

Global Journal of Arts Humanity and Social Sciences
ISSN: 2583-2034
Abbreviated key title: Glob.J.Arts.Humanit.Soc.Sci
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link: <https://gsarpublishers.com/journal-gjahss-home/>

Volume - 4 | Issue - 9 | Sept 2024 | Total pages 694-703 | DOI: 10.5281/zenodo.13825900

Evaluation of the Impact of Dredging Entrance Channel on Enhancing Port Productivity: A Case Study of Dar es Salaam Port, Tanzania

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Abstract

This study evaluates the impact of dredging the entrance channel on enhancing port productivity in Tanzania, with a specific focus on the port of Dar es Salaam.

The researcher employed a mixed-methods approach, incorporating both quantitative and qualitative data collection, to comprehensively understand the dredging process. Interviews and questionnaires from various stakeholders, such as port authorities, policymakers, and industry experts, gathered data and provided diverse perspectives. Additionally, a documentary review offered historical context and regulatory insights, enriching the challenges current trends, and challenges analysis.

The findings underscore the significant positive impact of dredging on port productivity. Dredging of the channel improved navigability, reduced waiting times for ships, and optimized port infrastructure. Moreover, the research also identifies challenges such as financial constraints and environmental concerns that hinder the dredging process. Despite these challenges, post-improvement outcomes demonstrated enhancements in safety, reliability, and environmental sustainability, indicating the overall effectiveness of the dredging efforts.

Overall, the study provides valuable insights into the importance of dredging the entrance channel for port productivity. By addressing challenges and maximizing the benefits of infrastructure improvements, ports can improve efficiency, safety, and sustainability. The researcher proposes evidence-based recommendations for policymakers and port authorities to optimize dredging strategies and enhance port efficiency.

Keywords: Evaluation; Dredging Entrance Channel; Port Productivity; Dar es Salaam Port

Article History

Received: 14- 09- 2024

Accepted: 20- 09- 2024

Published: 22- 09- 2024

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1.0 INTRODUCTION

The Dar es Salaam Port, located on the coast of the Indian Ocean in Tanzania, plays a crucial role as a central maritime center for East Africa, enabling substantial trade and commercial operations. Although the port plays a vital role, it consistently encounters obstacles concerning its entrance channel, which is necessary for ships to enter (TPA, 2021). The channel's limited depth and navigability have historically restricted the size of vessels and the amount of cargo they can carry. This has had a negative impact not only on Tanzania but also on surrounding landlocked nations such

as Zambia, Burundi, Rwanda, and Uganda (World Bank, 2019). These limitations have extensive implications for trade and economic growth at a regional level.

The quality and upkeep of the entrance channel are critical for the port's efficiency, as they impact the time it takes for vessels to enter and exit, the availability of berths, and the total port capacity. Dredging operations, aimed at improving the channel's depth and width, have been the focus of recent endeavors. Nevertheless, the efficacy of these dredging initiatives in improving port productivity continues to be a subject of continuous investigation and



discussion (UNCTAD, 2020). Enhancing the entrance channel is seen as a means to accommodate larger vessels, thereby increasing cargo throughput and operational efficiency. This has potential economic benefits, including the creation of employment opportunities due to the increased need for skilled and unskilled port labor to manage the loading and unloading of cargo (Michael, 2018). Improved channel conditions can thus contribute to both the local and regional economy (Tahar, 2017).

This study aims to evaluate the impact of dredging on the Dar es Salaam Port's entrance channel performance. By examining the effects of dredging on vessel accessibility, cargo throughput, and overall operational efficiency, the research seeks to provide valuable insights and recommendations for port authorities, policymakers, and stakeholders (McGrew, 2021). Understanding the influence of dredging initiatives on the port's capacity and competitiveness is vital for promoting sustainable economic growth and enhancing trade facilitation in the East African region. The state of the entrance channel of the Dar es Salaam Port and the efficiency of dredging operations are crucial factors that determine the port's performance and its significance in regional trade (Hilton, 2017). This study evaluates the correlation between dredging activities and port efficiency, providing evidence-based suggestions to tackle obstacles and capitalize on prospects for improvement.

A port is a facility located on a sea coast or estuary where ships load and unload cargo and passengers. However, ports can also be found inland, such as Hamburg, Manchester, and Duluth, which have access to the sea through rivers or canals (Joan, 2017). The port entrance channel is the channel that allows ships to enter the port. The characteristics of this channel may vary depending on the specific port. Some ports have channels that can accommodate ships of any type and size, while others have more limited access due to narrowness and depth. For example, there are ports with channels that can accommodate large container ships up to 290 meters in length, while others have restrictions. (Cleos, 2018).

The process of dredging a port entrance channel entails widening the channel and increasing its depth to accommodate huge containerized ships of any length to approach the port (Bryan, 2018). An enhanced channel leads to heightened port productivity, more deployment of large ships to the port, and a reduction in berth waiting time. This study focuses on the process of dredging the port entrance channel, which entails both deepening and broadening the channel. The objective is to enable the passage of vessels of any size, facilitating their entry and exit from the port.

Port productivity is the assessment and evaluation of several areas of a port's operations and activities to determine its efficiency, effectiveness, and overall usefulness. Maritime and logistics management is considered crucial since it assists stakeholders, including port authorities (Bill, 2019). Efficiently managing port productivity is essential for maximizing trade and logistics operations, cutting costs, eliminating delays, and improving the general competitiveness of an area or country in global trade (James, 2020).

Environmental and economic theory refers to the study of measurements related to the environment. (James, 2018) examines the relationship between the environment and the economy by investigating how the environmental conditions at port entrances can impact the economic performance of the port and the shipping process. The significance of expanding the port entrance channel lies in its ability to accommodate larger boats, enhance port efficiency, decrease waiting time at berths, and minimize ship turnaround time (Kuo, 2018). This idea highlights the significance of dredging the entrance channel and its effects on global shipping mechanisms (Ramus, 2018).

According to McGrew (2019), the economic significance of the port entrance channel lies in its ability to meet international standards, which enables various ships of varying sizes to approach the port for cargo loading and unloading (Bacchioni, 2018). Several cargo ships of 290 meters in length were unable to enter multiple ports due to the characteristics of the entrance canal.

The Balanced Scorecard is a theoretical framework for measuring port infrastructure, developed by Kaplan in 2015. It is a useful tool for studying and explaining the factors that contribute to port productivity, with a particular focus on the quality of port navigational infrastructure and the efficiency of cargo handling processes. This theory also elucidated the significance of enhancing the port entrance channel to augment port productivity by facilitating the deployment of a greater number of ships of varying sizes (Montewka, 2017).

The significance of the port entrance channel in relation to port productivity is widely acknowledged. Evaluating the effectiveness of performance and responding accordingly to the presence or absence of anticipated outcomes is also vital (Pollat, 2017). An examination of the impact of port entrance channels on port productivity. The balancing scorecard theory can be utilized to forecast future performance in terms of port productivity, specifically about the growth of the port entrance channel (Hayuth, 2017).

An economic theory of a port explains how the productivity of a port is enhanced by improving the entrance channel and addressing port facility issues (Wayne, 2007). The correlation between a port's maximum throughputs and the amount of its productive resources is shown by the quality of the port infrastructure, especially the condition of the port entrance channel. This theory can be employed to explain the extent to which enhanced port infrastructure improves the efficiency and productivity of a port. It focuses on the operational aspects that a port utilizes, including the quality of the port entrance channel, the capacity of berths, and the equipment utilized for handling cargo (Hayuth, 2020).

Increasing Dredging Depth and Improvements in Port Productivity
The relationship between dredging depth and port productivity has been widely examined in port management literature. Dredging, the process of removing sediment and debris from the bottom of water bodies, is crucial for maintaining or increasing the depth of navigation channels, berths, and turning basins (Gray, 2019). Studies have shown that deeper channels enable ports to

accommodate larger vessels, which are increasingly being used in international trade due to their economies of scale (Cullinane & Wang, 2020). For instance, the Port of Rotterdam and the Port of Hamburg have significantly enhanced their productivity and competitiveness by increasing their dredging depths, allowing them to handle larger container ships (Tahar, 2017).

At the Port of Dar es Salaam, increasing the dredging depth of the entrance channel is expected to similarly enhance productivity. By accommodating larger vessels and reducing the risk of groundings, the port can improve its handling capacity and turnaround times (Bendalla, 2017). The direct correlation between dredging depth and port productivity has been confirmed in multiple empirical studies, emphasizing that deeper channels can lead to more efficient port operations and increased throughput (Hussain, 2019).

In the context of Tanzania, Mwemezi (2019) examined the Port of Dar es Salaam and found that increasing the dredging depth significantly improved the port's productivity. The study noted that deeper channels allowed the port to accommodate larger vessels, enhancing its handling capacity and reducing turnaround times. This finding aligns with international studies, suggesting that dredging depth is a critical factor in port productivity.

Effect of Dredging on Reducing Pre-Berthing Waiting Time and Overall Port Productivity.

Pre-berthing waiting time, the duration vessels spend waiting at anchorage before being allocated a berth, is a critical factor affecting port productivity. Extensive research indicates that delays in pre-berthing waiting times can significantly hinder port efficiency and increase operational costs for shipping lines (Kelvin, 2020). Dredging the entrance channel has been identified as a key measure to mitigate such delays. A deeper and wider channel can facilitate smoother and quicker vessel movements, reducing congestion and waiting times at the anchorage (UNCTAD, 2018).

For example, a study on the Port of Shanghai demonstrated that dredging operations significantly reduced pre-berthing waiting times and enhanced the port's overall productivity (Gray, 2019). Similarly, the Port of Singapore's continuous dredging efforts have been linked to its ability to handle high vessel traffic efficiently, maintaining its status as one of the world's busiest and most productive ports (Wayne, 2019). In the context of the Port of Dar es Salaam, empirical evidence suggests that dredging the entrance channel can lead to substantial reductions in pre-berthing waiting times, thereby improving the port's operational efficiency and productivity (Bichou, 2020).

Local studies also highlight the importance of dredging in reducing pre-berthing waiting times. A report by the Tanzania Ports Authority (TPA) (2015) indicates that dredging projects at the Port of Dar es Salaam have led to notable reductions in vessel waiting times. This improvement has translated into better port efficiency and higher throughput. The study by Mwemezi (2019) corroborates these findings, emphasizing that efficient dredging operations are crucial for minimizing delays and enhancing port productivity.

Recommendations from local studies focus on the need for continuous investment in dredging projects. The Tanzania Ports Authority (TPA) (2015) recommends adopting public-private partnerships to secure funding for dredging initiatives. According to Mwemezi (2019) suggest that policymakers should prioritize the use of advanced dredging technologies and engage stakeholders in planning processes to ensure sustainable operations. These recommendations are consistent with global best practices, emphasizing the importance of strategic investments and collaborative approaches in port management.

Improve port productivity, improved port entrance channel leads to an increase of port productivity since many large containerized ships with 290m long can enter the channel hence many cargo being discharged or loaded at the port. (Chung, 2017). Port productivity depends mostly on port infrastructure including the quality of the port entrance channel as well as other port facilities (Esmer, 2018).

Deployment of large containerized ships of different sizes at the port, The quality of the port entrance channel allows large ships with large sizes (width and depth) to enter the port resulting of large cargo being discharged and loaded at the port (Tahar, 2017)

Deployment of large ships results in increasing port financial as well as port productivity. Large containerized ships of 290m length can enter the port due to the quality of the entrance channel involving the wideness and depth of the channel (Hussain, 2019).

Reduces Berth waiting time, the outcomes of having a quality port entrance channel results in a reduction of berth waiting time (BWT) at the port since more ships can enter the port as well as results in the construction of quality berth and other port facilities due to increase of port financial gain (Hussain, 2019).

Reduces ship turnaround time, quality of port entrance channel results in the reduction of ship turnaround time, the time the ship spent at the berth being reduced hence more large ships being able to occupy the berth at the right time. Also, more ships are served at the port since each vessel at the berth spends a few days to discharge the cargo or load the cargo due to the quality of port facilities as well as quality of cargo handling equipment.

2.0 RESEARCH METHODOLOGY

The methodologies employed in examining the effect of dredging the entrance channel at Dar es Salaam port on port productivity. It covers the research approach, design, population, sample size, sampling techniques, data collection procedures, data quality control, analysis methods, and ethical considerations.

The study uses a mixed-methods approach, combining both qualitative and quantitative data. The quantitative approach involves numerical data, frequencies, and percentages, while the qualitative approach delves into understanding complex content (Michael, 2018). This combination allows for a comprehensive representation of data in both tabulated and narrative forms.

A descriptive study design was utilized, focusing on the Dar es Salaam port as a case study. This design was chosen to gather in-

depth information on the impact of dredging activities, ensuring that data are accurate and unbiased (Braise, 2018; James, 2020). The study involved a sample of 60 respondents, including TPA officers, TASAC officers, Marine officers, port workers, and skilled laborers. This diverse group ensures a broad representation of stakeholders affected by the dredging activities (Drainer, 2017).

Stratified sampling was used to ensure a comprehensive evaluation of the impact of dredging on port productivity. The study includes data from structured interviews, questionnaires, and documentary reviews, providing a well-rounded perspective on the operational and strategic implications of dredging (McGrew, 2019).

Data collection involved both primary and secondary sources. Primary data was gathered through structured interviews and questionnaires, while secondary data was gathered from documentary reviews of reports and regulatory documents. The structured interviews mirror the questionnaire tool to enhance data comparability (Daniel, 2020; Valentino, 2016; Johansen, 2019). The data was processed using SPSS software, employing descriptive statistics and linear regression models to analyze the relationship between variables such as human resources, policies, port infrastructure, and productivity indicators (Kothari, 2019, Michael, 2019).

This research was conducted on the entrance channel at Dar es Salaam Region. The dredging area of the entrance channel of the Dar es Salaam port are well shown in Figure 1 below.



Figure 1: Dredging are of the Entrance Channel

3.0 FINDINGS AND DISCUSSION

The findings and discussion demonstrate that deepening and widening the entrance channel increased the entrance channel at the port of Dar es Salaam has a substantial positive effect on overall port productivity. By increasing the dredging depth of the channel, larger vessels can navigate more easily, resulting in reduced congestion and enhanced efficiency in loading and unloading operations. This accessibility improvement attracts a wider range of ships and increases the potential for increased traffic and commercial activities at the port.

The findings emphasize that deepening the entrance channel leads to increased efficiency within the port environment. Wider channels allow for smoother passage of larger vessels, reducing

congestion and waiting times for berths. This streamlined traffic flow leads to improved vessel turnaround times and heightened productivity. By minimizing offshore idle time and ensuring prompt docking for cargo operations, ports can handle a greater volume of shipments within a specific timeframe, ultimately enhancing overall port efficiency.

The analysis highlights the significance of optimizing resource utilization through dredging activities. By accommodating larger vessels and managing greater cargo capacities per ship, ports can take advantage of economies of scale and maximize the effectiveness of cargo loading and unloading procedures. This results in a more efficient utilization of resources and infrastructure, contributing to enhanced port productivity and economic growth. The analysis of the impact of dredging the entrance channel on reducing pre-berthing waiting time reveals significant improvements in port efficiency. By facilitating faster vessel turnaround times and optimizing resource utilization, dredging activities play a crucial role in enhancing port efficiency.

The findings from Figure 2 suggest that respondents strongly support the idea that improving the port entrance channel can enhance the port's overall productivity. With 92.2% of respondents expressing favorable opinions (agreeing or strongly agreeing), it is evident that there is widespread recognition of the positive impact that infrastructure improvements can have on port efficiency.

The data also reveals that only a very small percentage of respondents (3.8%) hold negative views on the matter, with 1.9% each strongly disagreeing or disagreeing. Additionally, a small proportion (3.9%) of respondents remain neutral, indicating that the majority of stakeholders have formed clear opinions regarding the relationship between port entrance channel improvements and port productivity.

The implications of these findings for port management and infrastructure development are significant. Firstly, the support for enhancing the port entrance channel suggests that there is a strong recommendations to stakeholders regarding the importance of investing in such improvements.

Furthermore, the positive response underscores the potential benefits that can be realized from investing in port infrastructure projects aimed at optimizing entrance channels. These benefits include smoother vessel traffic, reduced waiting times, increased cargo throughput, and improved safety.

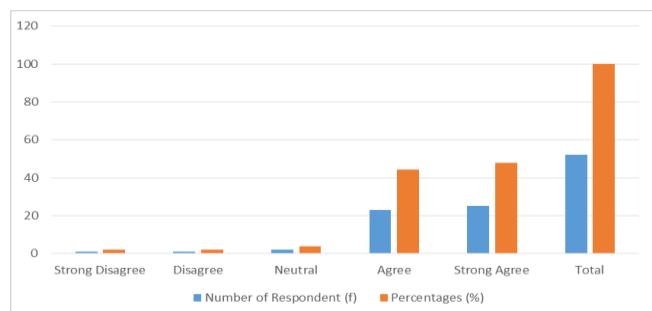


Figure 2: Response on improvement of port entrance channel

Figure 3, Presents respondents' opinions on whether the quality of the port entrance channel improves trade with neighboring countries. The data indicates a strong consensus among respondents, with a combined total of 94.2% (42.3% agreeing and 51.9% strongly agreeing) expressing positive views regarding this statement. This overwhelming agreement suggests a widespread recognition among the surveyed population of the importance of well-maintained port infrastructure for fostering regional trade relations.

Moreover, the data reveals that only a very small percentage of respondents (1.9%) expressed strong disagreement with the statement, indicating minimal dissenting opinions. Additionally, a small proportion (3.8%) of respondents remained neutral on the topic, further emphasizing the prevailing positive sentiment regarding the correlation between the quality of the port entrance channel and trade facilitation with neighboring countries.

The implications of these findings for policymakers, port authorities, and stakeholders involved in maritime trade are significant. The overwhelmingly positive response indicates a strong belief among respondents that investing in the quality improvement of port entrance channels can effectively boost trade activities with neighboring countries. A well-maintained and optimized entrance channel not only facilitates smoother vessel movements and reduces shipping costs but also enhances the port's attractiveness as a strategic gateway for regional trade flows.

Consequently, policymakers and port authorities may utilize these insights to prioritize investments in port infrastructure projects aimed at enhancing the quality and navigability of entrance channels. By doing so, they can foster economic integration, trade expansion, and regional development. Moreover, these investments can contribute to strengthening diplomatic and economic ties with neighboring countries, as well as positioning the port as a key player in regional trade networks.

In summary, the findings highlight the crucial role of port infrastructure in facilitating trade and economic development, particularly in fostering regional trade relations with neighboring countries. The strong consensus among respondents underscores the importance of prioritizing investments in port infrastructure projects aimed at enhancing the quality of entrance channels to realize the potential benefits of improved trade facilitation and regional integration.

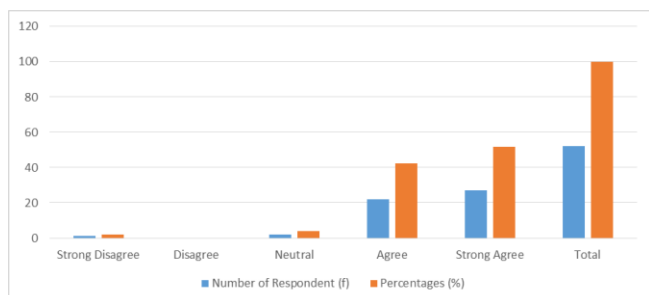


Figure 3: Responses on the quality of the port entrance channel

Figure 4, presents respondents' opinions on whether the presence of a quality entrance channel improves port efficiency and overall port productivity. The data reveals a predominant positive perception among respondents, with a combined total of 82.7% (42.3% agreeing and 40.4% strongly agreeing) expressing favorable views regarding this statement. This overwhelming agreement suggests a widespread recognition among the surveyed population of the importance of well-maintained port infrastructure for operational effectiveness.

Furthermore, the data shows that only a small percentage of respondents (5.7%) expressed strong disagreement or disagreement with the statement, indicating minimal dissenting opinions. Additionally, 11.5% of respondents remained neutral on the topic, suggesting that while there is general agreement on the positive impact of a quality entrance channel, there are some individuals who may require further information or persuasion.

The implications of these findings for port management, policymakers, and stakeholders involved in port operations are significant. The positive response underscores the perceived importance of investing in the maintenance and optimization of entrance channels to enhance port efficiency and overall productivity. A quality entrance channel facilitates smoother vessel movements, reduces waiting times for ships, and minimizes the risk of navigational incidents, all of which contribute to improved port operations.

Moreover, an efficient entrance channel enhances the port's attractiveness to shipping lines, cargo owners, and other stakeholders, thereby enhancing its competitiveness and position as a key maritime gateway. This not only benefits the port itself but also has broader implications for regional trade and economic development.

Consequently, policymakers and port authorities may utilize these insights to prioritize investments in infrastructure projects aimed at ensuring the quality and navigability of entrance channels. By doing so, they can drive economic growth, trade expansion, and regional development, while also enhancing the competitiveness and efficiency of the port.

The findings highlight the crucial role of well-maintained port infrastructure, particularly entrance channels, in driving port efficiency and overall productivity. The widespread recognition among respondents of the positive impact of a quality entrance channel underscores the importance of prioritizing investments in infrastructure projects aimed at optimizing port operations and fostering economic development.

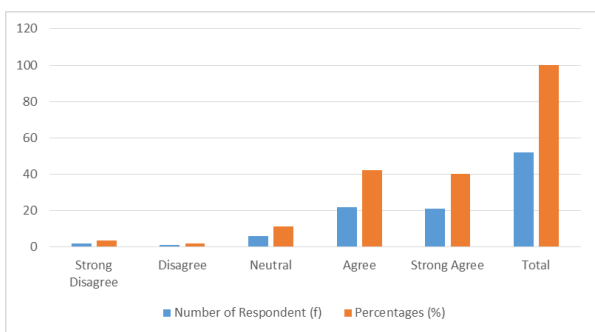


Figure 4: Response on presence of quality entrance channel

Figure 5 presents respondents' opinions on whether the shortage of funds is among the challenges facing the dredging process at Dar es Salaam. The data indicates a mixed perception among respondents, with a notable portion expressing agreement or strong agreement (69.2%) that the shortage of funds poses a challenge to the dredging process. Additionally, 23.1% of respondents remained neutral on the topic, while only a small percentage of respondents disagreed (1.9%) or strongly disagreed (5.8%) with this statement.

While there is no clear consensus, the proportion of respondents who perceive financial constraints as a significant challenge highlights the importance of addressing funding shortages to ensure the smooth progress of dredging activities at the port of Dar es Salaam. Adequate funding is crucial for acquiring and maintaining dredging equipment, hiring skilled personnel, and implementing necessary infrastructure upgrades.

The implications of these findings for stakeholders involved in the dredging process and port management at Dar es Salaam are significant. The acknowledgment of financial constraints as a challenge underscores the need for proactive measures to address funding shortages and ensure the continued development and competitiveness of the port.

Policymakers and port authorities may need to explore alternative funding sources or seek partnerships with public and private entities to secure the necessary resources for dredging projects. Additionally, proactive financial planning and budget allocation strategies may help mitigate the impact of funding shortages on dredging operations.

Furthermore, addressing financial constraints not only ensures the smooth progress of dredging activities but also contributes to the overall efficiency and competitiveness of the port. By investing in dredging infrastructure and addressing funding challenges, stakeholders can improve navigability, accommodate larger vessels, and facilitate increased trade volumes, thereby driving economic growth and regional development.

In summary, while there is no clear consensus among respondents, the acknowledgment of financial constraints as a challenge facing the dredging process at Dar es Salaam highlights the importance of addressing funding shortages to ensure the continued development and competitiveness of the port. Proactive measures, such as exploring alternative funding sources and implementing financial

planning strategies, can help mitigate the impact of funding constraints and ensure the smooth progress of dredging activities.

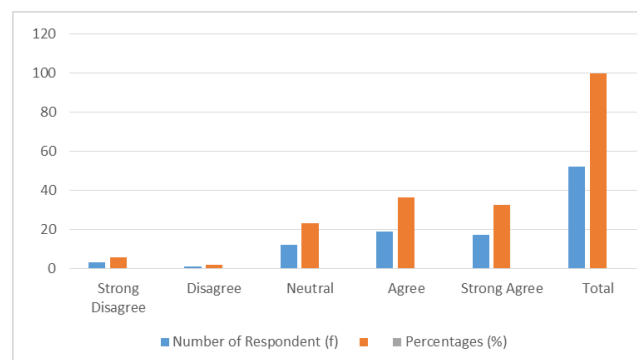


Figure 5: Response to shortage of funds

Figure 6 presents respondents' responses on whether poor government policy on the implementation of the project reduces the efficiency of operations. The data indicates a significant portion of respondents expressing concerns about the impact of government policy on project efficiency. Specifically, a combined total of 78.8% (48.0% agreeing and 30.8% strongly agreeing) of respondents believe that poor government policy negatively affects project operations' efficiency.

Only a minority of respondents disagree (1.9%) or strongly disagree (3.8%) with this statement. Additionally, 15.4% of respondents remain neutral on the topic. Overall, the data suggests that a substantial majority of respondents perceive government policy as a significant factor influencing project efficiency, highlighting the importance of effective governance in project implementation.

These findings have significant implications for project management and policymaking. The positive response regarding the influence of government policy underscores the critical role of regulatory frameworks and policy decisions in project success. Poorly formulated or implemented government policies can lead to delays, inefficiencies, and cost overruns, ultimately hindering project objectives.

Addressing this challenge may require policymakers to engage stakeholders, streamline regulatory processes, and establish transparent and consistent policies to promote project efficiency and effectiveness. Additionally, project managers need to navigate regulatory complexities and advocate for supportive government policies to mitigate risks and ensure project success.

Moreover, the data suggests that there is a need for enhanced collaboration and communication between policymakers, project managers, and stakeholders to address policy-related challenges effectively. By fostering a conducive policy environment, governments can support project implementation and facilitate the achievement of project goals. Addressing concerns related to poor government policy requires proactive measures from policymakers, project managers, and stakeholders to streamline regulatory

processes, enhance transparency, and promote supportive policies that facilitate project success.

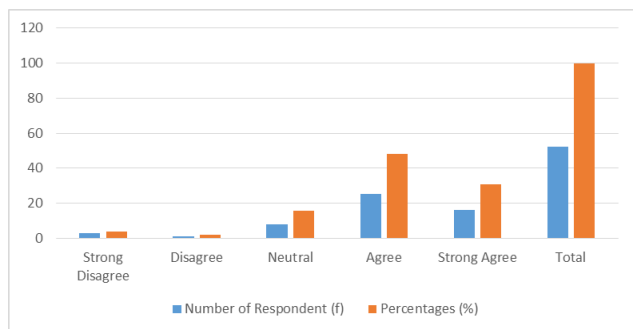


Figure 6: Response on poor government policy on the implementation of the project

Figure 7, presents respondents' opinions on whether environmental and social factors act as drawbacks to the implementation of dredging the entrance channel. The data reveals a range of perceptions among respondents regarding the significance of these factors.

A small percentage of respondents, comprising 1.9% who strongly disagree and 17.3% who disagree, believe that environmental and social factors do not pose significant drawbacks to the implementation of dredging the entrance channel. This suggests that some respondents perceive these factors as less influential or negligible in comparison to other challenges.

On the other hand, a notable portion of respondents, representing 19.3%, remain neutral, indicating a lack of a strong opinion regarding the impact of environmental and social factors on dredging implementation. This neutrality could stem from a variety of reasons, including insufficient knowledge or experience in this area.

However, the majority of respondents, comprising 48.0% who agree and 13.5% who strongly agree, recognize environmental and social factors as significant drawbacks to the implementation of dredging the entrance channel. This indicates a perception among respondents that these factors play a substantial role in influencing the success and challenges of dredging projects.

Overall, the data suggests that while there is some divergence in opinions, a significant majority of respondents acknowledge the importance of considering environmental and social factors in dredging project implementation. These factors can include ecological impacts, community concerns, regulatory compliance, and stakeholder engagement.

Addressing these challenges effectively requires careful planning, stakeholder consultation, and the implementation of mitigation measures to ensure sustainable and responsible dredging practices. Failure to adequately address environmental and social factors can lead to project delays, increased costs, and reputational damage, highlighting the importance of integrating environmental and social considerations into dredging project planning and implementation.

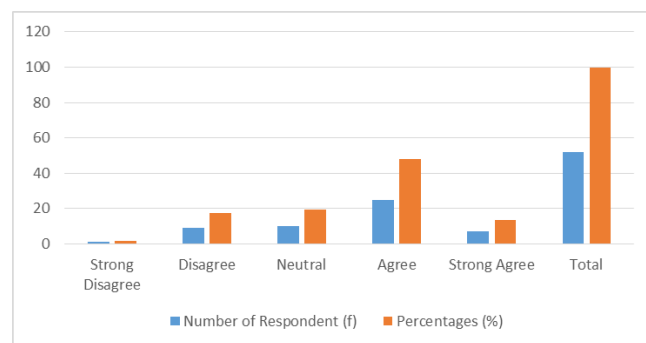


Figure 7: Response to environmental and social factors

Figure 8 presents respondents' opinions on whether the lack of skilled manpower for machinery operation is among the challenges facing the process of dredging the entrance channel. The data reveals a range of perceptions among respondents regarding the significance of this challenge.

A combined total of 30.8% of respondents, with 11.5% strongly disagreeing and 19.3% disagreeing, believe that the lack of skilled manpower for machinery operation is not a significant challenge in the dredging process. This suggests that a notable portion of respondents perceive the availability of skilled manpower as adequate or not as critical compared to other challenges.

Another 11.5% of respondents remain neutral, indicating a lack of a strong opinion regarding the impact of the lack of skilled manpower for machinery operation on dredging implementation. This neutrality could stem from a variety of reasons, including insufficient knowledge or experience in this area.

However, the majority of respondents, comprising 25.0% who agree and 32.7% who strongly agree, recognize the lack of skilled manpower for machinery operation as a significant challenge in the dredging process. This indicates a perception among respondents that the shortage of skilled operators poses a notable obstacle to the efficient and effective execution of dredging projects.

Overall, the data suggests that while there is some divergence in opinions, a significant majority of respondents acknowledge the importance of addressing the lack of skilled manpower for machinery operations in dredging projects. Ensuring an adequate supply of skilled operators is crucial for maintaining operational efficiency, safety, and project timelines.

Efforts to address this challenge may involve investing in training and education programs, promoting skills development initiatives, and collaborating with industry stakeholders to attract and retain qualified personnel in the dredging sector.

The findings highlight the critical importance of addressing the lack of skilled manpower for machinery operation in dredging projects. By recognizing and addressing this challenge, stakeholders can enhance the efficiency, safety, and success of dredging operations, ultimately contributing to the sustainable development of maritime infrastructure and related industries.

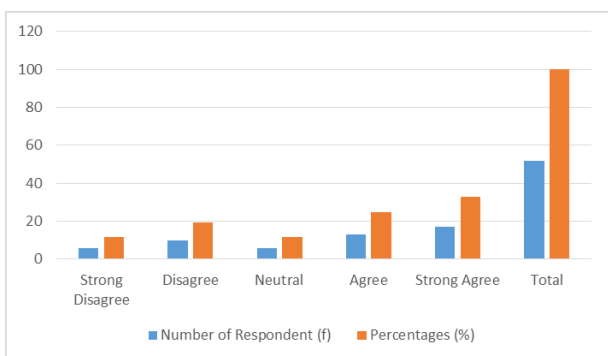


Figure 8: Response to the lack of skilled manpower for machinery operation

Linear Regression Model

Linear regression is a statistical method used to model the relationship between a dependent variable (often denoted as Y) and one or more independent variables (often denoted as X).

The equation for a simple linear regression model with one independent variable is given by:

$$Y = \beta_0 + \beta_1 X + \epsilon$$

Where:

Y is the dependent variable (e.g., port productivity), X is the independent variable (e.g., dredging depth of the entrance channel).

β_0 is the intercept, which represents the value of Y when X is zero, β_1 is the slope coefficient, which represents the change in Y for a one-unit change in X.

ϵ is the error term, representing the difference between the observed and predicted values of Y.

The goal of linear regression is to estimate the values of β_0 and β_1 that minimize the sum of squared residuals (the vertical distances between the observed and predicted values of Y).

To estimate the values of β_0 and β_1 , we can use the method of ordinary least squares (OLS). The formulas for the OLS estimators of β_0 and β_1 are:

$$\beta_1 = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sum_{i=1}^n (X_i - \bar{X})^2}$$

$$\beta_0 = \bar{Y} - \beta_1 \bar{X}$$

Where:

β_1 is the estimated slope coefficient.

β_0 is the estimated intercept.

\bar{X} and \bar{Y} are the means of the independent and dependent variables, respectively.

n is the number of observations.

Table 1 Attributes Related to Port Productivity

Attributes	Coef.	Std. dev.
Increases port productivity	4.436***	0.345

Reduction of pre-berthing waiting time	2.045*	0.561
Increases berth availability	1.436**	0.241
Enhanced vessel turnaround time	3.231***	0.119
Reduction of ship congestion	1.789*	0.345

Dependent variable: Port Productivity where ***, **, * indicates significantly

Table 1 presents an analysis of the effects of dredging the entrance channel on various attributes related to port productivity. Each attribute is accompanied by a coefficient (Coef.) and its corresponding standard deviation (Std. dev.). The asterisks (***, **, *) indicate the level of significance, with more asterisks denoting higher significance. The dependent variable for this analysis is port productivity.

The coefficients reveal the estimated impact of dredging the entrance channel on different aspects of port operations. Firstly, the coefficient of 4.436 with three asterisks indicates a highly significant positive effect on "Increases port productivity." This suggests that enhancing the entrance channel through dredging is associated with a substantial increase in overall port productivity. Similarly, the coefficient of 2.045 with one asterisk for "Reduction of pre-berthing waiting time" indicates a significant positive impact. This implies that dredging helps in reducing the time vessels spend waiting before berthing, thereby streamlining operations and enhancing efficiency.

Furthermore, the coefficients for "Increases berth availability," "Enhanced vessel turnaround time," and "Reduction of ship congestion" are also positive, indicating favorable effects of dredging on these attributes. The coefficients of 1.436, 3.231, and 1.789, respectively, are accompanied by asterisks, signifying their statistical significance. These results suggest that dredging the entrance channel leads to increased berth availability, faster vessel turnaround times, and reduced ship congestion, all contributing to improved port productivity.

However, it's important to consider the standard deviations accompanying each coefficient, as they indicate the variability or uncertainty associated with the estimates. Despite the significance of the coefficients, the standard deviations remind us to interpret the results with caution and consider other factors that may influence the observed effects.

The findings of this analysis underscore the positive impact of dredging the entrance channel on various attributes related to port productivity. Investing in dredging activities can lead to significant improvements in port operations, efficiency, and overall productivity, making it a crucial strategy for enhancing the competitiveness and performance of the port.

Table 2: Summary of Regression Variables

Variables	Mean	Std. Dev
Dredging of entrance channel	3.453	1.34
- Dredging Depth	2.098	0.984
- Widening the Channel	4.567	1.188
- Size of Vessels handled		
Efficiency Port Productivity	3.447	2.001
- Turnaround Time	2.134	1.903
- Vessel Waiting Time	1.305	0.345
- Berth Capacity	1.890	0.034
- Cargo Throughput		

Table 2 offers a concise overview of the mean values and variability of key regression variables related to dredging the entrance channel and efficiency port productivity, providing valuable information for assessing and analyzing port operations and performance. For the variables associated with dredging the entrance channel, the mean values indicate the average levels of each variable across the observed data points. With a mean value of 3.453, it suggests that, on average, the depth to which the entrance channel is dredged is moderate, likely sufficient for most vessels to navigate without significant restrictions. The mean value of 2.098 indicates that, on average, the entrance channel has been widened to a moderate extent, allowing for the passage of vessels of varying sizes, and with a mean value of 4.567, it suggests that, on average, the port is capable of handling relatively large vessels, indicating a substantial capacity to accommodate significant maritime traffic.

With a mean value of 3.447, it indicates that, on average, vessel turnaround times at the port are moderate, implying efficient port operations. Furthermore, the mean value of 2.134 suggests that, on average, vessels spend a moderate amount of time waiting at the port before being able to berth and commence port activities. With a mean value of 1.305, it indicates a moderate level of berth capacity, suggesting that the port has sufficient space for vessel docking and mooring and the mean value of 1.890 suggests a moderate level of cargo throughput, indicating the volume of cargo handled by the port within a specific timeframe. The standard deviation values for these efficiency port productivity variables provide insights into the variability of each aspect of port productivity. Lower standard deviations indicate less variability around the mean, suggesting greater consistency in port performance.

4.0 CONCLUSION

The findings on dredging the entrance channel and port productivity at Dar es Salaam provide valuable insights supported by empirical data. Respondents widely recognize the economic benefits of dredging activities, with a majority agreeing (78.8%) that it generates employment opportunities across various sectors. This data underscores the role of infrastructure projects in stimulating local economies, as evidenced by the positive perception of dredging's impact on job creation.

The findings also reveal strong opinions among respondents regarding the positive impact of improving the port entrance channel on overall port productivity. Data indicates that 92.2% of respondents agree or strongly agree that enhancing the entrance channel increases port efficiency. This agreement highlights the critical role of well-maintained infrastructure in optimizing operational efficiency and enhancing competitiveness in global trade markets.

There is a notable agreement among respondents regarding the relationship between the quality of the port entrance channel and trade facilitation with neighboring countries. Approximately 94.2% of respondents agree or strongly agree that the quality of the entrance channel enhances trade activities. This statistical evidence underscores the strategic importance of investing in port infrastructure to enhance regional connectivity and economic growth.

Furthermore, the findings highlight significant concerns regarding challenges faced in the dredging process. Data reveals that 69.2% of respondents agree or strongly agree that financial constraints hinder the dredging process, while 78.8% express concerns about poor government policy affecting project efficiency. These findings emphasize the need for supportive regulatory frameworks and adequate financial resources to overcome barriers to infrastructure development.

Also, the data underscores the importance of environmental and social considerations in dredging project implementation. Although there is some divergence in opinions, with 61.5% of respondents agreeing or strongly agreeing that environmental and social factors act as drawbacks, the majority recognize their significance. This data emphasizes the importance of adopting sustainable practices and engaging stakeholders to ensure the long-term viability of dredging projects while mitigating potential negative impacts on the environment and local communities.

Furthermore, the findings reveal strong opinions among respondents regarding the relationship between the quality of the port entrance channel and trade facilitation with neighboring countries. This emphasizes the strategic significance of investing in port infrastructure to enhance regional connectivity and stimulate economic growth. However, the data also highlights significant challenges faced in the dredging process, notably financial constraints and policy-related issues. Addressing these challenges requires collaborative efforts from policymakers, port authorities,

and stakeholders to ensure supportive regulatory frameworks and adequate financial resources for infrastructure development.

Additionally, the findings underscores the importance of environmental and social considerations in dredging project implementation. While there is some divergence in opinions, the majority of respondents recognize the significance of mitigating potential negative impacts on the environment and local communities. This emphasizes the need for sustainable practices, community engagement, and stakeholder consultation to ensure the long-term viability of infrastructure projects.

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