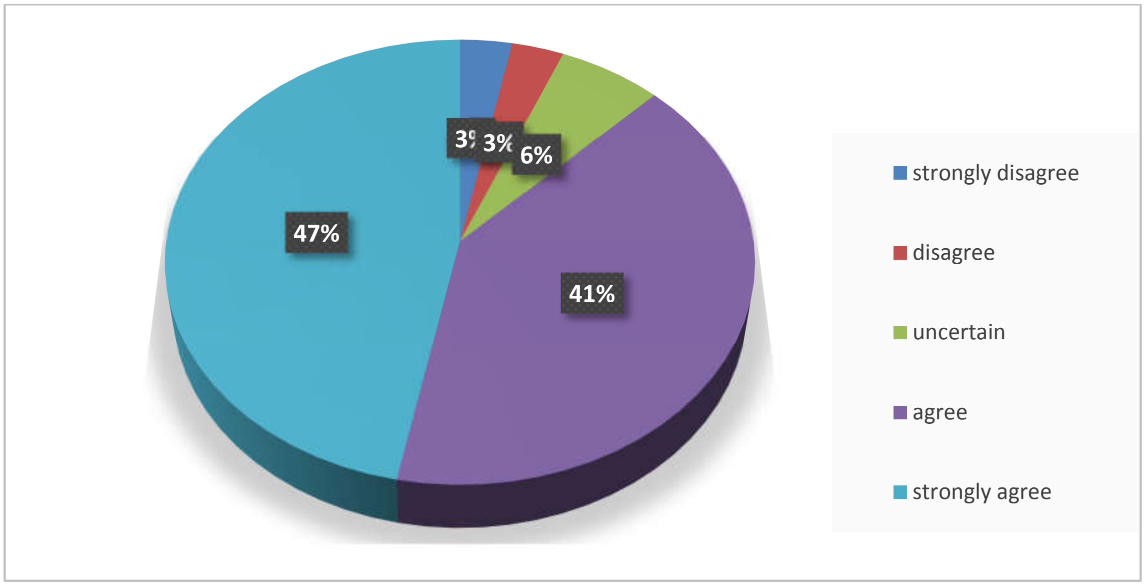


Figure 4.3: truck visit time as key performance indicators. (Source: respondents)

From the Figure 4.3 significant number of customers was believed truck visit time is the key performance indicators of the dry port by 47% which is high response on strongly agree and as well 41% of the respondents say agree and only 6% of the respondents uncertain from these what the researcher conclude that truck visit time for the company as key performance indictors is on strongly agree.

Figure 4.4 Truck visit time

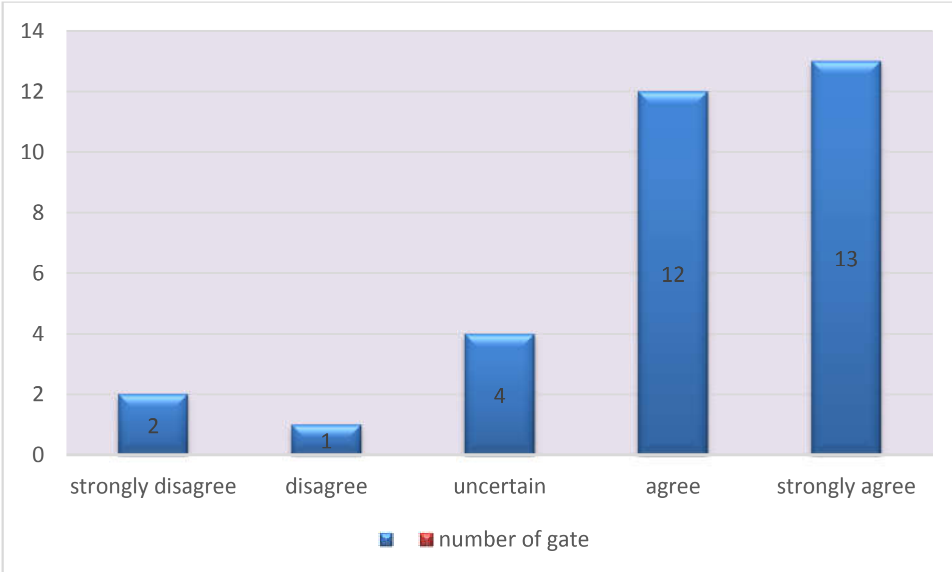


Figure 4.5: Number of gate as key performance indicators. (Source: respondents)

4.3.3. Assessment on numbers of gate operation.

From the Figure 4.5 significant number of customers was believed Number of gate operation is the key performance indicators of the dry port by 41% which is high response on strongly agree and 38% of the respondents say agree and only 12% of the respondents uncertain from these what the researcher conclude that number of gate operation for the company as key performance indictors is on strongly agree.

Figure 4.6 Gate operation. (Source: modjo dry port).

4.3.4. Assessment on container traffic

From the Figure 4.7 significant number of customers was believed truck container traffic is the key performance indicators of the port by 44 % which is high response on strongly agree and 33% of the respondents say agree and only 16 % of the respondents uncertain from these what the researcher conclude that container traffic for the company as key performance indictors is on strongly agree.

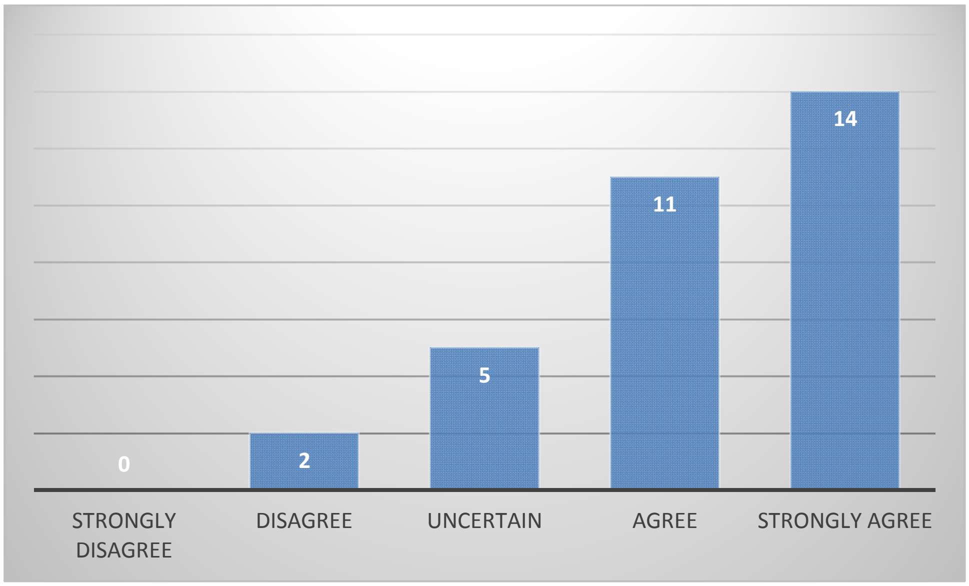


Figure 4.7: Container traffic as key performance indicators. (Source: respondents)

Container traffic. (Source: Modjo dry port).

4.4. Custom clearance

The procedures to store export containers vary among port terminals. The flow of containers could be directly from the yard stack to the outgoing terminal, during the loading process, or in other cases, the containers could be organized in another area (marshaling space) in which containers are sorted. This minimizes the truck service time, but also increases the number of movements. The study sought to find out the current average number of days used in clearing containers at the port. Finding reveals that 25 % of the respondents say within 24 hours, 44% of the respondents say 1-3 working days, 19 % of the respondents say 4-6 working days, while 7-9 working days was 13% This shows that the average number of days used in clearing containers at the port of dry port is 1-3working days. But depending on the risk level of container, which means Green, Yellow and Red it takes one day for the Green risk level, two days for the Yellow risk level and more than three days for Red risk level of container which is the boring custom clearance strategy for the company because it is the corrupted area.

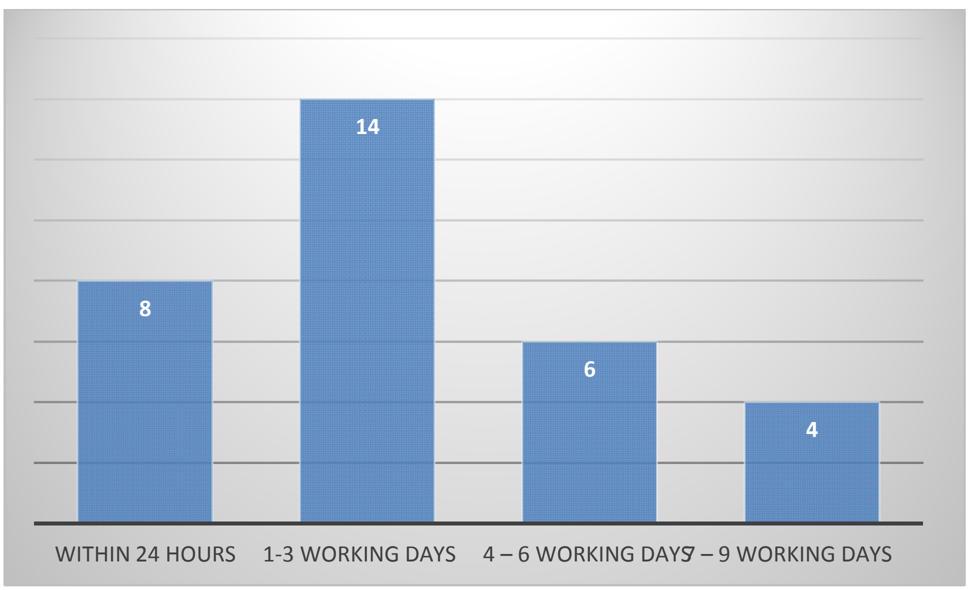


Figure 4.8**:** Number of days in clearing container. (Source: respondents)

4.5. Assessment on current performance of container terminal

The study aimed to grade the current container terminal performance of modjo dry port. Container terminal productivity or performance measures deals with the efficiency use of Labor, Equipment, and Land. Terminal performance measurement is a means to quantify the efficiency of the use of these three resources, accordingly in order to say the current terminal performance is good or poor it is important to assess productivity performance of labor, equipment, and land.

4.5.1. Labor productivity performance. This can be measured as the number of TEU per annum divided by the total number of staff employed in the terminal. The industry benchmark standard indicates figures for a medium sized terminal (210,000 TEU) of 900 TEU/man rising to 1,100 TEU/man in a large terminal (over 500,000 TEU).The current TEU container annual of the company is 133,070 and the current Labor is 589, then dividing the current total TEU container annual of the company by total Labor 133070/589 = 226 per labor/year

4.5.2. Equipment productivity performance

Total annual throughput =

the number of container crane available x No of cranes hours available x average crane rate.

Accordingly:

Number of Yard crane available (9) x Number of canes hours available (12) x average crane rate (20) touch per hour x 365 days = 788400 TEU

4.5.3. Land productivity performance: This is broadly the number of TEU's of container handled divided by the total area of the terminal. For MDP which is 133070/or 63 = 2112 TEU/hectare/year, while the industry benchmark standard is generally taken as 20,000 TEU/ hectare/year.

Table 4.1 Productivity level

Productivity level	Modjo dry port	Industry bench mark
Work force productivity	226 per labor/year	570 per labor/year
Equipment productivity	20-30 lift/hr.	25-35 lift/hr.
Land productivity	2112 TEU/hectare/year	20,000 TEU/hectare/year

From the following figure response of respondents indicated that out of the 32 respondents, 44 % of the respondent grades the current performance of container terminal poor, 31 % of the respondents grades the performance on the average or good, and 25% of the respondents grade the performance very good.

This concludes that the current performance of container terminal at the Port of Modjo Dry Port is poor.

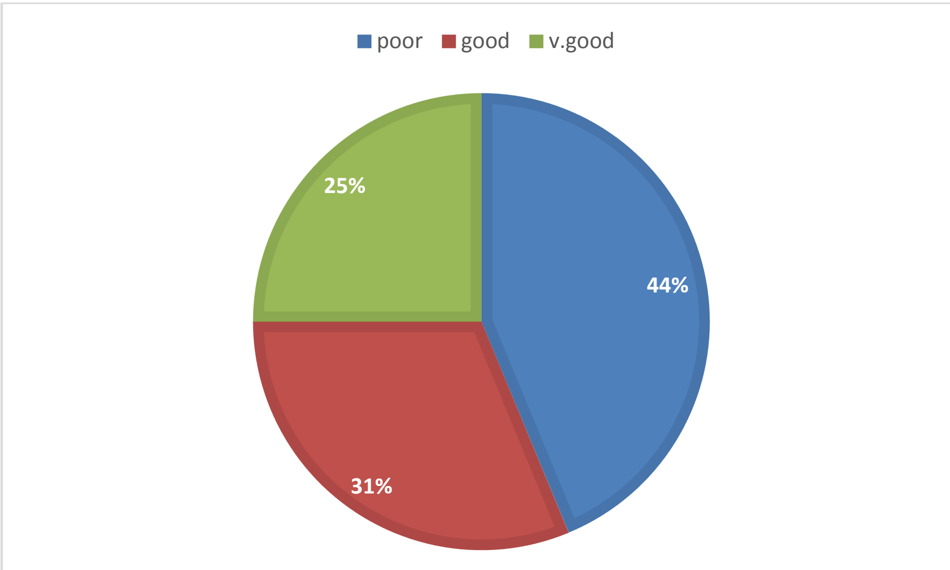


Figure 4.9 Assess on current performance of container terminal. (Source: respondents)

4.6. Assessment on turnaround time

The study sought to find out the average position of turnaround time of trucks at the company. In Modjo Dry Port container terminals, export container and import containers as well are brought by train and trucks to be delivered to the Modjo Port. One of the most imperative issues for in efficiency of the container carrying trucks is the long truck turn time (TTT). The following equation describes.

$$TTT = T_{wg} + T_{sg} + T_{wy} + T_{xg} + T_{sy} \qquad (4.1)$$

T_{wg}: waiting time at gate.

T_{sg}: Service time at gate.

T_{wy}: waiting time at yard.

T_{sy}: Service time at yard.

T_{xg}: Time spent at gate exit. (Adapted from ahmed.azab@ejust.edu.eg)

Terminal operators need to reduce the TTT as much as possible. The truck turn time has direct and indirect impacts on the terminal efficiency. As direct impacts, shorter waiting times and service times reduce the congestion outside the gates and within the yard area. In addition, decreasing the turn time increases the terminal throughput and reduces the processes cost. Indirectly, emissions are reduced by less waiting and idling of the trucks and terminal equipment. The gate operators usually force the trucks to wait outside the terminal or at specific waiting areas within the terminal to avoid the congestion at yard. This creates new congestions at the gates. Moreover, not all terminals have enough waiting space within the terminals. There are many factors that affect the TTT like the gate capacity, gate working hours, and resources within the terminal and truck arrival patterns.

The underlined dry port container terminals have long TTT been identified as bottlenecks and sources of delay for port drayage.

The time drayage trucks spent in the queue at the entry gate, container yard, and exit gate are often exceedingly long during peak times at this terminals

Figure 4.10 shows that, of the 32 respondents, 50 % of the respondents place the turnaround time of trucks below average, 31 % of the respondent place it above average, 19 % of the respondent indicates very much below average, while very much above average was unanswered. This infers that the turnaround time of trucks at the Port of Modjo Dry Port is below average.

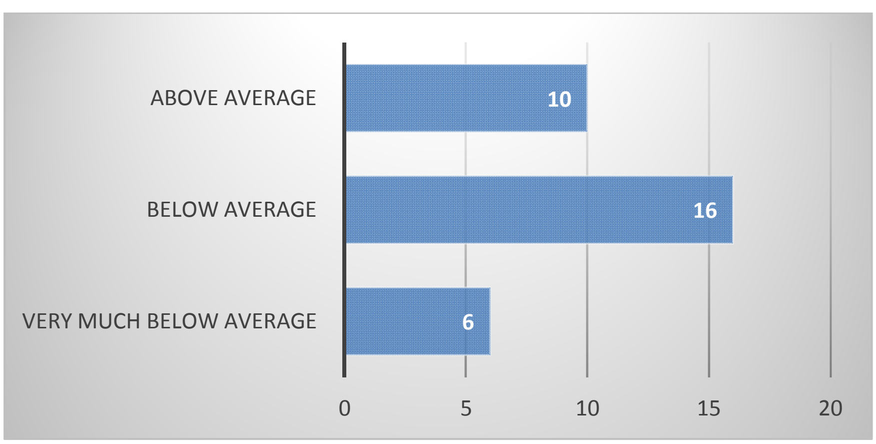


Figure 4.10: Assess on turnaround time. (Source: respondents)

4.7. Assess on congestion of container operations.

A 5-point Likert Scale was used to assess the congestion of container operations at the port of Modjo dry port. Finding reveals that of the 32 respondents, 19 % of the respondents assess the congestion problem of container operations to be bad, 50 % of the respondents assess it on average, 19 %of the respondents assess it as being good, 12 % of the respondents assess it to be very good, while none of the respondent mention it to be very bad. This infers that the congestion problem of container operations at the port of modjo dry port is on the average.

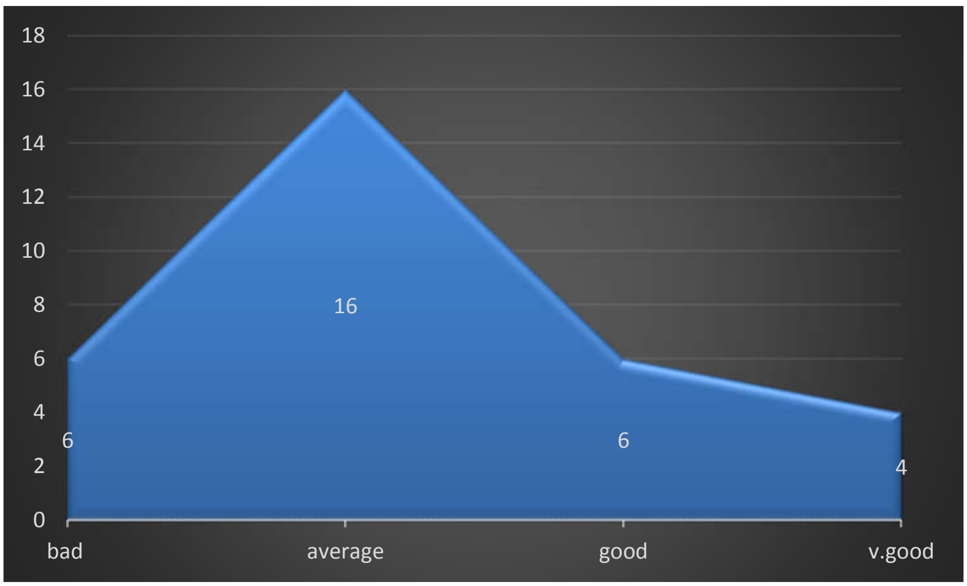


Figure 4.11: Congestion of container operations. (Source: respondents)

4.8. Assess on the nature of delays

The study aimed to describe the current nature of delays occurrence at the port. The finding shows that 25 % of the respondents describe the current nature of delays occurring occasionally, 50 % of the respondents describe it occurring sometimes, and 12.5 % of the respondent describe it occurring frequently, and almost always were 12.5 %. Therefore, this suggests that the current nature of delays at the Port of modjo dry port occurs sometimes.

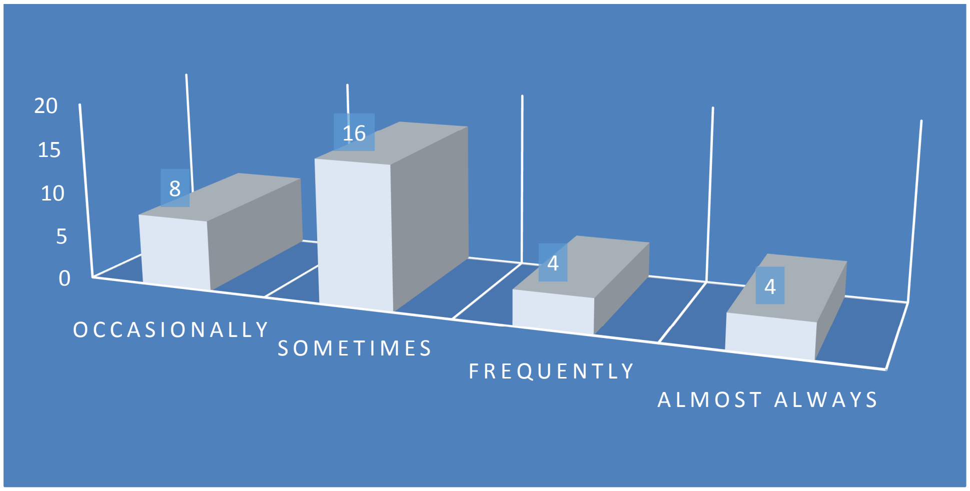


Figure 4.12: Assess on the nature of delays. (Source: respondents)

4.9. Effectiveness of custom clearance services

The study sought to measure the effectiveness of custom clearance services at the port. Finding shows that, 37 % of the respondents measure the effectiveness of custom clearance service ineffective, 19 % of the respondents measure it on average, 19 % of the respondents measure it effective, while 25 % of the respondent measure it very ineffective. This implies that the effectiveness of custom clearance services at the port of modjo dry port is ineffective

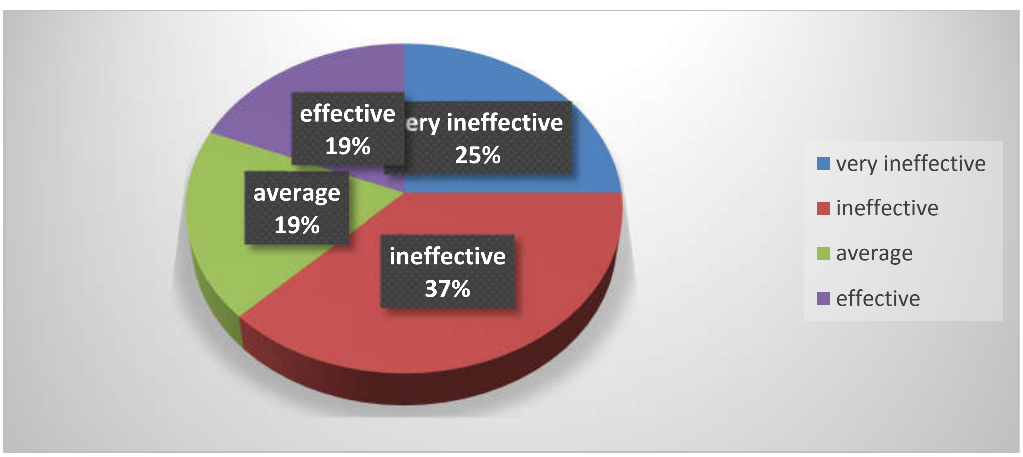


Figure 4.13: Assess on effectiveness of custom clearance service. (Source: respondents)

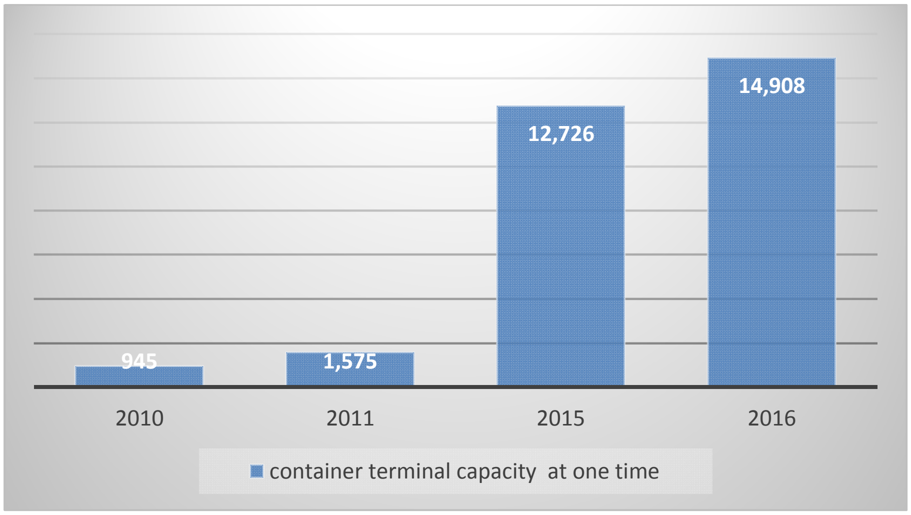


Figure 4.14: Increase in Modjo container terminal capacity. (Source : modjo dry port, 2017)

CHAPTER FVE

MODEL DEVELOPMENT AND SIMULATION RESULT

5.1. Identifying the bottlenecks and implementing solution

It is one of the aspirations of every terminal operator to have an efficient continuous sequence of movement in which the location of each container and its onward path is known, with its dwell time at any point in the terminal minimized. In most modern terminals the location of containers is assigned by Terminal Operating System (TOS) to assist in vessel loading or discharge to land transport. Drop off/pick-up times are then pre-assigned together with appropriate terminal equipment. In Modjo Dry Port location of containers terminal assigned by locally developed software which is named as Dry Port Operating system (DPOS) that needs currently update and has no so match differences from manual operating has major problems on container. In circumstances it is fairly easy to identify the problems and advise on measures to mitigate and even cure the problems to levels at which the terminal can operate reasonably effectively.

5.1.1. Yard and gate

In most container terminals, and especially those where space is at a premium, the minimization of dwell time is the single most important issue causing bottlenecks by congesting the yard. The Terminal Operator is reliant on the importer arranging collection and the only means of redress is against a scale of increasing storage charges. In most terminals collection within 3 or 4 days will engender no storage charge. The charges then generally move through a series of incremental increases until the ceiling rate per day is reached. The ease with which clients can pick-up or deliver the containers to the terminal is important in reducing congestion at the gate and optimizing the traffic movement through the terminal and proper container stacking. Many terminals are now operating with advanced logistic and communication systems such as pre-assigned collection and delivery windows for trucks and minimizing or avoiding time that truck drivers have to leave their cabs to complete paperwork.

5.2. Delivery operation and stacking system.

In order to take a loaded container out of the terminal the driver first arrives at the terminal gate. At this stage, the driver must scan or show his driver's license and then provide the container number to the gate clerk, he then proceeds to office to required goods released order and he then proceeds to pre-designated pick up area and waits to be serviced by a yard crane (reach stacker).The driver do the same activity on the gate to discharge or unloaded container to the terminals as well.

Once the yard crane arrives at the bay where the truck has been waiting, the crane operator must locate the requested container and must often re handle other containers on top before reaching the target container (i.e. reshuffling of containers to retrieve the desired one) is required**.** The container yard serves as a temporary storage systems. The export containers must be stored in the yard for the period of time between the container drop off at the yard by external trucks and the time when the container is delivered to customer. Containers arrive during time window interval in a random sequence that is unless the terminal has implemented an appointment system, which is not the case for the Modjo Dry Port (MDP) at present. The researcher observed that the yard is operated by reach stacker cranes, the yard supervisor should decide where to allocate depending on the random sequence of container arrival. The need for a good pre-specified space allocation policy for the containers is fundamental for the overall efficiency of the port. During the service time of a container, it is desirable to have a continuous flow of containers between the yard and the block.

Despite the random arrivals of the containers to the port, the port has advanced knowledge of at least a preliminary version of the loading (delivering) sequence of containers to the customer. Hence, a basic approach that the researcher consider is that the stacking plan is a piece of input data and is already known, even if it is a preliminary version that may be updated once the container has arrived at the terminal.

Typically, the container storage area of a port yard is constituted by blocks divided into Bays, Rows and Tiers according to the BAROTI system.

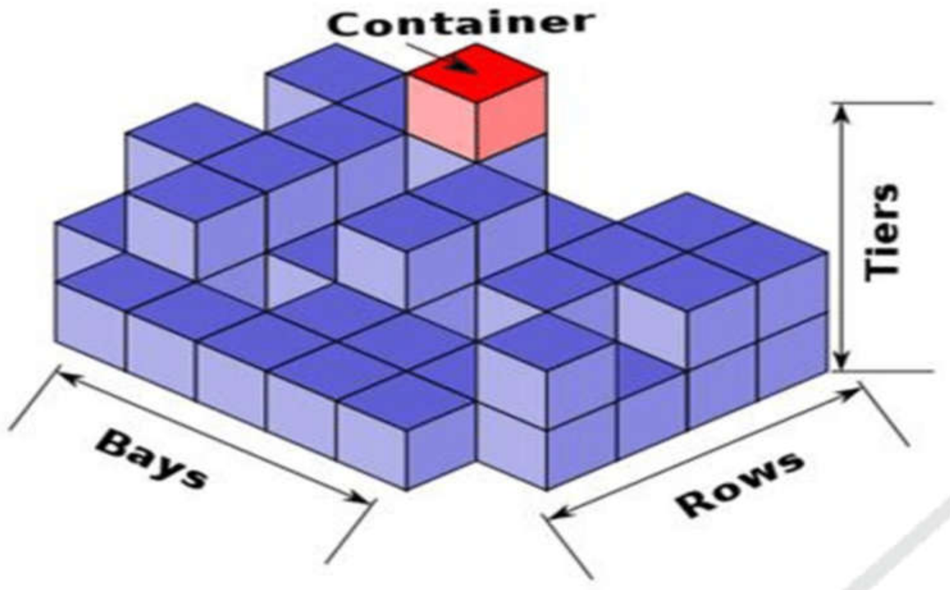


Figure 5.1: Illustration of bay, row, and tier in a yard bloc, adapted from (Huynh et.al, 2010)

A slot is defined as a BAROTI coordinate in which a TEU (Twenty-Foot Equivalent Unit) is stored. The blocks may be subdivided into sub-blocks of bays for space allocation purposes. A sub-block of bays is a set of adjacent bays. The containers are arranged based on common characteristics like destination port, weight, type, and size. A group of containers with the same characteristics is known as segregation. It is attractive to store all the containers with the same segregation in the same sub-block of bays or in consecutive ones as this may minimize the relocation or re-handling of containers during the loading operation.

The major problem in container stacking system is container's reshuffling/unproductive moves which occur due to not properly arranged stacking system the focus of this paper on operational performance. According to Ceyhun et al. (2014), an unproductive move of a container required to access another container stored underneath and has a negative effect on the operational efficiency of the container terminal in terms of cranes and operators' workloads. The additional movement (re-location) which assigns the position of a blocking container is called a reshuffle or unproductive move.

The containers' reshuffles at a container terminal is time consuming and increases container dwell time. This is the main reason of other problems which occur like delay in operational time at the terminal, cost increases and late container's delivery etc.

Therefore relocation is most important to storage and pickup operation in block stacking because it affects the handling cost. According to (Dayama et al, 2014), the total cost incurred in container handling operations is the sum of the (vertical) stack rearrangement costs and the (horizontal) crane movement cost.

There are two types of containers in stacking area, inbound and outbound containers at the Modjo Dry Port terminal. The import container is a container that unloads from train or truck and store in the yard. They are stacked in the allocated space without dwell time segregation. The outbound container is a container that waits for loading on the truck, the stacking area is divided according to types of containers which is TEU & FEU.

In this paper, the researcher focused on the assignment of containers in real time to a pre-specified block, as further described in the table below.

Table 5.1: Example of a sorting of containers based on arrival time. Source: the author

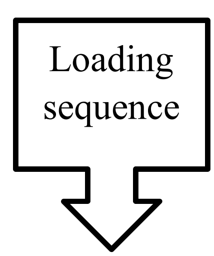
Container	1	2	3	4	5	6	7	8	9	10
Arriving time	2:15	2:25	2:40	2:55	3:05	3:30	3:57	4:21	4:49	5:01

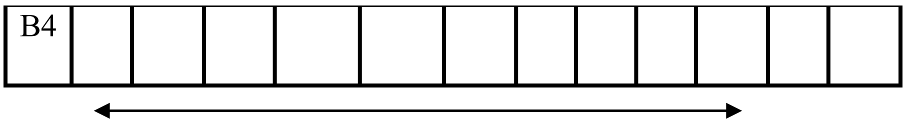
Table 5.2: Example of a loading sequence of container.

Container	1	2	3	4	5	6	7	8	9	10
loading sequence	3	2	5	1	10	7	6	4	9	8

Sub-block of empty bays where B is a bay

B1												
B2												
B3												





Containers with low Pk Containers with high Pk

Figure 5.2: Using the horizontal dimensions of a block to sort the containers according to the loading sequence.

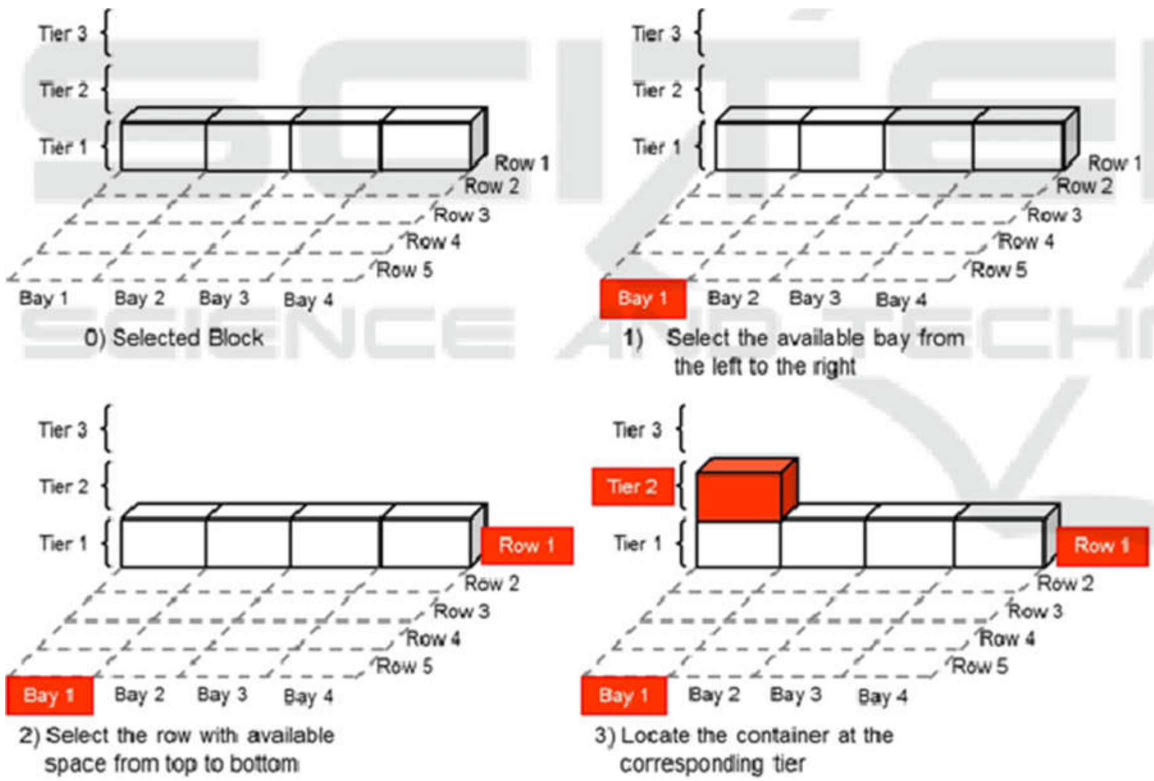


Figure 5.3: Sorting the containers according to the loading sequence. Adapted from (Nathan et al. 2010)

The procedure to allocate containers within the port yard consists of a set of criteria to assign a location to each arriving export container (BAROTI coordinate). The researcher propose a heuristic procedure based on the corresponding container's sacking plan.

Consider the particular instance of 10 containers with their arrival times, as shown in Table 5.1. The sequence in which containers will be loaded to the truck is shown in the Table 5.2.As we can observed from Tables 5.1 and 5.2, the loading sequence of containers does not follow a FIFO (first in-first out) policy, and hence, the arrival order of containers does not define the sequence in which they are loaded. The horizontal dimension of the block can be used as an indicator of how early a specific container should be loaded to the truck, according to the dwell time segregation plan. For instance let pk be the loading sequence according to the dwell time plan of the K^{th} container to arrive at the port. Therefore, a high $P_k$value indicates that the container with high P_k is delivere later than a container with a low pk. Fig. 5.2. illustrates the sub-block space allocation depending on the containers´ delivering sequence).Thus, the main principle of the proposed strategy is that containers to be first loaded on to the truck, should be allocated nearer to the left hand side of the block, and the containers to be loaded later should be allocated closer to the right hand side of the block.

The block of bays is subdivided into n sub-blocks and instances; different values of n were generated to examine the dependence of the number of re-handles with this parameter.

The Proceeding is filling the bays by allocating containers from the left to the right of the sub-block and from the back to the front of the sub-block. The sub-blocks of bays are empty at the beginning and that each sub-block is filled up with containers according to pk. When a new container arrives it is allocated either in an opened sub-block bay or in a new empty sub-block bay. The containers are allocated so that the number of re-handles required to load them onto the truck are minimized.

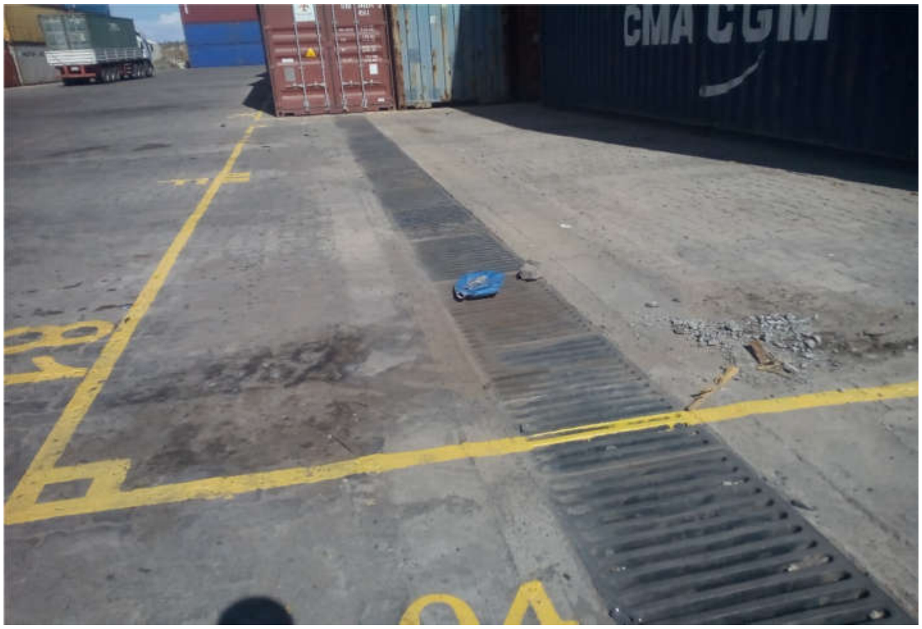


Fig 5.4 Empty block of the yard

Proposed Appointment system

Container terminal send container arrival message

↓

Customer send container receiving message in (time, day)

↓

Container terminal calculate and inform the expected delivery time (day)

↓

Customer informed the best receiving appointment schedule

↓

Container stacked (stored) by delivery order schedule

Figure 5.5 Proposed Appointment system

The parameters that define an instance of the problem are the number of sub-blocks in which the block of bays will be subdivided (n), and the maximum tolerable difference (Cr max) between loading sequences in the stowage plan Thus, one instance consists of the following parameters:

- Number of containers, A.
- Number of bays, N.
- Number of sub-blocks, n.
- Maximum capacity of the bay, Q.
- Maximum tolerable difference Cr max.

Suppose the first container to arrive at the port yard has $pk = p1$ and is allocated in the upper left corner of the corresponding sub-block. Due to random arrivals, suppose that the second has $pk = p2 \; with \; p2 < p1$; so the second container could be located in front of the first. To retrieve both containers will not necessarily involve any re-handle movement. However, all the containers having pk between $p2 \; and \; p1$ should be located somewhere else, and the total delayed time to deliver all the containers onto the customer will increase due to reach stacker displacement to different sectors of the sub-block. To avoid these the researcher find the difference between the last container allocated in each opened bay of the sub-block j and the container waiting to be allocated as shown in the following equation:

$$C_{ri} = P_{ik} - Pi_{k-1} \; \forall i \in Bj \tag{5.1}$$

Where:

C_{ri} is Tolerable difference (factor to assign container to the bays)

$Pik - 1$ is the loading sequence of the last container allocated to bay i,

Pk is the loading sequence of the arriving container, and,

Bj Is the set of all opened bays in sub-block j.

A Cri difference should be computed between the loading sequence of the incoming container and the loading sequence of the last container assigned to each opened bay in the sub-block. The researcher interested only in negative values of Cri because it indicate that no re-handles will be required if the incoming container is allocated in bay **i**. The value of Cri is restricted to a maximum tolerable value, defined as (Cr max). If the value of Cri is greater to or equal than Cr max, the container can be located in bay **i.**

The procedure can be summarized by the Dwell time segregated stacking strategies as the following series of steps:

1. Define the segregation of containers based on the Dwell time class prediction and determine Pk.
2. Calculate Cri and maximum negative element of Cri.
3. Assign to each block a segregated containers. One block can contain either a single or several segregation.
4. Once container arrives, assign it to the corresponding segregation block.
5. Define the location of containers in the block based on the semi-random or sequential stacking strategy.
6. If the a container arrives and there is no available space in the block corresponding to the segregation, then open new bay or randomly select block and repeat step 5

Note: Containers that arrive with more anticipation are allocated to other spaces from which they are relocated to the stacking area during the time window period.

To enable the procedure, the researcher provide a numerical example. Figure 5.6 shows a graphical representation of a block of 5 bays, each one has a maximum capacity of 4 containers. The bay number 5 has not yet been opened. There are 9 containers already in the block, and the tenth container to arrive to the port has a $pk = 16$. Cri values for bays 1, 2, 3 and 4 should be calculated in order to determine in which bays the incoming container can be assigned.

The value of Cr for the bay 1 is calculated as follows: $Cr1$= 16 – 7 = 8. Table 5.3 shows the Cri differences of all opened bays. Some Cri differences are positive and others are negative. A Cri greater than 0, such as the Cr of bay numbers 1 and 3, indicates that if the container with $pk = 16$ is allocated in any of those a re-handle movement will be required to retrieve the container.

According to the segregation strategy, the bays that are allowed to receive a container are those with a negative Cri value. Table 5.3 shows the Cri values for all opened bays. In this example, bays 2 and 4 are possible suitable bays to receive the container.

The Cr max is equal to -3, so bays with a value of $Cr = -1, -2 \ or \ Cr = -3$ can be chosen. The strategy will compare the Cri value of all candidates with the Cr max, and the final decision will be to allocate the container in bay number 2

Table 5.3. Cri differences of all opened bays

Bay	1	2	3	4
Cri	16-7	16-17	16-15	16-21
Cri	9	-1	1	-5

		1	2	3	4	5
	$Q = 1$	$Pk = 14$	$Pk = 22$	$Pk = 15$	$Pk = 21$	
Cr max = -3	$Q = 2$	$Pk = 13$	$Pk = 19$			
Pk= 16	$Q = 3$	$Pk = 9$	$Pk = 17$			
	$Q = 4$	$Pk = 7$				

Figure 5.6. Example of allocating an arriving container with $pk = 16$.

As can be observed in Table 5.3, a value of Cr = -1 implies that the containers have consecutive values of pk, and in general, a negative value indicates that no re-handles are required to retrieve the pair of containers. The decision to open a new bay must be taken only when all the Cri differences are positive or there is no longer a negative Cr greater or equal than Cr max for all opened bays in the block.

To open or use a new bay there must be at least one empty bay in the sub-block. When a container arrives, but it is not possible to open a new bay due to all bays being opened in the sub-block, the following activity is performed: Inspect if there is any Cri < 0 for any container that has not yet arrived from the sub-block. When a Cri < 0 is found, reserve the bay for that container. Allocate the newcomer container in the emptiest and a bay that is not reserved in the sub-block. Fig. 5.7. Shows a numerical example of this situation. For the container with $pk = 24$, the Cri vector is: {17, 7, 9, 3, and 21}. Neither component of the vector is negative, so the strategy will verify if there is a negative Cri for any container that has not arrived.

Note : in the following table Q represent Row.

		1	2	3	4	5
Cr max = -	$Q = 1$	$Pk = 14$	$Pk = 22$	$Pk = 15$	$Pk = 21$	$Pk = 3$
	$Q = 2$	$Pk = 13$	$Pk = 19$			
$Pk = 24$	$Q = 3$	$Pk = 9$	$Pk = 17$			
	$Q = 4$	$Pk = 7$				

Figure. 5.7 Example of a sub-block with all bays opened.

Bay	1	2	3	4	5
Cr	24-7	24-17	24-15	24-21	24-3
Cr	17	7	9	3	21

Table 5.4. Cri differences of all opened bays

5.3. Maximum re-handle estimation

In this section the researcher present an estimation of an upper bound on the maximum and an expected number of re-handles of a bay with capacity Q. In order to estimate the number of re-handles, I have seen that containers are retrieved by a reach-stacker crane. The reach stacker crane can retrieve containers only from the front side of the stack, and the maximum stack height reached by the equipment is four (MDP stacking capacity). I also observed that all the containers that need to be moved to retrieve the container are relocated in the same configuration as they were previously stacked in the block. Consider a bay with a capacity of 4 containers, as is illustrated in Figure 5.8

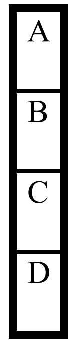


Figure 5.8. Initial configuration of a bay of capacity 4.

Suppose that the sequence to retrieve the containers according to the stowage plan is {A, B, C, D}. Three re-handles (A, B, and C) are required to retrieve container D. Once container D was retrieved, two additional re-handles are required to retrieve container C. Then, one additional re-handle should be made to retrieve container B. The last container to be retrieved does not require re-handles, so the total re-handles required to retrieve all the containers are:

$3 + 2 + 1 = 6$. This configuration is the worst one possible due to the order of retrieving the containers being exactly the opposite of the order of the containers allocated in the bay. Let Max - Re hand be the upper bound in the number of re-handles of a Bay with capacity Q. The maximum number of re-handles of a bay with capacity Q provides an upper bound (the worst case) for the number of re-handles that may be used to evaluate the effectiveness of the strategy, which is expressed in the following equation:

$$\text{Max-Re hand} = \sum_{j=1}^{Q-1} i = \frac{Q(Q-1)}{2} \qquad (5.2)$$

5.4. Mathematical representation of cost dependency on the number of moves of container

A mathematical model is an abstract model that uses mathematical language to describe the behavior of a system (www.sciencedaily.com/terms/mathematical model.html). Eykhoff, (1974) has defined a mathematical model as a representation of the essential aspects of an existing system which presents knowledge of that system in usable form. The mathematical equation has expressed the relationship between the variables and the equal sign between them has been showed that these two things are equal. (www.mathsisfun.com/algebra). A mathematical model is a set of mathematical statements and virtually serves as a door opener towards the "mathematical universe" where powerful mathematical methods become applicable to originally non-mathematical problem (Kai Velten 2009). I have introduced a mathematical model to express the relationship between container handling cost and container's reshuffles. This model shows that the container handling cost in the stacking yard is directly proportional to a number of moves (actual moves + unproductive moves) of containers. If the number of container's reshuffles increases then cost will also increase. When a container will be handled more than one time then each handling cost will be added more than one time. To minimize the cost, the company need to reduce the unproductive moves of containers. Through this, the port's authority can reduce the container handling cost and the container handling charges also

Notations

The notations used in this mathematical model are listed as follows. (Yang. et.al, 2006)

Late

M Total number of moves of containers in the yard

C Total cost of stacking system in the yard

$M \propto C$

(If number of moves increases then the cost of stacking will also be increased)

CR Containers need to reshuffle in yard

Ci Incoming container into the yard

Cc Container handling cost

EC Extra/Reshuffle container handling cost

Cst Stacked container in the yard

AC Actual cost to handle the containers

Cs Total containers handle to stack in yard

Ci = 1, 2, 3 … 300 where 300 is in coming container to the yard per day.

 Ci Є Cs, CR = 1, 2, 3… n

To calculate the total number of moves during stacking

$$M = Cs + CR \qquad (5.3)$$

To calculate the total container handling cost for stacking, equation (5.1) is multiply by container cost in equation (5.2).

$$C = Cc * M \qquad (5.4)$$

To calculate the extra cost, multiply the no. of reshuffles container with container handling cost. $EC = Cc \times CR$
(5.5)

To calculate the extra cost in percentage, extra moves cost divided by Equation (5.2) and multiply by 100.

$$\% EC = \frac{CR \times Cc}{C} \times 100 \qquad (5.6)$$

To calculate the actual cost of container handling during stacking without extra moves.

$$AC = C - EC \qquad (5.7)$$

To put the values of C from equation (5.2) and EC from equation (5.3) into the equation (5.5) $AC = (Cc \times M) - (CR \times Cc)$

To put the value of M from eq. (5.1) in the equation (5.6),

$$AC = (Cc \times (Cs + CR)) - (CR \times Cc)$$

$$AC = Cc \times Cs \qquad (5.8)$$

Equation (5.6) is showing the total container handling cost is equal to the actual cost of container stacking without unproductive moves. It means that the unproductive moves affect the handling cost and one major factor to increase the cost. The cost is directly proportional to the number of moves of the containers

5.5. Conceptual approach of the model

A model is used to represent the whole process flow graphically by using structural design. A conceptual model is used to take understanding about the whole system, its workflow and interaction between the subsystems. This paper describes the process of discrete-event simulation-based model of container stacking system in this section.

The below diagram shows the whole process of container storage in the yard. When Truck come with the container in the yard area and the crane pick up the container and store it into the best possible location where no need to reshuffle or minimum reshuffles require. If location is good and no need to further moves then put it at that location else check another location until the best possible location found and store the container based on Cr max. The second condition is, if no more containers are available for storage then wait for next incoming container. It will check the number of incoming containers. If a total number of incoming containers is more than the available bays then stop the whole process. No need to handle further containers.

This diagram shows the whole process of container handling for stacking in the yard of a dry port container terminal to avoid the unproductive moves. The yard crane checks that if the container is available to store in the yard the pick it up and move to the yard. After this, it will check the first best storage location.

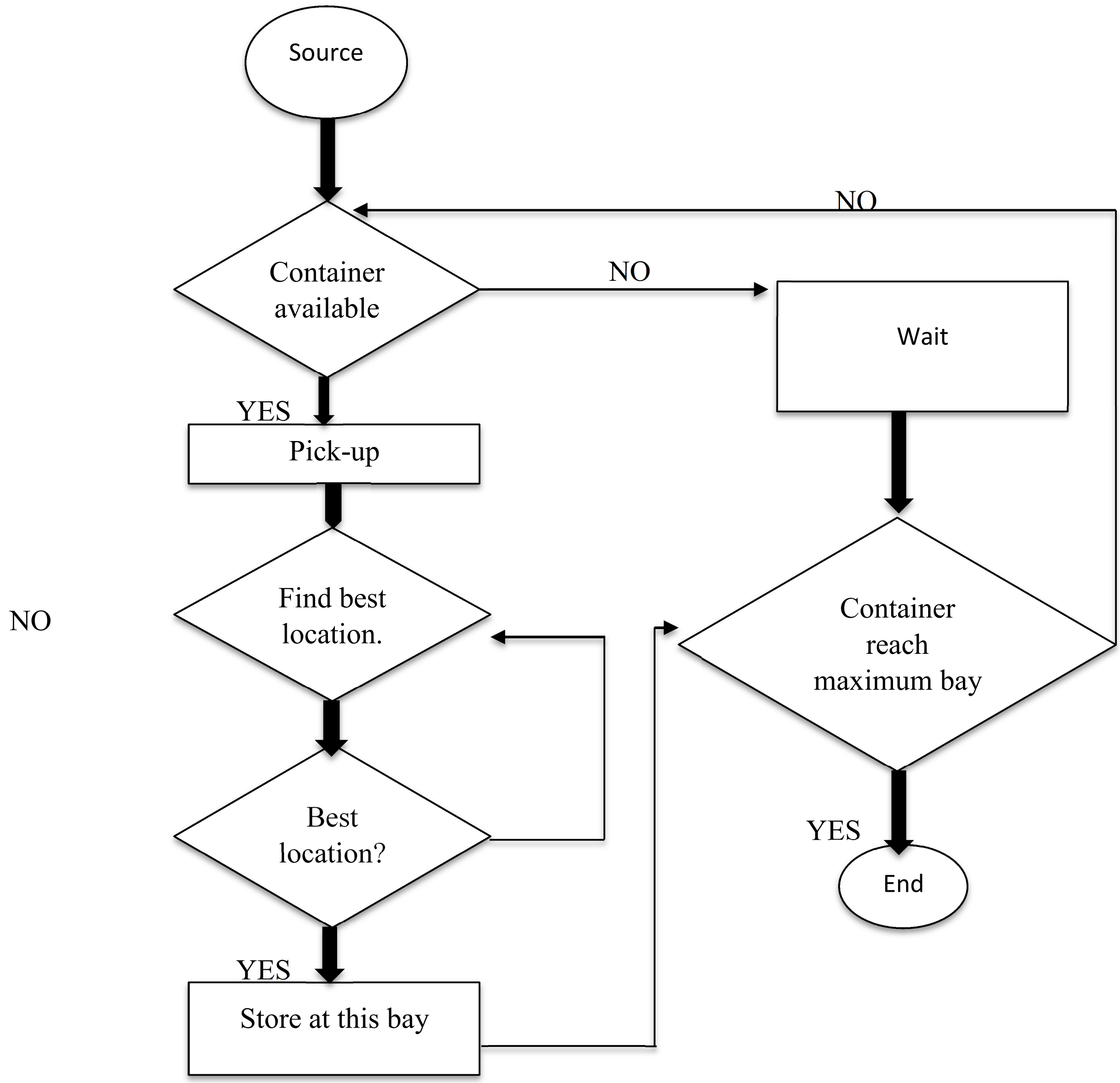


Fig 5.9 Proposed company container stacking strategy

5.6. Scenario development

The running simulation model provides statistical outputs that give timely measures of system performance and allows one to ask "What if?" questions about a system by performing different scenarios without having to experiment on the actual system itself.

Accordingly the researcher have built current scenario and "what if?" scenario to analyze the performance and utilization of the sources in the following table.

Table 5.5 current and what if scenario.

Department	Current scenario	The bottle neck	What if scenario
Gate and train operation (first operation)	-Single gate operation -Twelve hours working time. Check for security and damage Manual checking.	-long queue, too much time spent waiting for gate permission - Over utilization	Increase number of gate pass to two
Office (2nd operation)	-Document preparation	-Manual-excel spread sheet	Pre-preparation of document
Yard operation (third operation)	-Unloading, loading and Location allocation	-Location allocation problem -Non segregated stacking strategies Reach sacker Unproductive movement. Location miss information.	Dwell time dependent segregated stacking system.
Custom clearance (fourth operation)	Examining by risk level Red, yellow, green.	Itemization problem, Container non segregation on size TEU, FEU.	Separate by size TEU and FEU.

The scenario development sections consist of the investigations of the following:

- Change in the number of gate operation.

- Change in stacking strategies.

To evaluate the solution, current and if scenarios were generated using the simulation model. The generated scenario outcomes was used to formulate suggestions and recommendations on how to analyze resource utilization and reduce service time and decrease delays at yard container. The main objective of formulating different scenarios was to find possible sets of input parameters, structural assumptions or model specifications that could lead to best performance.

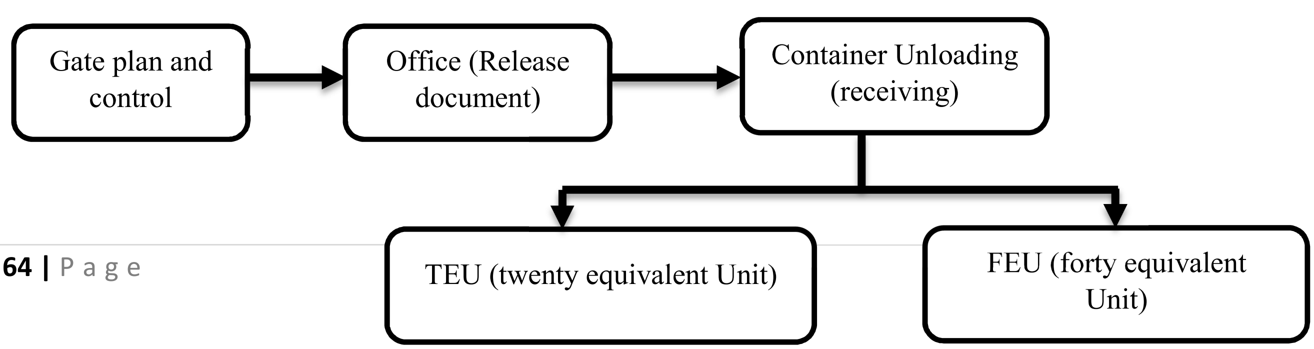
5.6.1. Increasing the number of gate

When there is less number of gate, the demand of some deliveries cannot be met and this results in the decrease of revenue. However, the use of excess gate may lead to underutilization of resources. The company is using nine productive reach stackers, one gate in and gate out and number of working time is 12 hours per day. In this scenario, the numbers of gate was increased to two gates to find the optimal number of gate pass Operators that can increase utilization. The main objective of this scenario was to study the effect of increasing the number of gate.

5.6.2. Changing stacking strategies.

The performance of the container stacking process at the port facility is dependent on the activities performed by the Yard operations or the container terminal operation departments. The productivity of the Customs operations and the container location allocation is directly proportional to the productivity of the cargo delivering process. Therefore, changing stacking strategies of container and locating container at best location may lead to an increase in operational performance and utilization of terminals. The objective of this scenario was to study the effect of changing stacking strategies on container terminal operational performance.

Full container receiving (unloading) process.



Full container loading (delivering to the customer) process.

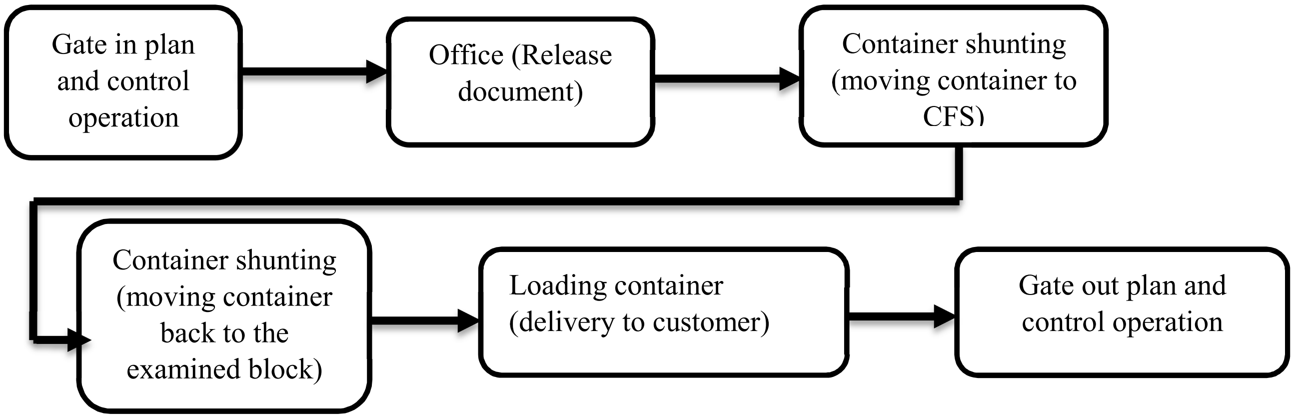


Fig 5.10 container receiving and delivering process respectively.

Table 5.6. The input parameters to DES model

General parameters	
Working hours	8:00 am- 8:00 pm
Terminal Area	630,000 m^2
Container dwell time	TRIA (10, 30, 40)
Gate Parameters	
Inter arrival time	TRIA (5,10,15)
Process time (min)	TRIA (5, 10, 15)
Gate capacity	1 truck/one gate
Yard parameters	
Crane speed (max)	90 m/min
Block capacity	16 containers
Crane net moves	20 move (touch) /hr. (average)
Train side parameters	
crane speed (max)	120 m/min

Crane net moves	30 move/hr. (average)
Customs clearance	
Process time (min)	30 (average)
Crane loading (min)	Uniform(3, 6)
Crane unloading (min)	Uniform(2, 4)

This model analyzed the current situation using some pre-defined performance criteria such as:

- average resource utilization,
- average queue waiting time,
- average service time ,
- The number of container handled.

These performance criteria are used to identify potential bottlenecks of the operational areas such as yard cranes performance and gate operation in the container terminal.

Note: equivalent unit for 1hr. of the actual time is 1minute on the simulation, and equivalent number of actual for three crane is one crane on the simulation, meaning that one crane on the simulation represent three crane of the actual crane. In these thesis the researcher created number of gate to two lane and changing stacking system strategies of container because it is the way to improve current conditions of operational performance without investment in equipment and land.

5.7. Simulation results

5.7.1. Scenario model result

In this paper the researcher built a terminal simulation model which allows evaluating the performance of the current and what if condition of the terminal using pre-defined performance criteria. The results of the simulation show that some operational management problems exist in the terminal. With the use of dwell time dependent segregated stacking system of the terminal and adding numbers of gates to two gate, the capacity utilization of the current terminal configuration can be improved without investment in equipment and land. This section gives the results of Gate and Yard operation for container unloading and loading model that were constructed.

To evaluate the model's performance, the results generated by current scenario model were compared to if scenario model as well as historical data. Note that the results depend on a number of assumptions. Therefore, the results might not match exactly with the real system. To meet the objective of the simulation model, the following performance indicators were analyzed, average yard crane utilization, average train crane utilization, average truck waiting time on gate operation indicating queue and Yard operation on stacking strategies, average number of containers handled and average terminal utilization resulting on the operational performance analysis, that expressed in Table 5.7 below. The full container unloading or container receiving model was designed to emulate the process of the yard operations and the gate plan and control. By using this model, the data on the utilization of crane, workers, land were analyzed. For evaluation, the following simulation parameter controls were used: Table 5.7 shows selected results of a simulation run length of 360 hr., with 30 replications for a 12 month simulation period with a one-month training period.

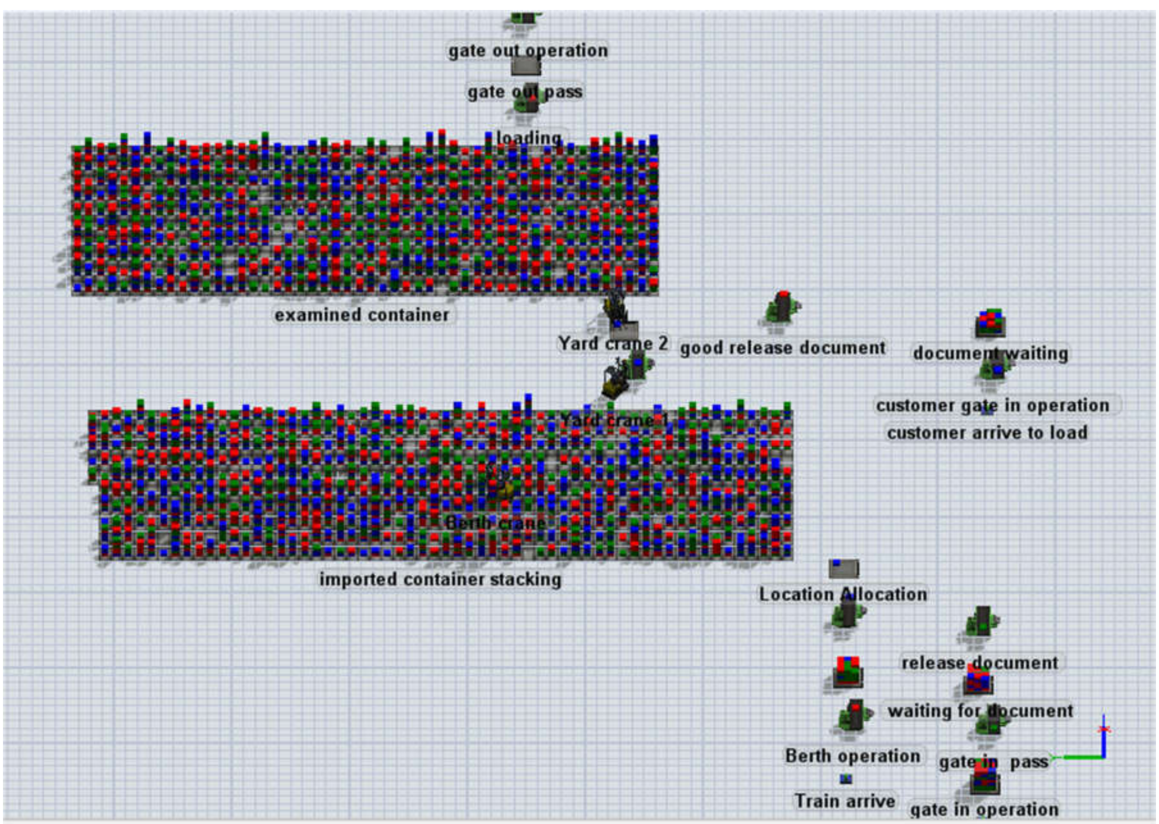


Fig 5.11. Structural diagram Flex sim simulation model for current scenario

Table 5.7. Performance Criteria current scenario simulation result.

Criteria	Average Value	Units
Average yard crane 1 utilization	100	%
Average yard crane 2 utilization	74	%
Average train crane utilization	100	%
Average truck waiting time at gate	5.25	Minute
Average waiting time at berth	12	Minute
Average no. of containers handled	220,212	TEUs
Average terminal utilization	35.0 (220,212 / 630,000)	%

5.7.2. Resource utilization

The purpose of this work was to analyze and propose a solution for container stacking system in the yard of container terminal to minimize the unproductive moves and facilitate the yard area management to reduce the container handling cost and save the time. The results of the crane utilization of the berth and yard crane utilization, average truck waiting time at gate, average waiting time at berth average number of containers handled and terminal utilization for the current scenario are best summarized by table 5.7. The gate pass operators check for Security and release truck. The container location allocators ensure that best location and appropriate reach stacker is available to locate the container and for farther loading container. From the simulation result, under current scenario the utilization of berth crane was 100% which indicate that the crane was over utilized, but in if condition scenario, utilization of berth crane was reduced to 72%

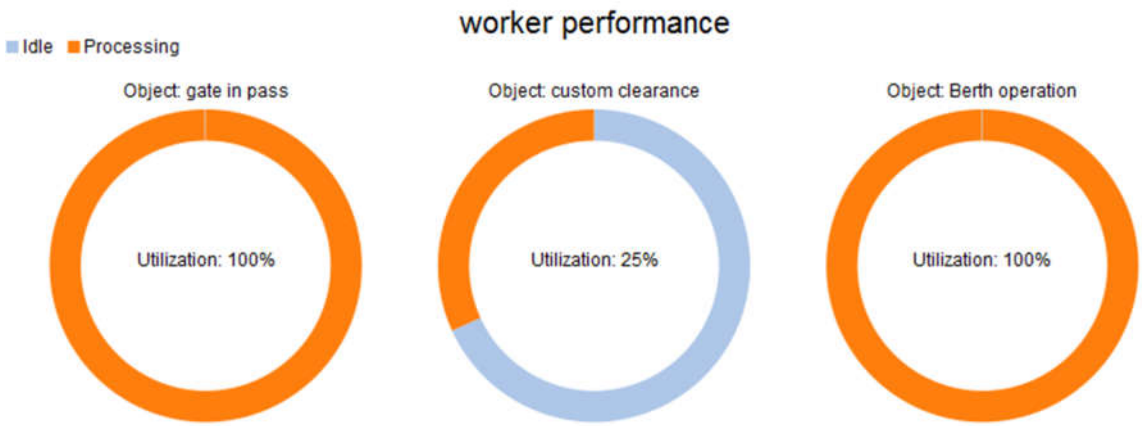


Figure 5.12 performance of worker under current scenario.

Under what if scenario increasing the number of gate to two lane, in average workers performance was 65%, which indicate that under current scenario even if the operator performance was over utilized (100%) there was a long queue as it was expressed in the current scenario. On the other hand workers performance of customs clearance is low (25%) due to lack of examining container depending on size of container but under what if scenario, the percent of Utilization of workers in average is 50% indicating twice that of the current scenario, there is no queue at present and has the ability of serving more object. Another operation system of container terminal was train operation, the performance of berth worker in the current scenario indicate that, it was over utilized (100%) while in if condition the performance of worker was decreased to 50% by using exact appointment of train arrivals indicating the performance of train operation worker or supervisor is still fairly working. For the crane utilization under current condition most of crane were over utilized, while in if condition there is good performance for each crane due to changing the stacking strategies and applying delivery appointment system.

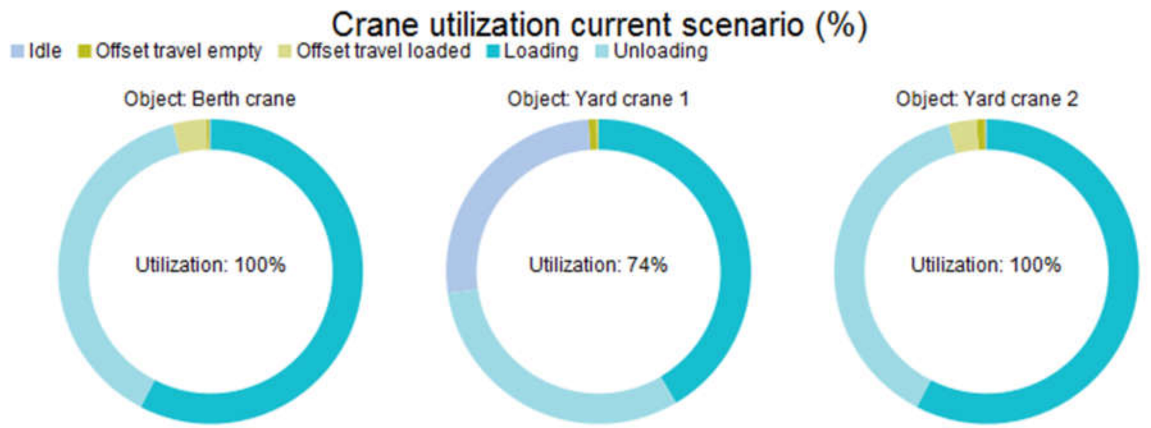


Figure 5.13 Crane Utilization simulation result current scenario**.**

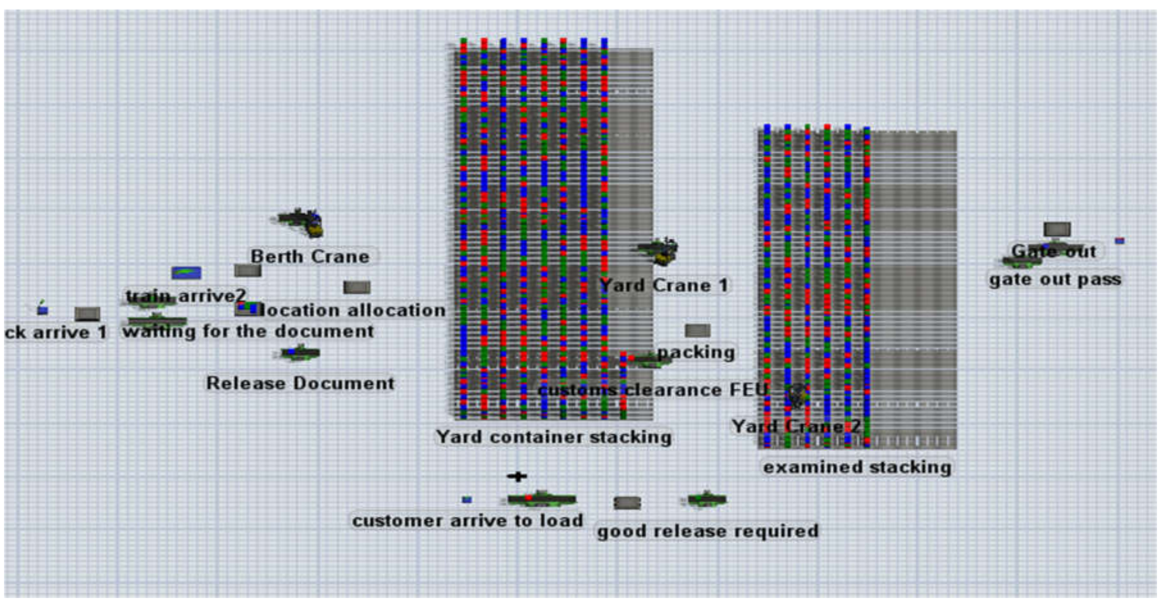


Fig 5.14. Structural diagram Flex sim model for if scenario**.**

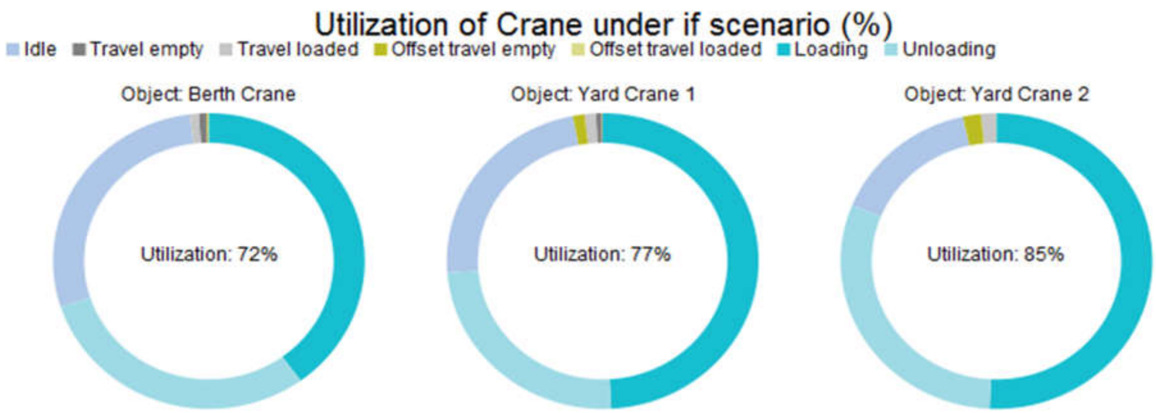


Figure 5.15 Crane utilization Simulation Result under if condition

Criteria	Average Value	Units
Average yard crane 1 utilization	77	%
Average yard crane 2 utilization	85	%
Average train crane utilization	72	%
Average truck waiting time at gate	3	minute
Average waiting time at berth	5	minute
Average no. of containers handled	307,008	TEUs
Average terminal utilization	48.8 (307800 / 630,000)	%

Table 5.8. Performance Criteria if scenario simulation result.

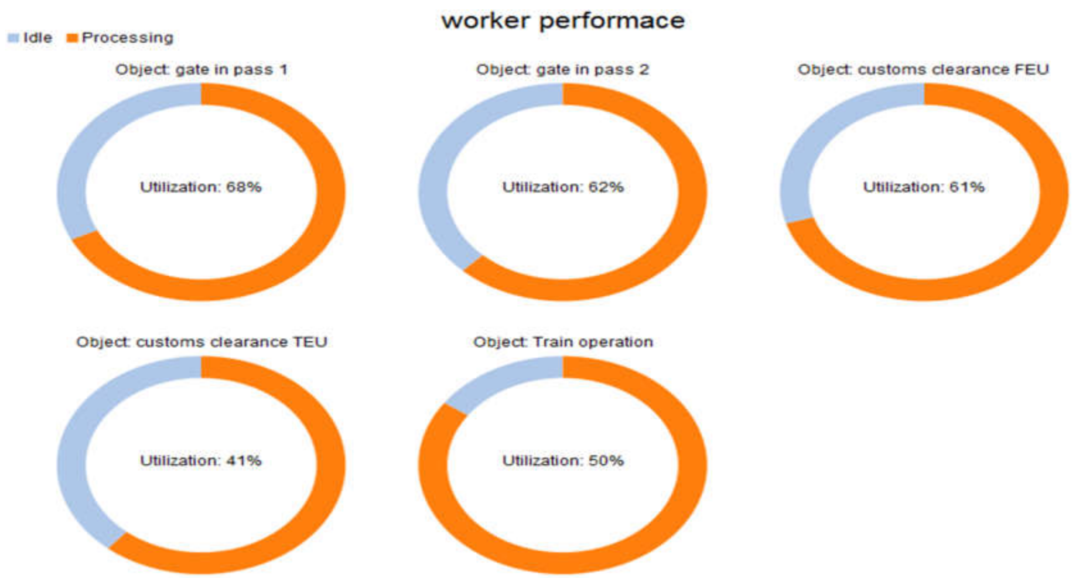


Figure 5.16 worker performance under if condition.

As it is clearly stated in scenario development Table 5.5, what if scenario on Yard operation is dwell time segregation stacking strategy resulting in increasing crane Utilization in all activity comparing with current scenario, the result from the current model shows that in average it takes 5.25 minute to examine container at the gate in and check for damage and there is no queue for if model, and the steady state time reached constant at 225 hr. of my simulation.

To sum up the result, simulation output indicate that the Gate operation and Yard operation is among the factors that effects operational performance of the MDP and under current operation system, it is due to some indicators on number of gate, average waiting time, stacking strategy has problems and could solved under scenario developed. Container staking strategies affect container terminal efficiency through three major factors: performance in term of loading and unloading of train/trucks; it operational effectiveness as well as operational efficiency.

5.8. Verification and Validation of the model.

Verification and validation of computer simulation models is conducted during the development of implemented models with the ultimate objective of producing an accurate and credible model, due to the increasing Utilization of simulation software to solve problems and to support in decision-making. In fact simulation models are approximate imitations of real world systems and they never exactly imitate the real life system; thus models should be verified and validated to the degree needed for the models intended purpose or application. Verification of a model is the process of confirming models are correctly implemented with respect to the conceptual model, meaning that they match specifications and assumptions deemed acceptable for the given purpose of application. The validation phase checks the accuracy and precision of the representation of the real system by the simulated models. In order to perform the required validation, the implemented models have to be a reasonable imitation or interpretation of a real world system, thanks to the assumptions necessary to build them which can be structural or data assumptions. The structural assumptions ware made about how the system operates and how it is physically arranged. Data assumptions allow building as close as possible to reality models with a sufficient amount of appropriate data available.

CHAPTER SIX

CONCLUSION, RECOMMENDATION, FOR FUTURE WORK.

6.1 Conclusion

In this paper the researcher developed a simulation model that can be used to simulate the container terminal operations and analyze the performance of Modjo Dry Port Container terminal. The objective of the model is to analyze the operational performance of container terminal for improving the efficiency of container terminal. A case study of the Modjo Dry Port. The study answered the following questions:

1. What are the key performance indicators (KPIs) of container terminal operation? What is main considerations on the K PIs selection?

2. What are the factors affecting efficiency of operational performance for container terminals at the port

3. How is the productivity level for container terminal to determine operational performance?

4. What are the performance improvement strategies and how can the poor performing continuation will be improved and controlled

The data was collected using questionnaires, observation and conversation in addition to Interview and discussed by descriptive statistics and analyzed using Discrete Event Simulation model. All the research questions of the study were answered in chapter 4. From the survey conducted, findings revealed that container terminal efficiency is measured by the level of increase inputs and throughput short dwell time and short turnaround time of truck.

This study introduced Discrete Event simulation model for gate operation and yard cranes at dry port container terminals to study how different service strategies affect truck turn time. To obtain the average truck turn time, the authors used a Discrete Event Simulation (DES) model and heuristics to solve the model. Simulation results shows that if crane operator stacks container depending on dwell time segregation, re-handling of container or time consuming process and the overall system performance in terms of average waiting time and average Crane utilization was better than if there were to stack randomly. Result also indicate that the increased number of gate to two lane reduce the degree of worker's over utilization and improves performance of worker. The researcher proposed a heuristic procedure to express the way haw to stack container with minimum re-shuffle or retrieval of containers arriving at a port terminal. It was to express the way how to stack container depending on the loading sequence and the simulation model was to show the stacking system by structural diagram and present as a model. Containers that arrive with more anticipation are allocated to other spaces from which they are relocated to the stacking area during the time window period.

The study found out that the key performance indicators of container terminals could number of container moves, terminal and storage area productivity, container dwell time, number of gate operation, average number of reach stacker touch/hr. container traffic, truck visit time or truck turnaround time, yard and crane productivity, container traffic.

There are many factors that affect the efficiency of operational performance like the gate capacity, gate working hours, and resources within the terminal and truck arrival patterns container stacking system, custom clearance container dwell time, operator experience, yard layout, maintenance problem, lack of integrated location allocation software System like Terminal Operating System (TOS) poses delays in container stacking procedures in increasing number of re shuffle or re handle of container which inversely effect container terminal efficiency. The study also found that, current container terminal productivity level was poor as comparing with industry bench mark as the researcher assess productivity performance of Labor, Equipment, and Land.

The performance improvement strategy as the researcher assess was changing current stacking strategies which means using delivery appointment system, evaluate the efficiency of each machine, labor, stay time in operation and average container handled. In addition the researcher concluded that increasing number of in gate increases the terminal productivity, Resource Utilization, truck turnaround time and reduces emissions especially at peak hours. The developed scenario are likely economical, it is improves the current bottle neck without investing equipment and land.

6.2. Recommendation for future work

The recommendations were made based on the failures observed and in a way that answers the major research questions and with intention to meet the objective of the study. The recommendations highlighted as follows.

The study was conducted to find out the major challenge on Modjo Dry Port container terminal inefficiency.

- The Company should have to utilize the resource like land (total Area of the container) equipment or machine, and man power as well efficiently. With regard to land or the physical facilities like number of gate lane, alternative path on container terminal, smart container terminal and best container stacking system are among the resource and activity that make inefficiencies of the port and it was recommended to utilize and design smart container location allocation policy, and improves performance of container terminal by changing current stacking strategies to dwell time segregated container stacking strategies.
- All the processes and activities has to be coordinate and work in simultaneous action to enable the maximum efficiency and productivity in ports. Indeed if only one activity, even if a container location is miss informed, all the other activities are influenced by it and then accordingly ports performance drastically decrease.
- The company should have to habit the delivery appointment system to support customer wisely and for the delivery of container easily, to minimize re-handling of container for the best stacking and to minimize the delays of container and to increase service rate and decrease service time. This is to create strong relationship with the customer and stockholder in addition to that more investor come from abroad this is to maximizing country economy and to gat valuable foreign currency.
- The company should also have to develop Terminal Operating System (TOS) for the awareness of container stations periodically. This to improve that automatic computer based system to increase service time and to reduce miss-allocation information and reduce human error.
- Evaluating resource performance (land, manpower and machine) regard with operational time survey, can also help the company to identify the potential

efficiency of services delivery problems that also have a direct relationship with the customer satisfaction. Besides that the company should providing extensive training can help to make employees capable of rendering the expected service.

- The company should have to minimize the free storage service from eight days as much as possible and average dwell time of the container as well by increasing demurrage cost from 99 Br and 192 Br a day for 20ft and 40ft containers, respectively to some extent as well and additionally, individuals whose containers stay for over a month will have to charge from 418 Br a day to some extent as high as a day.
- Finally what I would like to recommend is the company should have to apply the kaizen for the overall port, which means to have smart service you should have to have smart environment.

6.3. Future work

The study is limited only by one case study. Therefore, one of the directions for future research is a further extended analysis of various case studies, added by historical comparative analysis of container terminal operational systems, particularly evaluations will be done for solving Container Terminal Planning, Re-handling Strategies for Container Retrieval Problem considering terminal design and crane assignment by using simulation optimization technique.

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Introductory Letter to Respondents

Dear Respondent,

I am a student learning Master of Science (MSc) degree in Industrial Engineering and Logistics Management at Hawassa University. Currently, I am undertaking a research study ON OPERATIONAL PERFORMANCE ANALYSIS OF CONTAINER TERMINALS; A CASE OF MODJO DRY PORT, in partial fulfillment of the requirements for the award of the degree of Master of Science in Industrial Engineering and Logistics Management. You have been selected to participate in the survey and the researcher would highly appreciate if you assist him by responding to all questions as completely, correctly and honestly as possible. It is solely for academic purposes. Your opinions, responses and views are very important to this study and will be completely confidential. No respondent will be identified.

Thank you very much for your participation, cooperation and understanding.

Sincerely,

Mahmud Abdurrahman

Email: kananii2017@gmail.com

Researcher.

Questionnaires

Section A: - **Back ground information of the respondents**

1 Sex: (A) Male (B) Female

2. Age: (A) < 24 years, (B) 25 – 35 years, (C) 36 – 45 years, (D) > 46 years

3. Level of Education acquired: (A) Diploma (B) First degree (C) master degree (D) Other (Specify) ______________________

4. Type of job description: (A) Container Terminal Operations (B) Conventional Cargo Operations (C) Other (Specify) ___________________________

5. Name of Section/Department/Unit: ___________________________

6. What is your position/status in the organization?

(A) Senior Manager (B) Middle Manager (C) Junior Manager (D) Operator

(E) Other (Specify) ________________________________

7. How many years have you worked in this organization?

(A) since the starting of dry port, (B) 6-7 years, (C) 3 – 5 years (D) < 2 years

Section B: Container terminal efficiency

1. Do the operational performance of container terminals for modjo dry port efficient? {1} YES {2} NO {3} DO NOT KNOW

To what extend do you agree or disagree with the following statement.

2. Container Terminal Efficiency can be measured by key performance indicators that port terminals can use to improve operational efficiencies like

(A) Container dwell time. {1} strongly disagree {2} Disagree {3} No opinion or uncertain {4} Agree {5} strongly agree

(B) Container traffic. {1} strongly disagree {2} Disagree {3} No opinion or uncertain {4} Agree {5} strongly agree

(C) **Truck visit time**. {1} strongly disagree {2} Disagree {3} No opinion or uncertain {4} Agree {5} strongly agree

(D) Number of gate moves. {1} strongly disagree {2} Disagree {3} No opinion or uncertain {4} Agree {5} strongly agree

3. How do you grade the current performance of container terminal at the port of modjo?

{1} Very poor, { 2 } Poor, { 3 }good, { 4 }very good, { 5 }Excellent

4. How do you evaluate the overall system of container cargo at the Port of modjo currently? {1} Very low, {2} Low, {3} Moderate, {4} High, {5} Very high

5. How is efficient container terminals at receipts and delivering points of operations?

{1} Very poor { 2 } Poor { 3 }good, { 4 }very good, { 5 } Excellent

6. How faster the mechanical system on loading and discharging of containers on the Container operations? {5} Very slow, { 4 } slow, { 3 } Satisfactory, { 2 } high, { 1 } Very high

Section C: crane productivity

1. How do you rank the performance of Crane in terms of loading and unloading of train/trucks at the port of Modjo? {1} Very poor { 2 } Poor { 3 } Average { 4 } Good {5 } Excellent

2. On average, how could you measure crane operational efficiency? {5} Very good, { 4 } Good, { 3 } Satisfactory, { 2 } Poor, { 1 } Very poor

Section D: Dwell time

1. Do you agree or disagree that dwell time is an indicator to assess container terminal efficiency. { 1 } Strongly disagree, { 2 } Disagree, { 3 } No opinion or uncertain { 4 } Agree { 5 } Strongly agree

2. What position would you place the turnaround time (time needed to complete the task) of trucks at the port of Modjo? { 1 } Very much below average, { 2 } Below average { 3 } Above average { 4 } Very much above average.

3. How do you assess the congestion of container operation at the port of Modjo?

{1} Very bad, {2} Bad, {3} Average, {4} Good, {5} Very good

4. How would you describe the nature of delays at the port terminal currently?

{1}Hardly ever, {2} occasionally, {3} Sometimes, {4} frequently, {5} Almost always

5. Do you think by improving the operational performance will help to minimize the congestion problem at the port. {1} Yes {2} maybe {3} No

6. How do you express the competency of terminal operators at the Port of Modjo?

{1} Not competent {2} some competent {3} Uncertain {4} Competent {5} highly competent

Section E: Custom clearance

1. What is the average number of days used in clearing containers at the port currently?

(A) Within 24 hours, (B) 1-3 working days (C) 4 – 6 working days

(D) 7 – 9 working days (E) more than 15 working days

2. What is the average number of hours/days used in unloading containers at the port currently? (A) < 1 hours, (B) Within 2-3 hours, (C) Within 4-6 hours,

(D) Within 7-10 hours, (E) $> two$ working days

3. What is the average number of hours/days used in **sorting** containers at the port**?**

(A) < 10 hours, (B) Within 1-2 days, (C) Within 3-4 days, (D) Within 5-6 days,

4. What is the average number of hours/days used in **storing** containers at the port**?**

(A) $<$ 1 day, (B) Within 2-3 days, (C) Within 4-6 days, (D) Within 7-10 days,

5. How do you measure the effectiveness of custom clearance services at the port?

{1} Very ineffective {2} Ineffective {3} Average {3} Effective {5} Very effective

6. Do you think that the lack of Integrated IT System poses substantial delays in custom clearance procedures? {1} Yes, {2} Maybe, {3} No

7. What are the major problems you face regarding terminal operation?

____

____

____

10. In your own personal view what sort of measures would improve the efficiency of the container terminal operation better?

____

Interview

1. Introduce yourself? And define your job description?
2. What are the major problems of modjo dry port container terminal?
3. As a port chairman/deputy chairman, how do you see the container terminal of modjo from the operational point of view?
4. Can we say that high occupancy rate is influenced by many factors such as loading and discharging rate, Arriving time, waiting time, and service rate?
5. Can we say that these factors may lead to increase length of stay of truck/container in the port and this led to dissatisfy port users
6. Do you agree with me that managers should not focus on containerized cargo and container terminal in measuring port operational performance?
7. What is the importance of efficient for container terminals operational Performance?
8. What is the current situations of workers accountabilities to their duties?
9. What is the current situations of the modjo dry port container terminal operational performance?
10. What are the factors affecting timelines of container terminal services?
11. How is the provision of adequate, on time information of terminal operations on operational schedules?
12. How is the reliability of cargo handling equipment at container terminal for delivering processes