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COMPARATIVE EVALUATION OF OPERATIONS EFFICIENCY BETWEEN MAJOR SEAPORTS IN SOUTHERN AND EASTERN AFRICA USING DEA WINDOW ANALYSIS

Msabaha Juma Mwendapole[1], Mahamudu Mashaka Mabuyu[2], Jumanne A. Karume[3] and Lucas P. Mwisila[4]

[1]Dar es Salaam Maritime Institute, Maritime Transport Department,
Mchafukoge Street, Sokoine Drive, P.O.Box 6727 Dar es Salaam, Tanzania

[2]World Food Programme (WFP), Tanzania,
Kinondoni, Mwindu/ Burundi Street, Ada Estates, Plot No. 113221, P.O.Box 77778 Dar es Salaam, Tanzania

[3]Dar es Salaam Maritime Institute, Maritime Transport Department,
Mchafukoge Street, Sokoine Drive, P.O.Box 6727 Dar es Salaam, Tanzania

[4]Dar es Salaam Maritime Institute, Maritime Transport Department,
Mchafukoge Street, Sokoine Drive, P.O.Box 6727 Dar es Salaam, Tanzania

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ABSTRACT

The operations efficiency of Southern and Eastern Africa seaports was evaluated using DEA window analysis covering the period of ten years (2010-2019). The operations efficiency among the selected seaports from South and East African countries were compared and evaluated. The container throughput (TEUs), the available number of cranes, the quay length, the number of berths obtainable to hold up ships and total terminal area have been used as variables for input and output. The findings were; East African seaports have a lower container throughput volume (TEUs) and are smaller seaports size compared to South African seaports, but these East Africa seaports in general are more efficient than South African seaports. However, Durban seaport specifically in South Africa has been found to be the most efficient seaport among the six selected seaports from both regions (South and East African seaports). Moreover, the findings revealed that the least efficient seaport for the selected region over ten years is Walvis Bay seaport in South Africa. In this regard, policy maker should embrace the private and public investments as financial alternative sources. The timely, investment in port promotes a culture to modernise seaports so as to cope with the technological changes in maritime transport and improves seaport competitiveness and quality of services. The findings

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will be important in considering the selection of the future development strategies to be implemented by the seaports which are involved in this study.

KEYWORDS: Seaport Operations Efficiency, Container Throughput Volume, South and East Africa, Decision Making Units, DEA Window Analysis

1. INTRODUCTION

The Continent of Africa consists of more than sixty seaports located in various maritime countries. South and East African seaports are performing a significant role in supporting the progress of the global trade. Maritime transport is the foremost global carrier and driver of international trade, whereby through waterway it links huge industrial, trade and traffic hubs through seaports [1]. Large freight portions for many hinterland regions of African countries are passing through these seaports, these seaports are also regarded as heart for economic development for their contribution to the total nations' revenues. Every seaport is absolutely fixed with an aim of becoming efficient to attract more vessels calling the seaport in order to raise seaport revenue generation [2]. The significance of analysing South and East African seaports operations efficiencies will intentionally trigger arrangement and the execution of new strategies for development of the selected seaports. Also, the analysis will provide tangible information's to prospect customers and shipping lines regarding seaports operations efficiency status with their ranks in competitive environment. The paper evaluated the Operations Efficiency between Major Seaports in Southern and Eastern Africa; evaluation was very important in order to get the desired outputs for managerial decisions [3]. Operations efficiency of the seaport is extremely related with handling cost, nations with the most seaports efficiency characterised with lower handling costs. There is an inverse relationship stated that, nations with seaports which are considered to be inefficient are also the ones with higher seaports handling cost [4]. This study involving six major seaports where by three major seaports from each selected region (Southern and Eastern Africa). The South African seaports used in this study are Durban seaport in South Africa, Maputo seaport in Mozambique and Walvis Bay seaport in Namibia. The East African seaports used in this study are Djibouti seaport in Djibouti, Dar es Salaam seaport in Tanzania and Mombasa seaport in Kenya. DEA window analysis is adopted in this paper. DEA is normally employed to appraise the operations efficiency of selected seaports, as the capability of seaports to meet the optimum number of inputs at the specified output level [5]. In this paper, DEA evaluated seaport operations efficiency by means of panel data and cross-sectional analysis [6]. This paper is therefore aimed to evaluate and compare the relative seaport operations efficiency of the selected six seaports.

2. LITERATURE REVIEW

Efficiency in general, is a measure of deviation between actual performance and desired performance; efficiency can therefore be defined in terms of orientation i.e., Input oriented as well as an output-oriented

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measure of efficiency. An input-oriented measure of efficiency compares the observed level of input with the minimum input that could produce the observed level of output; alternatively, an output-oriented measure of efficiency compares the observed output with maximum output possible for a given input level [7]. The container throughput (TEUs), the available number of cranes, the quay length, the number of berths obtainable to hold up ships and total terminal area commonly used as output and input variables for measuring seaport efficiency [8]. Efficiency of the seaport is extremely related with handling cost, nations with the most seaports efficiency characterised with lower handling costs. There is an inverse relationship stated that, nations with seaports which are considered to be inefficient are also the ones with higher seaports handling cost [8].

Southern part of Africa is a region composed with ten nations while Eastern part of Africa is a region made up of nineteen nations. As rivalry between inter-continental seaports has become stiffed, the efficiency evaluation for seaport operations has turn into increasingly significant to enable each seaport to get tangible feedback regarding its efficiency status with its ranks in competitive environment together with the recognition of its strengths and weaknesses over competitors [9]. Research topics concerning African seaports draw interest of many researchers due to their strategic positions of seaports found in Africa. All maritime countries in Africa regions are surrounded by landlocked countries in which landlocked countries are using those nearby seaports to import and export their products. Definitely, a lot of researchers have written on related topics but they concentrated either on East or West African seaports, however this is the first study to evaluate and compare efficiency of major seaports from Southern and Eastern Africa regions.

It is well known that data envelopment analysis can be applied in various fields, also manifold input and output variables can be considered once applying DEA model. Xiaoling HUANG et al. (2019), they evaluated two seaports efficiency in China using three stage data envelopment analysis also they examined correlation between seaport efficiency and emissions and verified whether the correlation between affect the development of seaport, their finding revealed that shanghai seaport is inefficiency but it is because of its excessive pollutant emissions and finally they suggested measures to recover drawbacks [10]. Joanna Baran and Aleksandra Górecka (2015) they measured container ports total factor productivity and technical efficiency of using malmquist productivity index and DEA analysis. Their study showed that progress in technological aspect had a smaller impact on technical efficiency changes than the productivity change of container ports [11]. Tianci Huang et al. (2020), they conducted study concerning efficiency evaluation using DEA-SCOR Model for main seaports located alongside the Twenty-One Century Maritime Silk Road. Their findings demonstrated that the seaports of Shanghai Yangshan and Ningbo Zhoushan got rapid development and Qingdao seaport is considerably efficient, also Rotterdam port found

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to be the least inefficiency among major ports located alongside the Twenty-One Century Maritime Silk Road. Also, their study recommended some measures to be adopted [12].

Pascal K. P. Gamassa and Y. Chen (2017) in their article they analysed and compare seaports efficiencies between East and West Africa regions, their study confirmed that Tema seaport in Ghana is the most efficient seaport between two selected regions and the least efficient seaport is Dar es Salaam seaport in Tanzania. Finally, they suggested strategies for seaport development [13]. George Kobina and Van Dyck (2015) they adopted DEA method to assess efficiency of major six seaports in West Africa. Study findings determined that over the period of 7 years the most efficient seaport was Tema which is in Ghana and the least efficient seaport was Cotonou seaport in Benin, also study in general found that out of six selected seaports four seaport had average efficiency which is greater than 76 percent [14]. Hamadou et al. (2019), they used data envelopment analysis to assess dry port efficiency, their analysis study included 5 dry ports found in Africa covering the era of 4 years. Their study results revealed that dry port located in Mombasa is the most efficient and it scored highest average approximately to 1 throughout the study period while Casablanca dry port ranked the second one it scored 0.762, the least efficient dry port is Isaka which is located in Tanzania, it scored 0.142 throughout the study period. Finally, study pointed areas that need improvement [15].

Bomboma Kalgora et al. (2019), they applied various data envelopment analysis methods such as BCC, CCR and Windows I-C methods to measure 5 key commercial seaports efficiencies in West Africa over 11 years (2005-2016). Study found that Cotonou and Abidjan seaports should regulate their operational scales in order to improve their seaport efficiency, also they found that insecurity like terrorism and outbreak disease such as Ebola impacted seaport activities in West Africa [16]. Bomboma Kalgora (2019) he used Windows I-C method of DEA model to analyse competitiveness of strategic five container seaports in West Africa covering the period of 11 years (2005-2016). His study findings confirmed that, in West Africa the most efficient seaport is Tema seaport in Ghana with 95 percent average efficient score followed by Lagos seaport in Nigeria, Abidjan seaport in Ivory Coast, Lome seaport in Togo and Cotonou seaport in Benin [17]. Liu Dawei and Li Qian (2009) in their study they measured the 8 seaports efficiency in China based on DEA window analysis. They performed two separate models regarding collected data from companies of stock market in 2008, they started with DEA CCR model analysis then followed by DEA BCC. Their findings illustrated that inefficiency was just in half of 8 selected seaports. Model results found were compared and it found that the results of the BCC Model demonstrated more efficient seaports than CCR Model [18].

Rajasekar T et al. (2014) in their study they examined the operational efficiency of key Indian ports over the time starting from 1993-2011 using DEA. According to study findings it depicted those bigger ports

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in India named Jawaharlal Nehru and Mormugao ports also smaller ports which are Tuticorin and Ennore, their operations were evident to be efficiently. Study also confirmed that JNPT port is the most efficient port between the involved key ports in India [19]. YANG Hualong and Khin Lin (2010) they measured China ports efficiency against five ports from member nation of ASEAN using DEA. Their findings revealed that ASEAN-5 ports are inefficiencies compared to the ports of China [20]. Hong Gao et al. (2010) they assessed Shenzhen seaport's efficiency in china from 2003-2008 using data envelopment analysis. Their findings confirmed that during the study period Shenzhen seaport found to be efficient [21]. Jie Wu et al (2010) in their article the traditional DEA model analysis was used to verify the sensitivity of each variable for the DMU. For an effective decision-making unit, they calculated in what extent input variable can be enlarged or amount produced to be reduced without altering its efficiency status. In the case of an inefficient decision-making unit, they calculated in what extent input variable could be reduced or enlarged to reach the best practice frontier. New methods have been used to the efficiency analysis of seventy-seven international container ports. Study findings showed that capital invested and numbers of berths are the foremost factors deciding the efficiency level of most container ports [22]. Cheng-Yu Chang and Hsu-Hao Yang (2009) in their article they adopted DEA window for a constant and variable return-to-scale analysis to evaluate the efficiency of integrated telecommunications firms. Study was carried out in Taiwan covering a range of 5 years (2001-2005). The 1st results depicted that in short term acquisitions are defensible by a higher return to scale efficiency. The 2nd result showed that changing tactics like broadening market share to boost financial portfolios allows companies to attain superior scale. The 3rd result justified the government's attempts of privatising government companies and removal of economic restrictions so as to improve competitiveness [23].

3. DEA Model Methodology

DEA is a well-known model used by many researchers to evaluate performance efficiency; DEA Model was developed in 1978 by a PhD candidate by then known as E. Rhoders together with Charnes and Cooper when they conducted study which aimed to develop model that can be used to measure technical efficiency excluding the conversion of all variables to equivalent economic value and without conveying individual weights of output or input variables [24]. DEA is non-parametric method using linear programming to appraise a unit, program or an organisation which are known as Decision Making Units (DMUs) with similar features. DMUs considered to be efficient when efficient score equals or higher and approaching to 1, otherwise if efficient score is less than 1 and approaching to 0 means DMU is not efficient [25]- [26]. The ability of manipulating effectively over time a lot of output and input variables is the most benefit of this method, but also DEA can compare DMU straight vis-à-vis a DMU or DMUs with similar features. Additionally in DEA, any kind of assumption linked to input or output functional is not needed. DEA like any other models it also having some weaknesses. DEA guides to findings which are especially susceptible to errors measurement and only measures performance in relation to best practice

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in a limited study. Consequently, DEA cannot be applied to equate scores among two unrelated studies [27]. DEA model cannot disharmonize both outputs and inputs variables also it does not require presume about the technology applied [28]. Another DEA model problem is on the intensity of the efficiency scores vis-à-vis the selection and the varying of weight for input or output variables [29]. The model applied in this study is DEA-CCR, this approach is input oriented based and will be the right selection for evaluating seaports operations efficiency because seaport can manage its inputs in better way compares to outputs [30]. Overall efficiency evaluation and identification of the sources with approximation of the amounts for recognized inefficiencies can be provided by the CCR ratio model [31]. Optimization of DMU efficiency through the array of optimum weights correlated to individual input and output factors is the aim of the CCR model [32]. This study takes into account the container throughput (TEUs), the number of cranes, length of the quay, the number of berths available to hold up ships and total terminal area as output and input variables respectively. The mathematical equations of DEA model M1 are expressed as follows [33]-[34].

$$\text{M1}\begin{cases} Max h_k(u,v) = \dfrac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \text{ for all } k = 1,2,....,n & (1) \\ \dfrac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_r x_{ij}} \le 1, \quad j = 1,2,....,n & (2) \\ u_r \ge 0, \quad r = 1,2,....,s & (3) \\ v_i \ge 0, \quad r = 1,2,....,m & (4) \end{cases}$$

Where: hk: stand for relative efficiency of kth DMUs; n: stand for the number of DMUs; yrj: stand for amount of output r obtained by DMU j; s: stand for the number of outputs; m: stand for the number of inputs; ui: stand for the weight provided to input i; ur: stand for the weight specified to output r; xij: stand for the amount of input i utilized by DMU j.

By solving the equation number 1 up to 4 will maximize the efficiency of k-th DMU. It is understandable that hk will include values from 0 to 1. The k-th DMU will be efficient relative to

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other DMUs, when the value for hk is equal to 1; if not, the values of hk signify the inefficiency of k-th DMU. When the value of hk is close to 1 can also be considered as less efficiency for some DMUs. This is the predicament of CCR ratio model as described clearly by fractional linear programming model (M1), which can be condensed, by means of transforming the above formulas to linear programming model (M2) as follows

$$\text{M2}\begin{cases} Maxh_k(u,v) = \sum_{r=1}^{s} u_r y_{rk} \text{ for all } k = 1,2,....,n & (5) \\ \sum_{i=1}^{m} v_i x_{ik} = 1 & (6) \\ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1,2,....,n & (7) \\ u_r \ge \varepsilon, \quad r = 1,2,....,s & (8) \\ v_i \ge \varepsilon, \quad r = 1,2,.....,m & (9) \end{cases}$$

Where: hk: stand for relative efficiency of k-th DMUs; m: stand for the number of input values; n: stand for the DMUs numbers to be compared; ui: stand for weight of the input value i; ur: stand for weight of the output value r; s: stand for the number of output values.

Considering mathematical equations number 5 to 9 from the above linear programming model (M2) it shows clearly that time is not incorporated as a component. Hence solution can be determined at any point in time, also it is possible to use time series data analysis. The DMUs efficiency variation over time can assist in formulating significant suggestions and conclusions

4. Analysis based on Collected Data and Found Results

Required data for this study were obtained from various official archives, reports and databases through accessing their official websites. Considering the global fluctuation of the container throughput volume caused by the COVID 19, to avoid the effect caused by COVID 19 this study involved published and accessible data for seaport container throughput volume of South and East

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African seaports from all mentioned sources above were ended the year 2019. Therefore, this study will cover operations efficiency comparison of South and East African seaports for only ten years from 2010 up to 2019. Taking into account volume for container throughput in regional wise, Figure 1 below is clearly revealed that, South African seaports were largely overtakes East African seaports. It is extremely noticeable that seaports in South Africa between the years 2010 up to 2019 handled more cargo compared to seaports in East Africa. Indeed, in 2019, Durban seaport in South Africa was the seaport with highest container throughput volume among the selected seaports, Durban seaport had container throughput volume of more than 3.4 times of what the Mombasa seaport had, at the same time Mombasa seaport in Kenya was leading seaport with highest container throughput volume in East African seaports. This can be clarified by the reality that South Africa region has the first largest-country economy of Africa which is South Africa, also demand level for South Africa is higher compares to East Africa and the transit freight passing south African seaport are greater than what is passing in East African seaports.

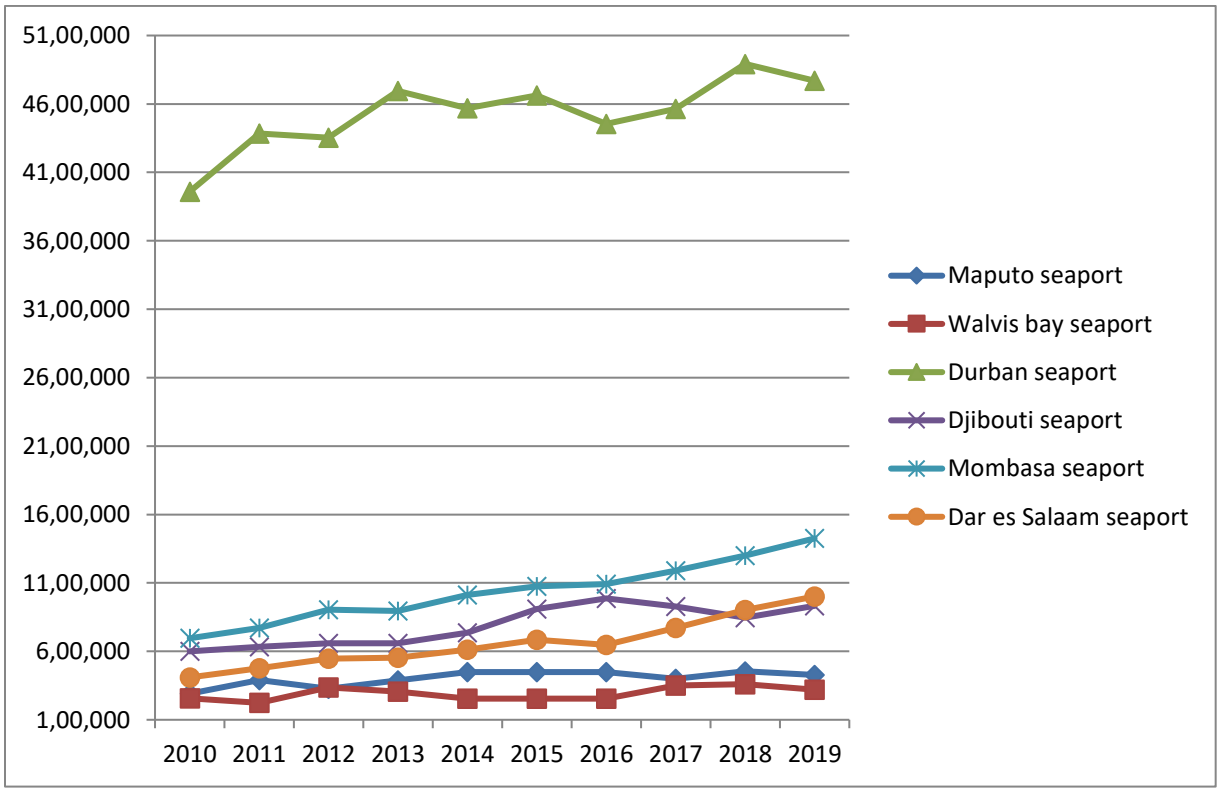

Figure 1: Container Throughput Volume Trends (in TEU's) for Selected Seaports from 2010-2019 Source: World Bank Database, 2021.

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The six seaports considered in this research have been selected by considering; their original locations specifically selected seaport is either from Southern or Eastern part of Africa, their container throughput volume, their countries economic development levels, their highest performance within the country it belongs, their seaport sizes, and their geographical locations. Figure 2 below shows all seaports which are in the Southern and Eastern part of Africa but, Table 1 below display only the six selected seaport for this study with their terminals based on the above criteria's.

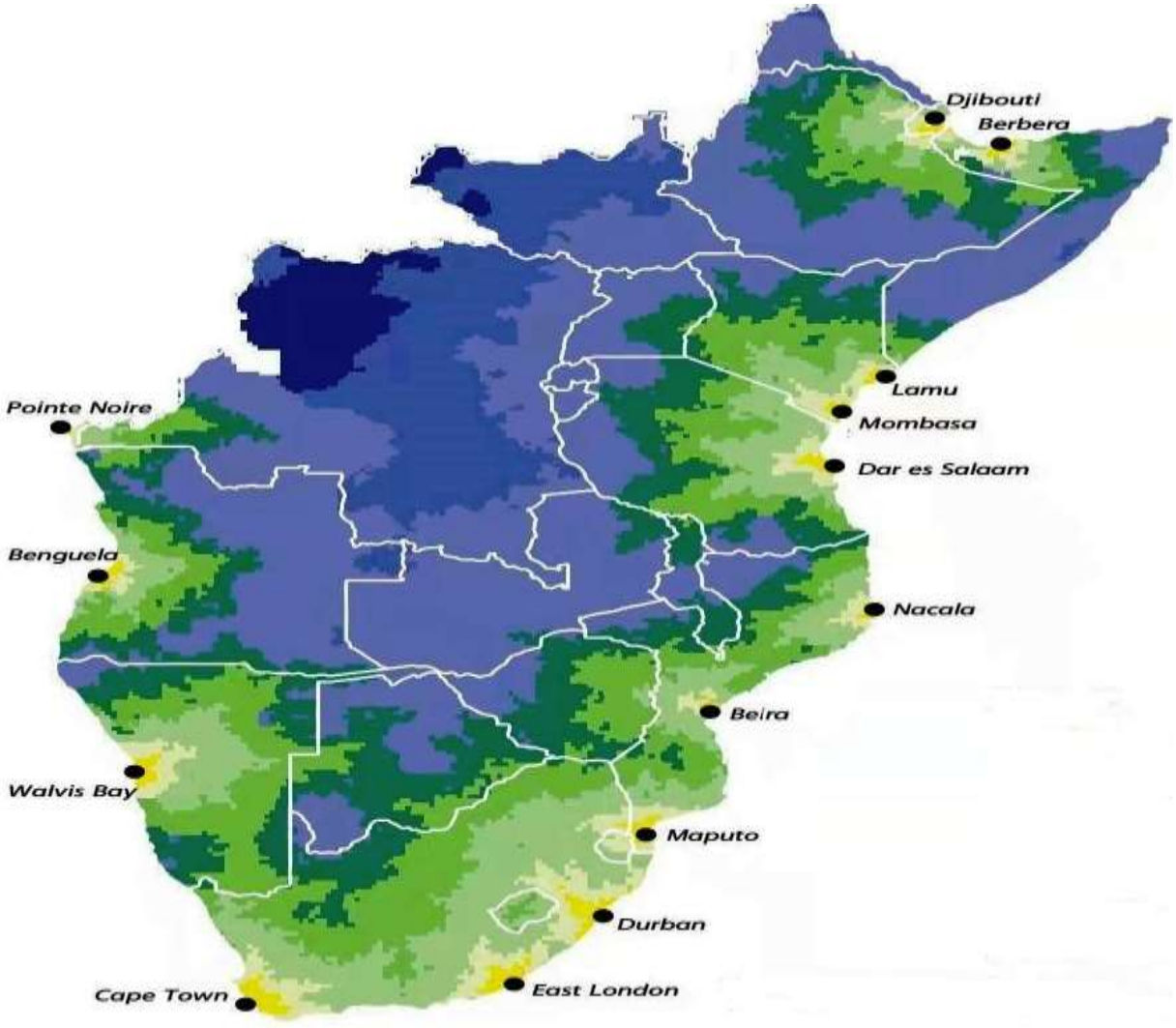

Figure 2: Seaports allocated in the Southern and Eastern Africa
Source: World Bank Database, 2021.

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Table 1 below display various terminals used for this study

Table 1: Container Terminals of South and East African seaports

Seaports	Terminals
Maputo seaport	DP World Maputo Terminal
Walvis Bay seaport	Walvis Bay Container Terminal
Durban seaport	Durban Container Terminal
Mombasa seaport	Mombasa Container Terminal
Djibouti seaport	Doraleh Container Terminal
Dar es Salaam seaport	TICTS Container Terminal

In this article, the only output variable used was container throughput volume (in Twenty Foot Equivalent Units) while input variables used were four namely the number of cranes, the total area for container terminal (in hectares), the quay length (in metres) and the number of berths. Specific data for output and input variables employed in this study are displayed clearly in Table 2 below. Time for vessels to stay at berths with its associated operation costs can be reduced through professional arrangement of berth together with quay crane. Also, this will improve vessels turnover rate and increase number of calling vessels to a seaport [35]. Ship owners are making more money in shipping business when their ships are sailing, also they lost much money when their ships are staying for so long in a seaport; therefore, loading and offloading speed is crucial productivity measure for both seaports and ships. Number of cranes at terminal has direct impact on the speed of loading and offloading the vessels which resulting to either increasing or decreasing the ship turn round time also the scalability of the seaport in general [36]. The length size of the container vessels to be accommodated at the container terminal can be determined by the quay length. Therefore, container volume to be handled by a terminal is greatly influenced by quay length [37]. The area dedicated for the marshalling yard, container yard side, container storage area and quayside area for loading and unloading all together gives the total area of container terminal in hectares [38].

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Table 2: Output and Input Variables of the selected Seaports in Southern and Eastern Africa

South and East African seaports	Year	Container throughput (TEUs)	Number of cranes	Terminal area (ha)	Quay length (in metres)	Number of berths
Maputo seaport	2010	290,800	5	13	308	1
	2011	389,300	5	13	308	1
	2012	326,200	5	13	308	1
	2013	387,000	5	13	308	1
	2014	449,700	5	13	308	1
	2015	449,700	5	13	308	1
	2016	449,700	5	13	308	1
	2017	400,300	5	13	308	1
	2018	454,300	5	13	308	1
	2019	427,300	5	13	308	1
Walvis Bay seaport	2010	256,276	8	40	895	3
	2011	223,711	8	40	895	3
	2012	337,124	8	40	895	3
	2013	304,792	8	40	895	3
	2014	255,246	8	40	895	3
	2015	255,246	8	40	895	3
	2016	255,246	8	40	895	3
	2017	351,428	8	40	895	3
	2018	360,214	8	40	895	3
	2019	320,656	8	40	895	3
Durban seaport	2010	3,953,192	64	102	2128	7
	2011	4,383,509	64	102	2128	7
	2012	4,353,256	64	102	2128	7
	2013	4,694,577	64	102	2128	7
	2014	4,567,993	64	102	2128	7
	2015	4,662,300	64	102	2128	7
	2016	4,454,000	64	102	2128	7
	2017	4,563,700	64	102	2128	7
	2018	4,892,400	64	102	2128	7
	2019	4,769,700	64	102	2128	7
Djibouti seaport	2010	600,000	16	22	400	2
	2011	634,200	16	22	400	2

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	2012	659,600	16	22	400	2
	2013	660,000	16	22	400	2
	2014	736,000	16	22	400	2
	2015	910,000	16	22	400	2
	2016	987000	16	22	400	2
	2017	928,000	16	22	400	2
	2018	847,000	16	22	400	2
	2019	932,000	16	22	400	2
Mombasa seaport	2010	695,600	28	14	840	4
	2011	771,000	28	14	840	4
	2012	903,400	28	14	840	4
	2013	894,000	28	14	840	4
	2014	1,012,000	28	14	840	4
	2015	1,076,100	28	14	840	4
	2016	1,091,000	28	14	840	4
	2017	1,190,000	28	14	840	4
	2018	1,300,000	28	14	840	4
	2019	1,425,000	28	14	840	4
Dar es Salaam seaport	2010	409,517	17	18.5	725	4
	2011	476,733	17	18.5	725	4
	2012	547,364	17	18.5	725	4
	2013	553,900	17	18.5	725	4
South and East African seaports	**Year**	**Container throughput (TEUs)**	**Number of cranes**	**Terminal area (ha)**	**Quay length (in metres)**	**Number of berths**
Dar es Salaam seaport	2014	612,600	17	18.5	725	4
	2015	683,600	17	18.5	725	4
	2016	648,100	17	18.5	725	4
	2017	771,000	17	18.5	725	4
	2018	903,000	17	18.5	725	4
	2019	1,000,775	17	18.5	725	4

Table 2 above demonstrates the tabulation of the model output and input variables for six (6) selected seaports from Southern and Eastern parts of Africa for ten years from 2010 to 2019.

Linear programming model (M2) in conjunction with MaxDEA 8.70 ultra-software was applied to analyse seaports efficiencies using data presented in a Table 2 above. Table 3 below present findings based on four-year DEA window analysis.

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Table 3: Findings of the DEA Window Analysis

Seaports	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average	C-Average
	0.94	1.00	0.98	0.96							0.97	
Maputo seaport		1.00	0.98	0.96	0.96						0.97	
			0.96	0.94	0.95	1.00					0.96	
				0.93	0.95	0.97	1.00				0.96	
					0.94	0.95	0.97	1.00			0.96	
					0.95	0.94	0.94	1.00			0.95	
						0.95	0.96	1.00	1.00		0.97	
							0.95	0.99	1.00	1.00	0.98	0.96
Walvis Bay	0.52	0.36	0.66	0.53							0.51	
seaport		0.36	0.66	0.53	0.40						0.48	
			0.62	0.50	0.38	0.35					0.46	
				0.49	0.36	0.34	0.35				0.38	
					0.35	0.33	0.35	0.55			0.39	
					0.37	0.35	0.34	0.57			0.40	
						0.33	0.35	0.56	0.50		0.43	
							0.34	0.55	0.50	0.47	0.43	0.44
	1.00	1.00	1.00	1.00							1.00	
Durban seaport		1.00	1.00	1.00	1.00						1.00	
			1.00	1.00	1.00	1.00					1.00	
				1.00	1.00	1.00	1.00				1.00	
					1.00	1.00	1.00	1.00			1.00	
					1.00	1.00	1.00	1.00			1.00	
						1.00	1.00	1.00	1.00		1.00	
							1.00	1.00	1.00	1.00	1.00	1.00
Djibouti	0.81	0.77	0.79	0.84							0.80	
seaport		0.77	0.80	0.81	0.93						0.82	
			0.81	0.78	0.90	1.00					0.87	
				0.75	0.88	0.97	1.00				0.90	
					0.86	0.95	0.99	1.00			0.95	
					0.90	0.95	0.99	1.00			0.96	
						0.96	0.98	0.99	0.95		0.97	
							0.99	0.98	0.96	1.00	0.98	0.90
Mombasa	1.00	1.00	1.00	1.00							1.00	
seaport		1.00	1.00	1.00	1.00						1.00	

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			1.00	1.00	0.99	1.00					0.99	
				0.98	0.98	0.98	1.00				0.98	
					0.98	0.97	0.98	1.00			0.98	
					0.99	0.97	0.97	0.99			0.98	
						0.96	0.98	0.97	0.99		0.97	
							0.97	0.99	1.00	1.00	0.99	0.98
Dar es Salaam	0.54	0.57	0.62	0.69							0.60	
seaport		0.57	0.61	0.67	0.72						0.64	
			0.63	0.67	0.70	0.71					0.67	
				0.69	0.68	0.71	0.69				0.69	
					0.70	0.68	0.67	0.78			0.70	
					0.67	0.70	0.67	0.76			0.70	

Seaports	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Average**	**C-Average**
Dar es Salaam						0.70	0.65	0.75	0.85		0.73	
seaport							0.66	0.77	0.85	0.93	0.80	0.69

Table 3 above presents the findings for the operations efficiency analysis and its comparative averages for all seaports considered in this study over the ten (10) year's period from 2010 up to 2019. It confirms that Durban seaport in South Africa scored the highest operations efficiency comparative average of 1, followed by Mombasa seaport in Kenya which scored operations efficiency comparative average of 0.98, and then Maputo seaport in Mozambique which scored operations efficiency comparative average of 0.96, there after Djibouti seaport in Djibouti which scored operations efficiency comparative average of 0.90. In this analysis, study found seaports with the lowest operations efficiency comparative average were Dar es Salaam seaport in Tanzania and Walvis Bay seaport in Namibia scored 0.69 and 0.44 respectively.

Table 4: Operations Efficiency Rank of the selected Seaports in Southern and Eastern Africa

Seaport	C-average score	Rank
Durban seaport	1.00	1
Mombasa seaport	0.98	2
Maputo seaport	0.96	3
Djibouti seaport	0.90	4
Dar es Salaam seaport	0.69	5
Walvis Bay seaport	0.44	6

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Table 4 above displays the position of the seaports according to its operations efficiency as shown in above analysis. Durban seaport ranked as the most efficient among all the seaports involved in this study, followed by Mombasa seaport, Maputo seaport, Djibouti seaport and Dar es Salaam seaport. As per this study analysis Walvis Bay seaport considered to be the least operations efficient seaport.

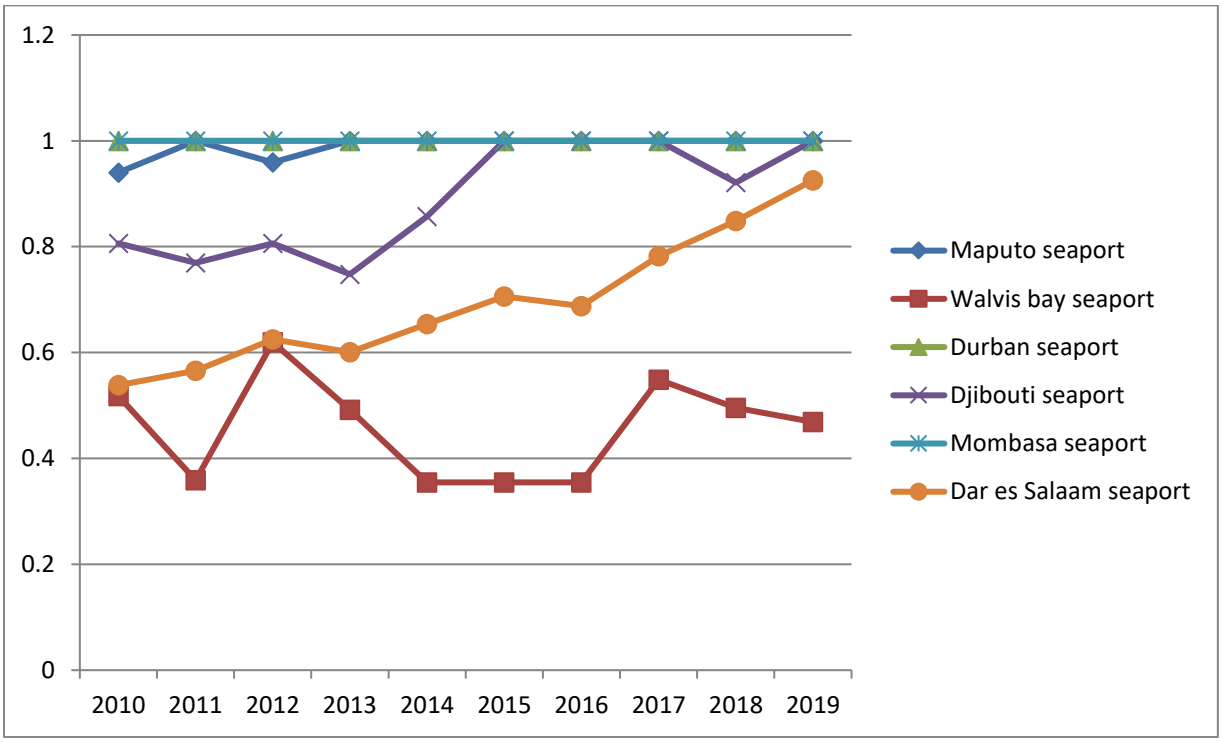

Figure 3: Annual Operations Efficiency Variation for Selected Seaport from 2010-2019
Source: Author Analysis, 2021.

Figure 3 above illustrates seaport operations efficiency variation per annual. From the Figure3 above, it can be observed that over the study period of ten years there is small variation of efficiencies for the individual seaports. All seaports except Walvis Bay seaport were tried to increase or maintaining their operations efficiency level.

5. Comparison of Operations Efficiency based on Study Findings

By considering study analysis presented in Table 3 and rank of seaport according to its operations efficiency as presented in Table 4, Durban seaport confirmed to be the most efficient seaport of the study region (Southern and Eastern Africa). Study analysis declared that this seaport attained the maximum level of efficiency, during the study period it maintained efficiency level of 100% from 2010 to 2019. This

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means its input and output arrangement is highly rational, which also implies that the Durban seaport resources are efficiently and fully utilized. Also, findings above showed that the least efficient seaport of two regions is Walvis Bay seaport, this means its input and output arrangement is actually irrational and its seaport resources are not completely utilized. On the other hand, Walvis Bay seaport and Dar es Salaam seaport their operations efficiency comparative average found to be less than 70% in which in this study implies inefficiency. These two seaports have to lower their high seaport costs, modernize their infrastructures so as to accommodate bigger vessels, by doing so will attract more customers and finally will increase their outputs and operations efficiency levels accordingly. For operations efficiency level of the seaport to be increased, the seaport should increase its output level and evade the wasting of resources. Maputo seaport regardless of its small seaport size and its low container throughput volume but is found to be efficient after Mombasa seaport in ranking. This is an outcome of fully utilization on the available seaport resources. Mombasa seaport which is in Kenya is regarded by many experts as a leading seaport in East Africa is still developing its infrastructures so as to improve its operations efficiency through increasing its output levels. This study ranked Djibouti seaport in fourth position, also it scored a good operations efficiency comparative average of 90% which can be regarded as an efficient seaport to be suggested to shipping lines. Operations efficiency levels and development resemblance of Mombasa and Djibouti seaports were significantly contributed by the existing high rivalry between them.

Comparative average (C-Average) results presented in Table 3 were used to compute and identifying the region with highest seaport efficiency between Southern and Eastern Africa. For South Africa seaport operations efficiency comparative average will be: Durban seaport (1.00) + Maputo seaport (0.96) + Walvis Bay seaport (0.44) / 3= 0.80 while for East Africa seaport operations efficiency comparative average will be: Mombasa seaport (0.98) + Djibouti seaport (0.90) + Dar es Salaam seaport (0.69) / 3 = 0.86. By considering these results, it confirmed that East African seaports possess an overall operations efficiency comparative average of 86% which is higher compared to the South African seaports which possess an overall operations efficiency comparative average of 80%.

6. CONCLUSION

East African seaports occasionally are highly considered compared to South African seaports. The ten year's period panel data from 2010 up to 2019 was helpful in evaluating the operations efficiency levels among the selected seaports. East African seaports have been confirmed to have a growing trend and execution strategies to continue developing their seaports. In regional perspective, findings of this study revealed that, the most efficient seaport in South Africa is Durban seaport, Maputo seaport was the second efficient seaport after Durban seaport and the last one is Walvis Bay seaport. Also, the most efficient seaport in East Africa is Mombasa seaport, Djibouti seaport followed after Mombasa seaport and the least efficient seaport in East Africa is Dar es Salaam seaport. In this paper, Maputo seaport was the smallest

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seaport among the selected seaports regarding to its size and the total number container handled by the seaport, but it has been found to be more efficient than other bigger seaports, this indicating that small seaport can also be more efficient than bigger seaports once its resources are well arranged and full utilized. The total efficiency comparative average of seaports of both of the two selected regions found to be below 90% which explains that all regional seaports are in moderate efficiency level. Also, the individual seaports with the lowest operations efficiency level should modernize their seaport by increasing the private and public investment so as to enlarge their seaport customer base. This study can be used by policy makers, planner, implementers, managers, administrators and authorities of the seaports. Seaports under this study can be used as benchmarks for better seaport development plans and improvement of operations efficiency levels. This study provides a significant insight on the importance of operations efficiency and consideration of a seaport with the best handling capacity thought as a regional hub seaport.

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