EDITORIAL NOTE

The present edition of the journal underscores its mission of advancing scholarly research that bridges theory, practice, and policy in maritime and coastal development. This issue brings together six diverse yet complementary manuscripts that engage with contemporary challenges in port operations, environmental sustainability, sustainable development goals, artisanal fisheries, and governance reforms, with implications across Africa and beyond.

The first manuscript investigates the moderating effect of artificial intelligence (AI) on the relationship between container terminal operations and service delivery responsiveness within Tanzania's ports. Drawing on systems theory and employing structural equation modelling, the study reveals that AI significantly strengthens the positive impact of operational efficiency on service responsiveness. The findings underscore the transformative potential of technology in advancing port performance and provide actionable insights for aligning national port policies with international best practices.

The second manuscript focuses on the sustainable development of the blue economy through environmental stewardship and its alignment with the Sustainable Development Goals (SDGs). By analyzing global conventions such as UNCLOS, CBD, and MARPOL alongside national environmental policies, the study highlights how governance frameworks influence climate action, marine biodiversity, and responsible consumption. Through a mixed-methods approach involving document review, interviews, and surveys, the paper emphasizes community engagement as central to advancing sustainability within coastal economies.

The third contribution examines the role of Green Human Resource Management (GHRM) practices in achieving the SDGs within Ghana's hospitality industry, particularly in coastal establishments. Using Smart PLS-SEM analysis, the study finds that while most green HR practices show limited statistical significance, green performance management and appraisal strongly drive environmental accountability. The paper offers a pathway for hospitality organizations to integrate sustainability into their workforce practices, thereby contributing to the broader blue economy agenda.

The fourth manuscript addresses the sustainability of artisanal fisheries in Tanzania, a sector critical to food security and livelihoods. Based on cross-sectional data from 500 fishers across five coastal districts, the study identifies persistent challenges such as overfishing, weak enforcement of regulations, inadequate infrastructure, and declining fish stocks. The findings call for policy reforms, capacity building, and participatory governance models to ensure artisanal fisheries contribute effectively to sustainable coastal development and regional blue economy strategies.

The fifth manuscript analyzes the synergy between port policies, infrastructure development, and leadership commitment in improving operational performance at Ghana's major seaports. Grounded in the resource-based view and tested through SEM, the findings confirm that leadership commitment exerts the strongest influence on key performance indicators, while amplifying the benefits of sound policy and infrastructure investment. The study provides actionable guidance for port authorities, managers, and policymakers seeking to enhance competitiveness and efficiency.

The final paper explores renewable energy integration in Ghana's blue economy, evaluating technologies such as offshore wind, solar, and tidal systems for fisheries, ports, and coastal tourism. Combining quantitative energy-use assessments with qualitative interviews, the research identifies cost-effective and scalable models to reduce emissions and improve operational sustainability. Policy recommendations advocate for financial incentives, regulatory reform, public-private partnerships, and investment in local expertise to accelerate the transition toward cleaner energy systems aligned with global climate commitments.

Collectively, these papers contribute to a deeper understanding of how technological innovation, governance, environmental ethics, and strategic policy reforms shape the future of Africa's maritime and blue economy sectors. They offer valuable insights for policymakers, practitioners, and scholars committed to advancing sustainable development, operational excellence, and inclusive growth across coastal and marine systems.

AI EFFECT ON CONTAINER TERMINAL OPERATIONS AND RESPONSIVENESS: EXPERIENCE FROM TANZANIA PORTS

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Abstract

Purpose: This study examined the moderating effect of artificial intelligence (AI) on links between container terminal operations and responsiveness of service delivery as constructs based on the empirical evidence drawn from Tanzania's port operations. Design/methodology/approach: Data came from structured questionnaires administered to 349 port stakeholders drawn from a population of 2,222 agents based in four selected Tanzania ports using simple random sampling. The sample size is 21 more respondents or 6.4 percent above the originally projected sample of 328, hence further enriching the quality of the study. The resultant data enabled hypotheses testing using Structural Equation Modelling (SEM) through Smart PLS 4.0 and SPSS version 27. Employing a positivist philosophy and deductive approach coupled with an explanatory design and quantitative method, the study used the Systems Theory (ST) to operationalize the interactions of the three constructs. The study proceeded from the assumption that there has been no extensive research model that had hitherto compounded the joint effects of this triad of constructs. The results indicate that container terminal operations have a significant positive impact on the responsiveness of TPA services' delivery with the moderated relationship of AI accounting for higher positive significant effects. Moreover, the Importance-Performance Matrix Analysis (IPMA) results indicate that container terminal operations have the highest levels of both importance and performance in predicting TPA's responsiveness. As the study provides strong empirical evidence confirming that container terminal operations positively influence TPA's responsiveness. Additionally, the study expands the ST dimensions. The results shed light on potential areas for further improvement by Tanzania Ports Authority and other Stakeholders from both public and private sectors to enhance TPA's responsiveness. Also, the study findings have implications for relevant policies including The Ports Act 2004, National Transport and Trade Policies of 2003, and the Agenda 2063 The Africa We Want which need further streamlining to be in sync with the demands of modern port operations. This research has identified dimensions of container terminal operations and determined the moderating effects of AI in addition to examining their impacts on TPA's responsiveness.

Keywords: container terminal operations, responsiveness, port service delivery, and supply chain.

1.0 INTRODUCTION

Ports serve as vital nodes in the maritime shipping network and significantly contribute to the development of the multimodal transportation system (Pallis et al., 2011). Transportation systems and other technological innovations such as artificial intelligence (AI) and automation provide numerous opportunities that optimise processes, generate new business, and link effectively with global logistics and supply chains (Tsvetkova et al., 2021). In recent times, AI has gained popularity and relevance while presenting immense potential for transforming a wide range of sectors (Nagarajan et al., 2023). In fact, the consequent drastic changes in port operations in the twenty-first century have inevitably affected global logistics and services

(Bassan, 2007). For international trade, transport services at port terminals including containers, efficient operations are essential (Ahmad et al., 2021). Some 50 years ago, containers entered the global maritime freight business as comparatively homogeneous boxes that facilitate quick and simple handling of cargo (Kara, 2016). These containers account for the hauling of a considerable and increasing proportion of about 35 percent of the total volumes and more than 60 percent of commercial value (WorldBank, 2024). Sea ports handle over 75 percent of the global trade and thanks to the economy of scale favouring maritime transport the rapid growth continues unabated (Ghazaleh, 2023). Apart from being effective at loading and unloading cargo, containers also facilitate scheduling and control essential in managing and offering weather and theft protection while enabling ports to serve as trans-shipment, distribution, and logistics hubs (Uzun, 2021; Zehendner, 2013).

Furthermore, the emergence of containerization has introduced significant changes regarding how and where goods are manufactured and processed, a trend set to continue with digitalization (World Bank, 2024). In fact, a combination of increased digitalization, new technologies, and the willingness of the industry to work collectively toward systemwide improvements now provides the capacity and opportunity to measure and compare container port performance robustly and reliably (World Bank, 2022). Also, the latest review of Maritime Transport highlights the poor performance of ports in southern Africa relative to other regions in the world (World Bank, 2022). Similarly, the World Bank's Container Port Performance Index ranked Dar es Salaam port of Tanzania at the 361st position out of 370 ports worldwide with other African ports such as Durban, Cape Town, Maputo, and Mombasa located further down the bottom of the list (World Bank, 2021).

In essence, the port performance in Tanzania including operations and service delivery has remained a rather neglected issue and, consequently, a lacuna for assessing how the TPA's performance can evolve in the face of a shift in national leadership has remained (Bassan, 2007; Issa & Masanja, 2022; Mwisila & Ngaruko, 2018). Moreover, studies on the significance of efficiency and innovation in attaining sustainable performance are pivotal (Issa & Masanja, 2022). Even though Tanzania is one of the least developed countries, its ports serve many land-locked countries through its numerous sea and lake ports (Bigg & Dodds, 2019; Issa & Masanja, 2022). The market share analysis for Tanzania and Kenya ports in East Africa for the 2017 – 2013 period shows that the average percentages of incoming cargo traffic from Burundi, Rwanda, the Democratic Republic of the Congo, and Uganda,
53.4 ,77.2 ,88 ,97.92, and 2.8 and 46.6 ,22.8 ,12 ,2.08 and 97.2 went through Tanzania and Kenya ports, respectively. Such market share and huge potentials amidst competition and future dynamic demand in the port industry signal the necessity to probe factors for enhancing the responsiveness of TPA service delivery to retain the existing and attract new customers through container terminal operations and examine the moderating effects of the AI on container terminal operations and how responsively TPA can provide services.

Empirical evidence on the relationships among study variables enhanced knowledge of and understanding at the local level. Container terminal operations and the responsiveness of TPA's service delivery happen to be competitive factors in setting port improvement priorities and strategies. The Important-Performance Map Analysis (IPMA) for Tanzania ports has been developed based on the study findings through variables and established relationships for management consideration. In this regard, the study objectives have addressed, firstly, the Ports Act 2004 No 17 on page 12 about port promotion and, secondly, the mission of the National Transport Policy of 2003 (Tanzania, 2003), and the vision of the National Trade Policy for a Competitive Economy of 2003 (Viwanda, 2003).

2.0 LITERATURE REVIEW

Theoretical Literature Review

To address its objectives, the study was informed by the Systems Theory (ST): Systems Theory (ST)

Building on Von Bertalanffy (1951), Ashby (1956) further developed the system theory aimed to explain all systems in all fields of science by exploring interdependencies of relationships for managing complex entities. A system comprises frequently interrelating groups of activities and parts that form the subsequent whole entailing the exchange of input or output through processes linking subsystems mediated by the transfer of resources including decisions, support, and responsibility for four universal function aspects—adaptation, goal-attainment, integration and pattern maintenance. The following review covers studies that applied ST to inform the investigation the three (3) variables of this study:

Relationship between ST and container terminal operations

The utility of the container terminal has become quite remarkable all over the world, according to Mazouz et al. (2017). The study focused on optimising the staging of containers in a terminal gate system using a port within China. The analysis concluded that both the facility and the terminal gate applied the systems theory to make daily operation suited for the container terminal. Also, Nayak et al.›s (2024) study developed a unified port performance index (PPI) that considered container cargo among other haulage categories and the multi-dimensional nature of port performance indicators. The study used secondary data for 12 major Indian ports on five significant dimensions including container terminal operations. The results further affirm that the container terminal operations have a positive and significant impact on port financial performance. Furthermore, Kuo and Chen (2021), who examined the extent to which lean management practices could improve operational performance with the application of System Theory in Taiwan, associated the operational performance of the container terminal with business performance and affects the container shipping companies. The study had generated data from 212 respondents. The study had assessed the relationships between lean policy, lean practices, operational performance, and business performance in the context of container shipping.

Relationship between ST and AI

Yu et al.›s (2023) study found that the application of AI at the workplace to be on a steady rise. To enhance advancement, the study developed the antecedents of AI to capture the essence and consequences of its adoption for the workplace with ST application. The study concluded that AI adoption at the workplace would enable managers and practitioners to develop effective AI adoption strategies and achieve a competitive advantage for organisations. In this regard, Lima and Custodio›s (2004) study assessed the creation of efficient AI models without compromising environmental issues in line with the ST application. Its objective was to develop a tool for planning and performing task control execution in a distributed environment. The successful creation of efficient AI models can materialise without compromising environmental issues including planning and performing task control execution, concluded the study.

Relationship between ST and service delivery responsiveness

Israel (2023), who examined the mediating effect of an integrated health commodities procurement system on the relationship between responsiveness and health service delivery, collected data from 274 respondents employed in the28 government hospitals of six regions in the Southern Highlands of Tanzania. After confirmatory factor analysis (CFA) and structural equation modelling (SEM), the results revealed a positive relationship between responsiveness and service delivery with the ST application.

Empirical Literature Review

Container terminal operations and responsiveness of TPA's service delivery

In a global context, seaports—as centres for trade activities—contribute to strengthening the development of the multimodal transportation system by boosting cargo networks (Weerasinghe et al., 2023). International transportation draws special attention to competitive factors such as quality and spectrum services provided, the port's capacity to manage large cargo volumes promptly, and cost and efficiency (Rana, 2019). Moreover, hubs and transhipment terminals continuously improve their network to fulfil new roles in global supply chains due to the tremendous growth of containerised cargo at main transportation routes (Rana, 2019). Containers are relatively uniform boxes that allow for easy, fast handling of freight; moreover, they are strong enough for repeated use, and they are usually stackable and fitted with devices for transfer between modes (Jonker et al., 2021). Besides efficient discharging and loading processes, these containers also simplify scheduling and controlling cargo in addition to serving as protection against ravages of weather and pilferage (Zehendner, 2013). Recently, the connection of a container terminal to its hinterland gained significance, with terminals offering short and reliable delivery times having an advantage over their competitors (Notteboom & Rodrigue, 2008). The study treated these container terminal operations as contributing factors to the responsiveness of port service delivery, hence the generation of the following hypothesis:

H1: Container terminal operations positively influence the responsiveness of TPA's service delivery

Artificial intelligence, operations, and responsiveness of service delivery The application of artificial intelligence (AI) technology has evolved into an influential endeavour in improving port performance, but little research has considered the relationship among AI capability (Chen et al., 2022). Industries including the port sector seek opportunities for integrating AI methods with traditional approaches, the concepts and technologies of the Internet of Things (IoT), and cyber-physical systems to convert real-time data into actionable decisions (Chen et al., 2022; Munim et al., 2020). In fact, AI is a crucial component of data-driven decision-making in the port industry, which is one of the oldest and most traditional industries that still rely more on intuition than on data due to the vast size of network and planning problems (Munim et al., 2020). The application of AI affects the relationship between terminal operations and responsiveness of service delivery. As such, we hypothesise:

H2: Artificial intelligence moderates the relationship between container terminal operations and responsiveness of TPA's service delivery.

3.0 METHODOLOGY

This study adopted a positivist philosophical stance to relate the natural scientist stance with an observable social reality in a bid to produce law-like generalizations (Saunders, 2019), and deductive reasoning for the study's hypotheses and observable consequences that should have occurred with new empirical data if the hypotheses were found to be true (Antwi & Kasim, 2015). Moreover, the study applied an explanatory design to explore a new universe based on the variables, relationships, and associated objectives, which had hitherto not been studied earlier in terms of causes and reasons/factors behind some phenomenon related to study variables (Megel & Heermann, 1993). Also, the study applied the quantitative method to determine and support what is embedded in the positivism paradigm that focuses on fresh data (Rahi, 2017). Also, it integrates deductive, objective, and generalized purposes and procedures (Morgan, 2014). Furthermore, the study applied the Krejcie and Morgan›s (1970) formula, which Januszyk et al. (2011) and Minani (2019) had already applied as precedent, to a population of 2,222 to obtain a representative sample of n = 328.

3.1 Sample Selection, Unit of Analysis and Inquiry

The projected sample size—after applying Krejcie and Morgan›s (1970) formula— amounted to 328 port customers; however, due to extraordinary turnup, the size was expanded to 349 to include other key responders drawn from Other Government Departments and Tanzania Ports Authority. The sample covered five regions under review selected using simple random sampling, which had given everyone a fair chance of being drafted into the sample (Creswell, 2014). The participation of several stakeholder groups made the study present a more comprehensive analysis of the research issue (Kovacs & Moshtari, 2019). Clearing and Forwarding Agency Company (employer) were the study's unit of analysis and staff members (employees) of the firm who had adequate information about the Tanzania Ports Authority (TPA) services were the units of inquiry.

The study used a self-administered two-part questionnaire to collect data. The first part gathered the respondents' demographic information alongside the company profile whereas the second part contained -7point Likert-scale type statements with measures ranging from 'Strongly agree' to 'Strongly disagree'. Techniques to address the common method bias included reverse coding of the variable values applied in the questionnaire during data entry and the application of the -7point Likert scale for independent and dependent variables instead of the -5 or three -3point scale. The reliability of the responses on the former scale is better than on the latter lower scales owing to the construct defining items on the scale (Joshi et al., 2015).

4.0 RESULTS AND DISCUSSION

Respondents' Profile

The study generated data from an expanded size of 349 due to an extraordinary turnout beyond the expected 328 questionnaires distributed in the five regional ports under review, hence a response rate of 106.4 percent. The gender split of the final sample was

87.1 percent male and 12.9 percent female. The mean age of the sample was 35.5 years. The sample comprised 49.6 percent of respondents with University degrees, 27.2 percent with secondary school certificates, 20.92 percent with College certificates, 1.4 percent with nonformal education, and 0.88 percent with primary-level education. The majority (%40.7) had a mean work experience of five years.

Assessment of the Measurement Model

The assessment of the measurement model conducted by composite reliability, Cronbach alpha, rho_A, AVE, and HTMT yielded the following results:

Table 1: Measures of Construct Validity and Reliability

	Composite Reliability	Cronbach Alpha	rho_A	Average Variance	HTMT (HTMT < 1)		Decision
					AI	CO	
	(>0.7)	(>0.7)		Extracted (>0.5)			
AI	0.914	0.874	0.876	0.726			Good
CO	0.928	0.905	0.910	0.682	0.932CI0.95 [0.714;0.982]		Good
DR	0.910	0.874	0.884	0.671	0.876CI0.95 [0.722;0.954]	0.884CI0.95 [0.737;0.928]	Good

Source: Field Data (2024)

The results presented in Table 1 show that exogenous latent variables have good measures of validity and reliability for all the variables, including the endogenous variable, PCS.

Assessment of Common Method Bias

The CMV subjected to a simple Collinearity Test using VIF showed that all the constructs had variance inflated factor (VIF) values of less than the proposed threshold of 5. As such, CMV posed no threat.

Assessment of model's predictive power (PLSPredict) (out-of-sample)

The assessment of the model's predictive power found the RMSE of LM (i.e. prediction) to be greater than that of PLS-SEM (i.e. actual) in DR1, DR2, DR3, and DR4, implying lower prediction error. Also, the values of Q^2_predict in the four indicators of the endogenous variable are above 0, between 0.367 and 0.615 meaning a lower prediction error. As such, the model has higher predictive power.

Direct and Final Measurement Models

Figures 1 and 2 presents the direct and final measurement models and, significantly, with the indicator loadings that satisfied the criterion as indicated:

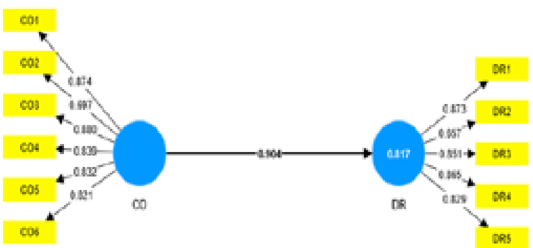


Figure 1: Direct Measurement Model.

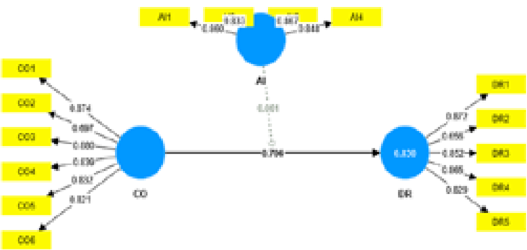


Figure 2: Moderated Measurement Model.

Evaluation Results of the Structural Model

The measuring of the VIF values indicates that both independent variables of 1.552, which are acceptable level of collinearity, hence the structural model has no collinearity issues. Also, the path coefficient value of 0.904 indicates a strong positive relationship, which explains a 90.4 percent increase in DR. Impliedly, if the CO construct increases by one standard deviation unit, the DR construct would increase by 0.904 standard deviation unit, assuming all other independent constructs remain constant. The result of the coefficient of determination of R2 stood at 0.817 for the direct model, which explains that an 81.7 percent change in DR can be accounted for one (1) exogenous construct. Also, the effect size of f2 yielded 0.716, which translates into a large effect size on R2. The measuring of the predictive relevance of Q2 produced a value of 0.542. Thus, the model has predictive relevance.

Model assessment

The structural model results reveal a significant relationship between CO and DR. In this regard, the study measured the direct model. The coefficient of determination of the R2 value was 0.817, implying that an 81.7 percent change in DR can account for two (2) exogenous constructs as follows:

Direct effect of container terminal operations on TPA service delivery responsiveness

The first hypothesis, H1 states that container terminal operations positively influence the responsiveness of TPA's service delivery. The study results indicate that CO has a significant impact on DR (β = 0.904, t = 50.202), i.e. one unit increase of CO raises DR by a path coefficient of 90.4 percent, ceteris Paribas (Hair et al., 2017). Also, the confidence intervals [0.933 ;0.862] do not include 0, indicating the existence of a direct effect (Hair et al., 2017). Furthermore, the t-value of 50.202 is above the critical value for the z-test of 1.645. These results support and validate H1.

Moderation analysis results

The measurement of moderated model reveals that the coefficient of determination of R2 value improved from 0.817 to 0.830, hence an 83.0 percent change in DR for the two
(2) exogenous constructs.

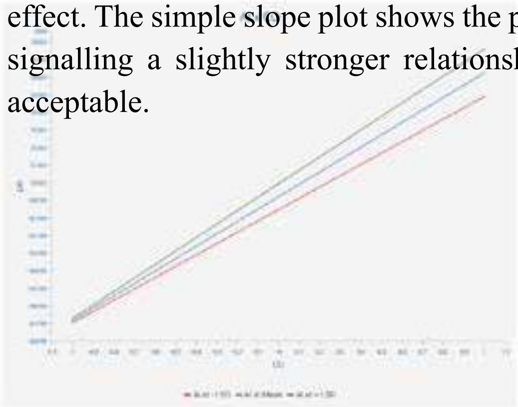
Effect of AI and container terminal operations on TPA service delivery responsiveness The second hypothesis, H2 states that the higher (lower) the artificial intelligence, the weaker (stronger) the influence of container terminal operations on the responsiveness of TPA's service delivery. The results indicate that AI*CO has a significant bearing on DR (β
= 0.061, t = 3.014). Implicitly, if one unit increases (or conversely decreases) of the artificial intelligence, then the influence of container terminal operations and responsiveness of TPA's service delivery increases (or decreases) based on the size of the path coefficient (%6.1), ceteris Paribas (Hair et al., 2017). In other words, there is a weakening or reduction of the t-value from 50.202 to 3.014, which nevertheless remains above the critical value for the z-test of 1.645. These results, therefore, support and validate H2 .

Simple Slope Analysis

A typical moderator analysis results in representation using simple slope plots (Hair et al., 2021). This study has one simple slope plot delineated in Figure 3.

Moderation effect of simple slope analysis between CO, AI, and DR

The relationship between CO and DR is positive. Hence, lower levels of CO represent lower levels of DR. The upper line (in green), which represents a higher level of the moderator AI with standard deviation above the mean, has a steeper slope, hence representing a weaker positive effect. Also, the bottom line (in red), which represents a lower level of moderator AI with a standard deviation below the mean, has a flatter slope, thus depicting a stronger positive effect. The simple slope plot shows the positive interaction terms that enhance AI levels, hence signalling a slightly stronger relationship between CO and DR and vice-versa, which are acceptable.



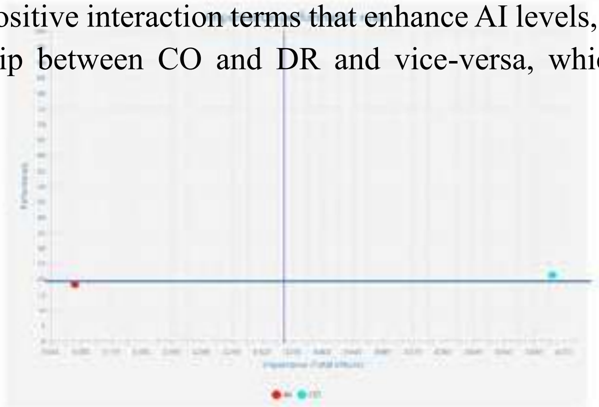


Figure 3: Moderated Effect of Simple Slope Figure 4: Importance–Performance Map Analysis.
Analysis.

Importance-Performance Map Analysis (IPMA)

Ringle and Sarstedt (2016) contend that multiple moderators in a total or moderated effect complicate the interpretation of IMPA's importance dimension. As such, it is advisable to exclude moderators in an IPMA (Hair et al., 2017; Ringle & Sarstedt, 2016). This study conducted IPMA using Smart PLS, with the results based on the total effect of one exogenous variable (CO) on the endogenous variable (DR). The findings confirm that CO, the exogenous variable, has high levels of importance and performance in Quadrant I with 'Concentrate Here' status as in Figure 4.

5.0 CONCLUSION, IMPLICATIONS, AND RECOMMENDATIONS

Effect of container terminal operations on PTAservice deliveryresponsiveness To begin with, the study findings uphold hypothesis H1, by confirming that container terminal operations positively influence the responsiveness of TPA's service delivery. The findings provide empirical support to the ST, by showing that TPA service delivery the responsiveness, specifically its container terminal operations has a significant and positive relationship with the responsiveness of TPAs' service delivery. These findings are consistent with finding by Jonker et al. (2021), Kuo and Chen (2021), Mazouz et al. (2017), Notteboom and Rodrigue (2008), Rana (2019), Weerasinghe et al. (2023), and Zehendner (2013), who have associated container terminal operations with some aspects of responsiveness of service delivery.

Moderating Effect of AI on Container Terminal Operations in service delivery responsiveness

The study findings also validate hypothesis H2 by ascertaining that artificial intelligence moderates the relationship between container terminal operations and the responsiveness of TPA's service delivery. Moreover, the study findings support the findings of Chen et al. (2022), Lima and Custodio (2004), (Munim et al., 2020); Yu et al. (2023), whose studies have associated container terminal operations and AI with some aspects of responsiveness of service delivery. Also, the study found all the measurements of the container terminal operations variable reliable and valid. Nevertheless, the container terminal should prioritise the following three operations: i) vessel tallying activities during discharge operations, ii) execution of container cargo transfer, and iii) receiving processes of container cargo at the yard and positioning prompt updates for enhancing TPA's service delivery responsiveness. Furthermore, application of AI in port operations should be enhanced to ensure: i) less frequent stoppages of Information Systems that affect port service delivery, ii) adequate tools for information and data gathering for data- driven decision-making, and iii) consistent running of information systems to let port users predict with certainty the time to be spent on cargo clearance to further boost TPA service delivery responsiveness.

Conclusion and Implications

Overall, the IPMA findings indicate that amongst the exogenous variables, the ones with high levels of importance and performance were CO and, subsequently, AI with the lowest performance measure among all. As such, the TPA Management ought to maintain the productive commitment, initiatives, and resources dedicated to CO. To further strengthen the TPA service delivery responsiveness, enforcing vessel tallying activities during discharge operations, execution of cargo transfer and receiving processes, and position updating in the container terminals are crucial. Moreover, terminal managers should ensure that the planning and distribution of equipment and technical resources are fully and effectively integrated at each stage of the cargo clearance processes and supply chain generally. After all, the TPA Ports Act 2004, No 17 aim to promote efficient seaport management and operations, ensure the provision of services related to the loading and unloading of cargo and passengers, and the provision of suitable and effective maritime and port services and facilities. The study findings further indicate that CO has significantly positive high levels of importance and performance in TPA service delivery responsiveness. Thus, corporate policymakers must check the container terminal operations policies and procedures to further enhance and optimise the potential of TPA's service delivery responsiveness. As such, policymakers should prioritise container terminal operations to enhance service delivery, which is currently not the norm in the TPA Ports Act objectives.

Recommendations for Future Studies

Even though this study found AI container terminal operations to positively influence TPA service delivery responsiveness, future studies could apply these variables in other terminals with different settings such as Ro-Ro and Oil Jetty for comparative purposes. Moreover, future studies could use other terminal operations attributes on TPA's service delivery responsiveness to bring more insight into the two interfaces. Also, collaborative research studies covering the same or similar objectives could be undertaken with other international ports and institutions for comparative analysis and experiences.

REFERENCES

Ahmad, R. W., Hasan, H., Jayaraman, R., Salah, K., & Omar, M. (2021). Blockchain applications and architectures for port operations and logistics management. Research in Transportation Business & Management, 100620 ,41. https://doi.org/https://doi.org/10.1016/j.rtbm.2021.100620

Antwi, S., & Kasim, H. (2015). Qualitative and Quantitative Research Paradigms in Business Research: A Philosophical Reflection. European Journal of Business and Management, 2839-2222 ,(3)7.

Ashby, W. R. (1956). An introduction to cybernetics (Vol. 35). J. Wiley.

Bassan, S. (2007). Evaluating seaport operation and capacity analysis - Preliminary methodology. Maritime Policy & Management, 19-3 ,34. https://doi.org/03088830601102725/10.1080

Bigg, T., & Dodds, F. (2019). The UN commission on sustainable development. In The Way Forward (pp. 36-15). Routledge.

Chen, D., Esperança, J. P., & Wang, S. (2022). The impact of artificial intelligence on firm performance: an application of the resource-based view to e-commerce firms. Frontiers in Psychology, 884830 ,13.

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications. https://books.google.co.tz/ books?id=PViMtOnJ 1 Lc C

Hair, Sarstedt, & Ringle. (2017). Partial Least Squares Structural Equation Modeling. In. https://doi.org/1-15_8-05542-319-3-978/10.1007

Hair, Sarstedt, & Ringle. (2021). Partial Least Squares Structural Equation Modeling. In Handbook of Market Research (pp. 47-1). https://doi.org/-05542-319-3-978/10.1007 2-15_8

Israel, B. (2023). Mediating effect of integrated health commodities procurement system on the relationship between responsiveness and health service delivery. International Journal of Health Governance, 298-284 ,(3)28.

Issa, F. H., & Masanja, E. P. (2022). Change for performance improvement in the Tanzania Ports Authority, a public sector organization in Tanzania. International Journal of Public Leadership, 354-337 ,(4)18. https://doi.org/10.1108/IJPL0061-2021-12-

Jonker, T., Duinkerken, M., Yorke-Smith, N., de Waal, A., & Negenborn, R. (2021). Coordinated optimization of equipment operations in a container terminal. Flexible Services and Manufacturing Journal, 311-281 ,33.

Joshi, Kale, Chandel, & Pal. (2015). Likert scale: Explored and explained. British journal of applied science & technology, 396 ,(4)7.

Kara, E. (2016). Analysis of accidents at the quayside operations in the Turkish port.

International Journal of Renewable Energy Technology, 5-1 ,(3)5.

Kovacs, G., & Moshtari, M. (2019). A roadmap for higher research quality in humanitarian operations: A methodological perspective. European Journal of Operational Research, 408-395 ,(2)276. https://www.sciencedirect.com/science/article/pii/S037722171830674X

Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities.

Kuo, S.-Y., & Chen, L.-B. (2021). Applying sociotechnical systems theory to examine the values of lean practices in the context of container shipping. IEEE Access, -146921 9 146937.

Lima, P. U., & Custodio, L. M. (2004). Artificial intelligence and systems theory: Applied to cooperative robots. International Journal of Advanced Robotic Systems, 15 ,(3)1.

Mazouz, A. K., Naji, L., & Lyu, Y. (2017). Container–terminal–gate–system optimization. Megel, M. E., & Heermann, J. A. (1993). Research design. Plast Surg Nurs, 210-209

,(4)13. Morgan, D. L. (2014). Integrating Qualitative and Quantitative Methods: A Pragmatic
Approach https://methods.sagepub.com/book/integrating-qualitative-and- quantitative-methods-a-pragmatic-approach

Munim, Z. H., Dushenko, M., Jimenez, V. J., Shakil, M. H., & Imset, M. (2020). Big data and artificial intelligence in the maritime industry: a bibliometric review and future research directions. Maritime Policy & Management, 597-577 ,(5)47.

Mwisila, L. P., & Ngaruko, D. D. P. (2018). Factors affecting Productivity of Container Terminals of Ports in Tanzania: Case of Dar es Salaam Port.

Nagarajan, G., Arunadevi, R., & Banu, R. (2023). Artificial Intelligence (Ai) In Banking Industry and Customers Perspective. Journal of Survey in Fisheries Sciences, 1596-1590.

Nayak, N., Pant, P., Sarmah, S. P., Jenamani, M., & Sinha, D. (2024). A novel Index-based quantification approach for port performance measurement: A case from Indian major ports. Maritime Policy & Management, 205-174 ,(2)51.

Notteboom, T., & Rodrigue, J.-P. (2008). Containerisation, Box Logistics and Global Supply Chains: The Integration of Ports and Liner Shipping Networks. Maritime Economics and Logistics, 174-152 ,10. https://doi.org/10.1057/palgrave.mel.9100196

Pallis, A. A., Vitsounis, T. K., De Langen, P. W., & Notteboom, T. E. (2011). Port economics, policy and management: Content classification and survey. Transport Reviews, 471-445 ,(4)31.

Rahi, S. (2017). Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. International Journal of Economics & Management Sciences, 5-1 ,(2)6.

Rana, K. (2019). Role of Port Managements in Global Shipping. In.

Ringle, C. M., & Sarstedt, M. (2016). Gain more insight from your PLS-SEM results. Industrial management & data systems, 1886-1865 ,(9)116. https://doi.org/10.1108/IMDS-10-0449-2015

Saunders. (2019). Research Methods for Business Students.

Tanzania, U. R. o. (2003). National Transport Policy. In: Ministry of Communications and Transport.

Tsvetkova, A., Gustafsson, M., & Wikström, K. (2021). Digitalizing maritime transport: digital innovation as a catalyzer of sustainable transformation. In A Modern Guide to the Digitalization of Infrastructure (pp. 148-123). Edward Elgar Publishing.

Uzun, A. (2021). DRY BULK AND GENERAL CARGO TERMINALS IN THE SUPPLY CHAIN: A DELPHI STUDY FOR ALIAGA Gül DENKTAŞ ŞAKAR1.

Viwanda, W. y. (2003). National Trade Policy Background Papers: Trade Policy for a Competitive Economy and Export-led Growth. Dar es Salaam University Press.

Von Bertalanffy, L. (1951). Problems of general system theory. Human biology, 302 ,(4)23. Weerasinghe, B. A., Perera, H. N., & Bai, X. (2023). Optimizing container terminal operations: a systematic review of operations research applications. Maritime Economics &
Logistics, 35-1.

WorldBank. (2022). The container port performance index 2021: A comparable assessment of container port performance.
WorldBank. (2024). Container Port Performance Index 2023. https://doi.org/10.13140/RG.2.2.16650.68806
Yu, X., Xu, S., & Ashton, M. (2023). Antecedents and outcomes of artificial intelligence adoption and application in the workplace: the socio-technical system theory perspective. Information Technology & People, 474-454 ,(1)36.
Zehendner, E. (2013). Operations management at container terminals using advanced information technologies Ecole Nationale Supérieure des Mines de Saint-Etienne].

Environmental Protection and Sustainability: Exploration for the Strategies of Environmental Stewardship and Community Engagement

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Abstract
The sustainable development of the blue economy is critical for preserving biodiversity, promoting economic growth, and ensuring human well-being. This study investigates how environmental stewardship aligns with key Sustainable Development Goals (SDGs), focusing on SDG 13 (Climate Action) and SDG 14 (Life Below Water), while also exploring its broader impact on SDG 8 (Decent Work and Economic Growth) and SDG 12 (Responsible Consumption and Production). Through an in-depth analysis of international agreements such as the United Nations Convention on the Law of the Sea (UNCLOS) 1982, the Convention on Biological Diversity (CBD) 1992, the OSPAR Convention 1992, the Barcelona Convention, and the Marine Pollution Convention (MARPOL) 1973 (Annexes I, IV, and VI), this research evaluates the effectiveness of these frameworks in supporting sustainable blue economy strategies. Additionally, national policies on fishing practices, pollution control, and habitat conservation are reviewed to assess their role in fostering environmental sustainability. This study adopts a mixed-method approach. A document review of key international conventions, policies, and strategies forms the foundation for evaluating global and national environmental governance. Data is further collected through interviews and questionnaires targeting coastal communities in Mtwara, Mbeya, Zanzibar, and Dar es Salaam, as well as maritime professionals, to capture insights on policy effectiveness and community involvement. The gathered data is subjected to qualitative content analysis to identify key themes, patterns, and relationships, providing a deeper understanding of policy implementation, governance effectiveness, and community engagement. The study aims to offer practical strategies for improving community participation in environmental stewardship and advancing sustainability within the blue economy, contributing to the global goals of sustainable development.
Keywords: Blue economy, SDGs, environmental stewardship, community engagement, sustainability, policy, governance, pollution control.

INTRODUCTION

The sustainability of blue economy is vital in many scopes. The world at whole depends on Ocean and water bodies to sustain the livelihood in the matter of economic, social and biodiversity. This makes a call upon humans to invade the strategies for Environmental

Stewardship basically the Blue Environments together with communities around coastal and lake shores to be engaged on the all strategies for environmental sustainability.
However, Sustainable practices on the context of Ocean, are not merely the responsibility of governments and organizations; they require the collective effort of individuals and communities. Engaging local populations in environmental decision-making fosters a sense of ownership and accountability, which can lead to more effective and everlasting outcomes. By examining case studies and current initiatives that exemplify successful community engagement in environmental protection and stewardship, this paper highlights innovative strategies for environmental stewardship and how the community can be engaged into those strategies so as to empower residents, promote resilience, and contribute to the creation of sustainable environment stewardship.

BACKGROUND

Environmental issues in Tanzania have been a challenge for a while. Around 1980s – 1990s We used to engage in environmental destruction, such as cutting down trees for cleaning purposes, as the community fought tsetse flies, collected firewood and charcoal for domestic use, and cut mangroves for building houses and making fishing boats. The villages and towns were not properly planned, resulting in poor sewage systems that led to the discharge of wastewater into the ocean and other water resources.
Environmental stewardship in the context of marine resources has evolved further with environmental movements that particularly focused on ocean environments. Several key events have taken place within these movements, such as Early Awareness (early 1900s), marine conservation movements in the mid-20th century (1950s-60s), international focus on oceans (1970s-1980s), and Sustainable Development. Several policies have been formulated to ensure the sustainable use of the ocean, such as the MARPOL Convention, 1973 and the OSPAR Convention. Along with the Sustainable Development Goals, these have been established to guide future efforts.

MAIN OBJECTIVES

The objective of this study focused on exploring the strategies for environmental stewardship and how those strategies can be devoted to the community engagement.
The specific objectives typically include strategies for environmental stewardship; presenting the reliable, innovative strategies for the environmental stewardship to ensure the sustainable use and sustainable life for the marine environments and water bodies. Approaches for community engagement for environmental stewardship; presenting approaches that show how the community can be engaged in Marine environmental stewardship.

LITERATURE REVIEW

In spite of having different Maritime Conventions the matter of Environmental protection still a crucial issue. This is because all policies and conventions are including more marine professionals and stakeholders while the communities are not exactly directed to the implementation of such policies and conventions and goals.
Strategies for environmental stewardship Especially in Tanzania has highly based on protecting the Land environments where by all Strategies and community engagement has focused on land protection mostly.

Communities are seen as the lowest implementers of the policies and conventions while involving local communities in decision-making processes regarding marine resource management. Lack of trainings and capacity-building programs which can help enhance their skills in sustainable practices has led to the partial participation of community in the implementation of the imposed policies.

METHODOLOGY

Data on this study were collected through mixed-method approach where by it involved:

Documents review on the international conventions, policies and strategies for Environmental Governance.

Document review is referred as process of collecting relevant documents, analyzing them, and extracting information that adds to understanding of the research topic (Harry F. Wolcott, 1994). In this paper document review approach was applied so as to provide deep background information and offers the valuable data that has been helpful in the completion of this paper. This method therefore, involved the selection of Documents where by the selected documents were adhere to meet the information that were needed due the accessibility and credibility. The Documents selected were Maritime Conventions, SDG 2015 and books.

Questionnaires

Questionnaire is one of the most commonly used methods for collecting data in both quantitative and mixed-methods research (John W. Creswell 2014). In this paper Questionnaires used as the tool to collect primary information from the targeted coastal communities from different regions Mtwara, Mbeya and Zanzibar and marine professionals. The Questions provided were open questions where by individual were given the opportunities to express themselves.

Interviews targeted to coastal communities in Mtwara, Zanzibar, Mbeya and Marine professionals.

Interviews also were applied to get more secondary information from targeted coastal communities in Mtwara, Mbeya and Zanzibar, together with the Marine professionals

DISCUSSION

This part represents the all findings including the interpretation and explanation, comparison, implications of the study done.

INTERPRETATION OF THE FINDINGS

The problem is due to the increase of population along coastal areas has led to the unsustainable use of water resources which threatens the ocean ecosystem. For instance, overfishing where by 70% of the world’s fish stock has already been exploited which is beyond the sustainable boundary.

Cumulative impacts of land-based activities; the study finds that land based human activities are sources of environmental destructions for instance the destruction of wetlands, mangrove damages, damage of watersheds and impounding of water supplies to support development activities in coastal and lake shore areas such as constructions and recreational places

People consider ocean as the ultimate sink for discharges of waste of all kinds; communities and buildings especially hotels along the coastal areas tends to empty their septic and discharge all sewages wastes to the sea, the wastes carry microbes like Coliforms which are harmful to human and fish. When accumulated at large number in fish tissues coliforms cause diseases such as CHOLERA when the fishes doesn't well cooked (McGeorge, H. D. (1998). Spillage of the oil, transport of hazardous wastes, and nuclear test.

Poor urban and village planning that allows the building of big hotels and industries along the coastal areas; findings reveal poor urban and villages planning disrupts marine habitat like mangroves, coral reefs, and sea grass, which serve as vital breeding grounds for marine ecosystem.

Lack of environmental education to the communities along the lake shores and coastal areas; the findings reveal that many communities live along the coastal areas and lake shore has no education on how to accumulate water resources sustainably, local fisher men still use wrong fishing tools like dynamites, uses wrong size of fishing nets which led to the exploiting of small fishes, destruction of mangroves for building boats and houses.

Lack of awareness concerning with the marine environmental conservations;

In spite the efforts and initiatives the world has taken such as having the world Ocean Day which is celebrated every year, establishment of different maritime conventions, environmental campaigns and documentaries. Communities seem not to be aware and taking it seriously for their roles on protecting and conserving marine environments. The policies, campaigns and documentaries are barely understandable to the communities which are the primary implementers in maintaining and protecting environments the communities are not aware of toxic pollutions, effluents discharge management. All strategies, Goals and conventions are understandable only to marine professionals and environmental experts only.

RECOMENDATIONS

This study has found out the environmental stewardship in the context of includes different stakeholders from the national level to the community level . The findings has come up with the following Approaches to be implemented by the Nation and the community.

The inclusion of marine environmental issues in school curriculum Children have to learn about the marine environmental issues from the early age from primary school level of education to secondary. This will ease the understanding of environmental issues in communities since it will reflect what they have learn from school to the society.

The Inclusion of community engagement in legislation

The legislation in protecting marine environment should address the communities and recognize the communities as the prior pioneers to sustainable environmental practice. The legislation also should include the penalties and fines that will be charged to whoever caught destructing marine environments.

Engaging the community in proper village and town planning Community has to be engaged in planning of village and towns, thus will help more to create a sense of ownership and responsibilities to the community and hence will enable them to be fully responsible for environmental protection and conservation.

Creating awareness to the community

The findings show that majority of community is not aware on the importance of protecting Marine environments therefore, strategies like campaigns, use of community leaders to create awareness to the community they are leading, training and workshops, and participatory method on things that concerns with the marine environments.

Provision of Education to the community

For accomplishment of anything Education is highly needed so as to raise the further knowledge of something. The community has to be provided with education learning on the important of protecting and conserving the marine environments for the present and future generation. The community has to be educated about the climate change that will impact the marine environmental stewardship.

Engaging the community in technology advancements

Community needs a full engagement in the advancement and innovation of technology especially the management of waste the Use of effluent treatment plant. Like Fumba Town in Zanzibar, the Town is well planned along the sea shore and has been built with the effluent treatment plant which recycles all waste sewages and they are not discharged to the ocean.

Engaging the communities in Aqua Agriculture like planting of sea weeds and mangroves

Community has to be empowered and given the facilities to engage themselves in Aqua Agriculture not only for economic benefits but also for environmental protection and sustainability, This can be practically implemented IMO week 20th-25th September every year to raise awareness to the community

Preparation of National Blue economy road map identifying the respective areas that needs to be protected

The Maritime Authority should focus on Maritime environment protection

The Maritime Authority should be adhere for the protection of Maritime environments not only focusing on ships but also the communities along shore and coastal areas.

Establishment of projects to empower shore side communities

Projects like the provision of advanced fishing tools to the fishing communities as loans from the Government, this will help in banning the use of illegal tools for fishing activities. Also the Advanced fishing tools can be provided as the grants from Maritime stakeholders especially in Maritime days.

Establishment for Ships reception facilities

Ships reception facilities will help to receive the spent oil (dirty oil) from ships and recycling them to be useful again in running industries machine.

CONCLUSION

We depend on Environments, and Environment depends on us , we should take the Efforts to protect the environment for the future generations. The Development activities have to go hand in hand with the protection of our environments. The community has to look on Marine Environmental stewardship approaches with the open Eyes. Oceans carry wealth and sustainable development for the future in scope of Climate change, economic benefits and social life.

REFERENCES

Cambridge University Press. (1998). The ocean: Our future. Cambridge University Press.

Wolcott, H. F. (1994). Writing up qualitative research. Sage Publications.

McGeorge, H. D. (1998). Marine auxiliary machinery (7th Ed.). Butterworth- Heinemann

GREEN HRM PRACTICES AND SUSTAINABLE DEVELOPMENT GOALS IN THE HOSPITALITY INDUSTRY OF GHANA

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Abstract
This study explores the impact of Green Human Resource Management (GHRM) practices on achieving the Sustainable Development Goals (SDGs) within the hospitality industry of Ghana. Specifically, this study evaluated the impact of various GHRM practices (green recruitment and selection, green performance management and appraisal, green training and development, and green reward and compensation) on SDGs 6, 11, 12, and 14 and identified the challenges faced by hospitality organizations in achieving the SDGs in the hospitality industry with emphasis on the coastal establishments. The study population comprised 105 hospitality establishments within the coastal communities in Accra. A multi-stage sampling technique, which integrates convenience and lottery sampling was employed to select 105 respondents. The study employed a quantitative approach and adopted the explanatory research design. The data gathered was analysed using Smart PLS-SEM 4. The findings indicated that the relationship between green recruitment and selection, green reward and compensation, and green training and development on the SDGs are statistically insignificant. However, it is worth noting that the relationship between green performance management and appraisal and the SDGs is statistically significant in the hospitality industry of Ghana. The study concluded that to harness the potential of GHRM fully, the industry must adopt a holistic and transformative approach to recruitment and selection strategies that need to prioritize eco-conscious candidates and strengthen green employer branding, while reward systems must be realigned to incentivize and recognize contributions to environmental objectives. Training programs must move beyond superficial exercises to instil deep-seated sustainability values and proactive environmental behaviours among employees. The study recommends hospitality establishments highlight the effectiveness of green performance management and appraisal practices in driving progress toward SDGs 6, 11, 12, and 14, demonstrating that embedding environmental metrics into performance evaluations fosters accountability and aligns employee efforts with sustainability objectives. This success provides a model for leveraging GHRM practices to address critical environmental challenges toward the blue economy.

Keywords: *Environmental Sustainability, Green Human Resource Management, Hospitality Industry, Marine Ecosystem, and Sustainable Development Goals.*

Introduction

The hospitality industry in Ghana, as highlighted by the Ghana Statistical Service (GSS, 2022), has emerged as a dynamic and essential sector, significantly contributing to the country's economic growth and employment through its diverse offerings such as hotels, resorts, restaurants, and tourism services (Otoo, 2019). The GSS (2023) estimates that the industry contributes approximately 5.5% to Ghana's GDP, underscoring its critical role in the nation's economic landscape. However, despite these positive contributions, Mensah (2019) asserts that the sector faces numerous challenges that threaten its sustainability and environmental impact. For instance, a report by the Environmental Protection Agency (EPA) of Ghana, as noted by Milla-Amekor (2024), reveals that many hospitality establishments exhibit limited compliance with environmental regulations, resulting in issues such as poor waste management, high energy consumption, and water pollution.

The hospitality industry in Ghana, particularly in Accra, faces significant environmental challenges linked to rapid urbanization, population growth, and inadequate waste management infrastructure (Arthur et al., 2023; Hart, 2022). Inefficient waste collection and disposal practices, such as open dumping and burning, contribute to soil and water contamination, air pollution, and degraded ecosystems, including water bodies like the Sea, Korle Lagoon, and Odaw River (Anokye et al., 2024; Ntajal et al., 2022; Clottey et al., 2022). These issues are exacerbated during rainy seasons when clogged drainage systems lead to flooding, worsening sanitation conditions, and spreading waterborne diseases like cholera and dysentery (Owusu & Obour, 2021; Yeboah et al., 2024). This study integrates the resource-based view (RBV) and the theory of planned behaviour (TPB) to address these sustainability challenges. The RBV focuses on strategically managing internal resources, such as green-skilled employees, for competitive advantage, while the TPB explains how these resources can be motivated to exhibit behaviours that support organizational sustainability goals (Conner & Armitage, 1998; Madhani, 2010). This integration, particularly relevant to Ghana's hospitality sector, highlights how Green Human Resource Management (GHRM) practices can foster pro-environmental behaviours and align human capital with Sustainable Development Goals (SDGs). As underscored by Sakshi et al. (2020) and Legrand et al. (2022), the hospitality industry plays a critical role in addressing sustainability challenges due to its significant environmental impact. GHRM has emerged as a key strategy to integrate sustainability into workforce management, including practices like green recruitment, training, performance management, and reward systems (Roscoe et al., 2019; Joshi et al., 2023). By improving employees' skills, motivation, and opportunities to support sustainability, GHRM aligns operational efficiency with broader environmental goals (Molina-Azorin et al., 2021; Schroeder et al., 2019).

Green recruitment and selection are key elements of GHRM, focusing on hiring individuals with relevant skills who share a commitment to environmental sustainability (Jamil et al., 2023; Pham & Paillé, 2020). In Ghana’s resource-intensive hospitality industry, green recruitment aligns new hires with sustainability values, supporting Sustainable Development Goals through reduced carbon emissions and sustainable practices. Green performance management and appraisal systems are equally important, as they assess and enhance employee contributions to sustainability by using green performance indicators like waste reduction, energy efficiency, and resource conservation (Ardiza et al., 2021; Fernandez & Ganesan, 2023). These systems promote accountability and continuous improvement, driving initiatives aligning with the hospitality sector's SDGs. Green training and development equip employees with skills and knowledge to adopt eco-friendly behaviours, such as water conservation and energy-efficient operations (Yusoff, 2015; He & Zaman, 2024). These programs reduce ecological footprints and create a sustainability-focused culture that supports SDGs. Lastly, green reward and compensation strategies motivate employees by linking rewards to environmental performance and sustainable contributions (Ahmed et al., 2021; Pham et al., 2019). By recognizing and reinforcing eco-friendly behaviours, these strategies align personal and organizational goals, fostering a culture of sustainability and advancing sustainable development across multiple dimensions.

Efforts to address Accra’s environmental challenges have largely been ineffective due to inadequate funding, poor coordination, and limited community participation (Zhou et al., 2021; Oduro, 2019; Deku, 2020). Despite public education campaigns and the National

Sanitation Campaign, improper waste disposal methods like open dumping and burning persist, exacerbated by weak regulatory enforcement and insufficient infrastructure (Anokye et al., 2024; Mensah, 2019; Lartey et al., 2023). Private waste management companies have also struggled due to operational challenges, ineffective contracts, and inadequate recycling systems (Aning-Agyei, 2020; Seah et al., 2021). Achieving lasting environmental cleanliness in Accra requires coordinated efforts, enhanced GHRM practices, improved policy implementation, and community engagement (Debrah et al., 2022). The hospitality industry in Ghana, a significant contributor to economic growth and employment (GSS, 2022), faces challenges aligning with Sustainable Development Goals due to its environmental impact, including greenhouse gas emissions and unsustainable resource use (Geoffrey et al., 2021; Ali et al., 2021). While GHRM practices can help align industry operations with SDGs like clean energy and responsible consumption (Roscoe et al., 2019), only 30% of establishments have adopted sustainable practices, limiting the sector's contribution to sustainability (GTA, 2022). Moreover, over 60% of hospitality establishments fail to comply with waste disposal regulations, harming public health and ecosystems (EPA, 2022). The limited adoption of GHRM practices such as training employees in sustainable practices and incentivizing green behaviours further undermines progress (Suleman et al., 2022). Existing research highlights gaps in the literature on GHRM's role in fostering sustainability within Ghana's hospitality industry, emphasizing the need for focused studies to address the sector's unique environmental impacts and potential for sustainable development (Ali et al., 2021; Baffoe et al., 2021; Kissi et al., 2024).

Moreover, several studies from other geographical contexts, such as India (Mishra, 2017) and Pakistan (Ghani et al., 2024), employ methodologies like PLS-SEM and SWOT analysis, yet there is a need for more in-depth empirical research using a quantitative approach to capture the nuances of GHRM's impact on sustainability within the Ghanaian hospitality industry. Additionally, although prior research has examined the relationship between GHRM and SDGs broadly, few studies have explored this relationship through the lens of employee behaviour and organizational practices specific to the hospitality industry. This gap presents an opportunity to investigate the impact of GHRM practices on achieving the Sustainable Development Goals 6, (Clean Water and Sanitation), 11, (Sustainable Cities and Communities), 12, (Responsible Consumption and Production), and 14, (Life Below Water) within the Ghanaian hospitality industry along the coastal communities in Accra. Consequently, this study aims to evaluate the impact of various GHRM practices on SDGs while identifying the challenges and barriers faced by hospitality organizations in implementing GHRM practices in Ghana's hospitality sector.

Literature Review

Theoretical Review

The resource-based view (RBV) Theory, introduced by Jay Barney in 1991, highlights that an organization's competitive advantage stems from internal resources that are valuable, rare, inimitable, and non-substitutable (VRIN) (Chacha, 2010). These resources, including technology, infrastructure, skills, and organizational culture, significantly influence organizational performance and success (Rantanen, 2021). In Green Human Resource Management (GHRM), RBV underscores human resources as critical assets for driving sustainability initiatives (Jamil et al., 2023). Practices like green recruitment, training, and performance management align workforces with environmental sustainability, enabling organizations to achieve sustainability goals. However, RBV faces criticism for focusing primarily on internal resources while overlooking external factors such as market dynamics and competition. Despite this, RBV is pivotal in linking GHRM to Sustainable Development Goals (SDGs) by leveraging human capital for sustainable development. Furthermore, the theory of planned behaviour (TPB), developed by Icek Ajzen in 1985, explains individual actions through three components: attitude toward behaviour, subjective norms, and perceived behavioral control (Hagger, 2019). These elements shape behavioral intention, which predicts actual behaviour (Ajzen, 2011). Within GHRM, TPB demonstrates how green initiatives, such as training and performance management, influence employee attitudes and behaviours toward sustainability. These practices foster pro-environmental behaviours and enhance employees' perceptions of their ability to support environmental goals. Although TPB has been criticized for emphasizing intention over unconscious behaviours or external constraints, it remains a valuable tool for structuring GHRM practices to influence employee behaviours toward achieving sustainability objectives. The RBV and TPB theories complement each other by integrating internal resource management with employee behavioural perspectives (Madhani, 2010). RBV focuses on leveraging green-skilled employees for competitive advantage, while TPB explains how these employees can be motivated to exhibit behaviours supporting sustainability goals (Conner & Armitage, 1998). This integration is particularly relevant in Ghana's hospitality industry, where GHRM practices (RBV) and pro-environmental behaviours (TPB) can collectively advance SDGs. Together, these theories provide a strategic and behavioural framework for examining the impact of GHRM on sustainable development.

Conceptual Review

Concept of Green Human Resource Management Practices

According to Podgorodnichenko et al. (2020), modern organizations emphasize environmental protection alongside achieving success. Human resources play a vital role in embedding environmental initiatives within HR management processes, referred to as Green Human Resource Management (GHRM) (Molina-Azorin et al., 2021). This approach supports organizations in achieving environmental objectives and adhering to regulations. GHRM integrates environmental management principles into HR practices such as recruitment and selection, performance management and appraisal, training and development, and reward and compensation (Amjad et al., 2021). Green recruitment and selection focus on environmental awareness and criteria that attract eco-conscious candidates. Environmental training enhances employees' knowledge, skills, and proactive efforts in reducing waste and upholding environmental standards. Performance management and appraisal in this context involve aligning employee evaluation goals with green job descriptions. To motivate employees to meet environmental objectives, organizations align rewards and incentives with their green strategies. Additionally, empowering employees to engage in environmental activities strengthens their commitment to sustainability.

Adopting a holistic approach to GHRM practices is essential for achieving effective and long-term environmental sustainability. According to Anlesinya and Susomrith (2020), using a GHRM bundle rather than isolated practices enhances environmental performance. A comprehensive approach fosters a loop of positive environmental behaviours. For example, hiring environmentally conscious individuals enables targeted training on both job-specific tasks and broader environmental impacts. This knowledge can be applied collectively, reinforced through performance reviews, and rewarded to sustain green initiatives. Such integrated practices are particularly relevant in industries with significant environmental impacts, such as hospitality, and in economies prioritizing sustainability. HRM practices such as green recruitment and selection, training and development, performance management and appraisal, and reward and compensation remain foundational to supporting these green initiatives.

Green Recruitment and Selection

Recruitment refers to the process of attracting a large pool of candidates from which the most suitable individual can be chosen by an organization (Aliyu, 2021). To adopt a green approach in recruitment, organizations have two main strategies. First, organizations can design recruitment strategies aimed at attracting candidates who are knowledgeable about and concerned for the environment. Alternatively, organizations can position themselves as "green employers," appealing to individuals who value environmental protection. The most effective approach is to recruit talent committed to environmental causes in the long term. Additionally, HR departments can utilize electronic platforms to convey their green message and accept applications, reducing the environmental impact. Following recruitment, the selection process identifies the most suitable candidate for a specific role. A green selection process could include evaluating candidates based on their responses to environmentally focused questions, allowing the organization to assess their alignment with green objectives (Adjei-Bamfo et al., 2020). Additionally, minimizing the use of paper in selection tests is a simple yet effective way to integrate environmental considerations into the selection process.

Green Performance Management and Appraisal

Bayo-Moriones et al. (2020) posit that the performance management and appraisal aspect of HRM focuses on assessing how well individuals contribute to achieving organizational objectives. In the context of Green HRM, this involves evaluating an employee's contributions toward the organization's environmental goals. Some scholars suggest incorporating specific environmental performance criteria into appraisal systems to ensure these contributions are formally recognized (Hameed et al., 2020; Ren et al., 2021). To make this process effective, it is essential that employees are fully aware of the environmental standards being assessed and that appraisals are conducted fairly and transparently.

Green Training and Development

Training and development are crucial once an employee joins an organization. It becomes the organization's responsibility to invest in its workforce, aligning their growth with the organization's goals (Mahapatro, 2021). This commitment reflects how much the organization values the importance of training and development. Green training and development emphasize educating employees about eco-friendly practices, the significance of environmental management initiatives, and methods to reduce waste and conserve energy (Gull & Idrees, 2022). Such programs should aim to enhance employees' knowledge, skills, and abilities in addressing environmental challenges while fostering their sense of responsibility as global citizens. Additionally, HRM should prioritize cultivating a sustainable organizational culture to ensure lasting environmental and social impacts.

Green Reward and Compensation

Das et al. (2021) postulate that compensation is a critical and complex component of HRM, encompassing all forms of payment and benefits provided to employees in exchange for their work. Its primary purpose is to attract, retain, and motivate the workforce. In the context of Green HRM, organizations can integrate environmental goals into their compensation strategies by offering rewards tied to the achievement of green objectives identified during performance appraisals (Martins et al., 2021). For example, some companies recognize and incentivize environmentally responsible behaviours. Additionally, employees can be rewarded for obtaining green certifications or completing specialized training programs that align with the organization's sustainability goals.

The Role of Green HRM in Sustainable Development Goals

The study of sustainability within HRM emerged to address the growing demand for sustainable development. Roorda (2020) emphasises sustainable development as meeting current needs without hindering future generations' ability to meet theirs. Achieving sustainability requires a deep cultural and societal transformation that fosters new collective values and beliefs (Hammond, 2021). According to Wijaya and Mursitama (2023), Elkington's concept of the Triple Bottom Line emphasizes a balanced approach to sustainable development, urging businesses to consider social, environmental, and economic impacts. This approach reflects a paradigm shift that prioritizes social and environmental performance alongside economic growth. Green HRM evolved as a response to traditional HRM practices to focus on addressing environmental challenges.

In line with the transformative 2030 Agenda for Sustainable Development, the United Nations established 17 Sustainable Development Goals (SDGs) and 169 associated targets, providing a framework for actionable and collaborative solutions to global sustainability challenges. Six out of the seventeen SDGs are directly crafted to achieve environmental sustainability. These six SDGs (SDGs 6, 7, 11, 12, 13, and 14) focused on clean water and sanitation, affordable and clean energy, sustainable cities and communities, responsible consumption and production, climate action, and finally, life below water. Companies play a crucial role in achieving these goals, particularly SDG 6, 11, 12, and 14, which call for responsible consumption and production. This includes adopting sustainable practices and integrating sustainability into GHRM practices. Research highlights the critical role of HRM in tackling sustainability challenges, emphasizing the importance of employees as key agents of change (Podgorodnichenko et al., 2020; Podgorodnichenko et al., 2022). Unlike traditional HRM, Green HRM incorporates environmental management into all HRM functions and practices. By aligning HRM strategies with environmental objectives, employees can drive more sustainable production processes and product development, significantly contributing to achieving sustainable consumption and production patterns as outlined in SDG 6, 11, 12, and 14.

Hypotheses and Question

After an extensive review of existing scholarly works and the comprehensive theoretical framework, the following research hypotheses and question were posed to guide the study:

H_1: There is a significant positive relationship between green recruitment and selection and Sustainable Development Goals in the hospitality industry of Ghana.

H_2: There is a significant positive relationship between green performance management and appraisal and Sustainable Development Goals in the hospitality industry of Ghana.

H_3: There is a significant positive relationship between green training and development and Sustainable Development Goals in the hospitality industry of Ghana.

H_4: There is a significant positive relationship between green rewards and compensation and Sustainable Development Goals in the hospitality industry of Ghana.

1. What are the challenges and barriers faced by hospitality organizations in implementing Green Human Resource Management (GHRM) practices in Ghana’s hospitality sector?

Proposed Conceptual Framework

The figure below is the conceptual framework illustrating the impact of GHRM practices on SDG.

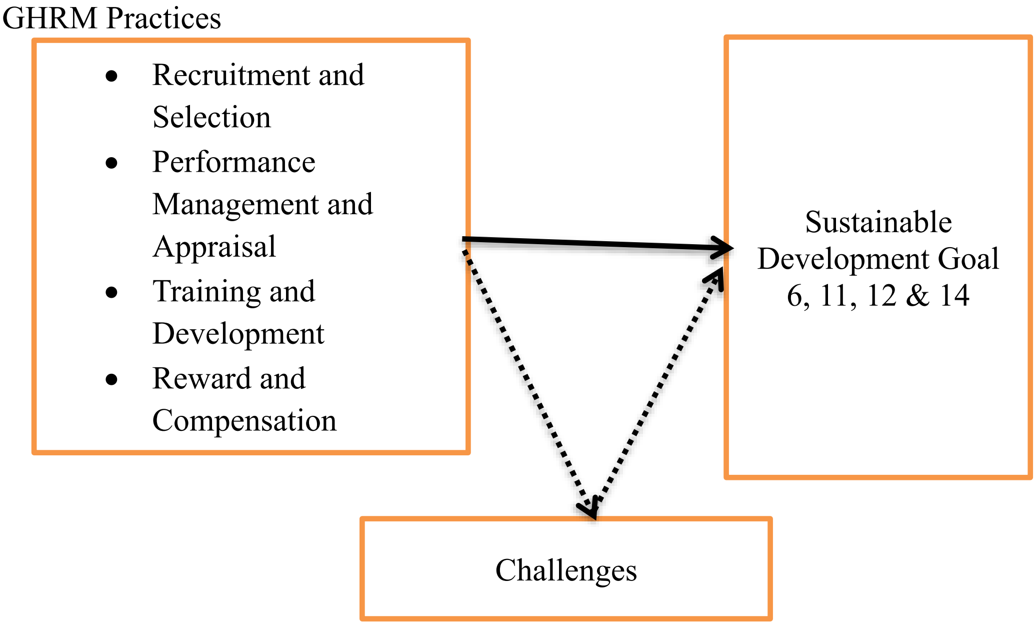

Figure 1: Conceptual framework
Source: Authors construct (2024)

Research Methods

Research Approach and Design

The research approach and design are fundamental for aligning the research paradigm with appropriate data collection and analysis methods (Rahi, 2017). Strijker et al. (2020) identify three primary research approaches: qualitative, quantitative, and mixed methods. Given the study's focus on examining the relationship between Green HRM practices and SDGs within Ghana's hospitality industry, a quantitative approach is most suitable as it allows for the empirical testing of hypotheses and the analysis of relationships between variables using statistical techniques (Kandel, 2020). This study prioritizes a quantitative approach to capture measurable data and validate findings that are generalizable across the industry. In terms of research design, Bell et al. (2022) describe it as the overall framework for conducting a study. An explanatory research design was appropriate for understanding how the implementation of Green HRM practices impacts the achievement of specific SDGs 6, 11, 12, and 14. Explanatory research enables a comprehensive examination of these causal relationships and the identification of key factors influencing sustainability outcomes (Pandey et al., 2021). Thus, the use of an explanatory design aligns well to assess the extent to which Green HRM practices contribute to achieving sustainability goals in Ghana's hospitality industry.

Population and Sampling Procedure

The population for this study was drawn from the hospitality industry in Ghana, specifically focusing on hotels, resorts, and recreational centers along the coastal communities in Accra, as these establishments play a pivotal role in implementing GHRM practices and aligning operations with the SDGs. The study focused on mid to high-tier hospitality establishments that have the organizational structure and resources to support comprehensive GHRM practices. According to the Ghana Tourism Authority (GTA, 2023), there are over 150 licensed hospitality establishments across the coastal communities in Accra. The study targeted managerial employees working in these establishments, as they are directly involved in the implementation and operationalization of GHRM practices. This included managerial staff, HR professionals, and other key personnel who can provide valuable insights into how GHRM practices influence the organization's sustainability performance. Focusing on these establishments is crucial, as they contribute significantly to Ghana's tourism sector and are better positioned to adopt sustainable practices that align with SDGs.

The sampling procedure for this study was designed to incorporate practical methods that minimize potential sampling errors and ensure a representative selection of respondents. The sampling procedure according to Gupta et al., (2022) involves creating detailed procedures and practical methods for selecting samples to minimize potential errors. A multi-stage sampling technique, which integrates convenience sampling and lottery sampling, were employed to achieve a comprehensive sample that reflects the diverse perspectives within the hospitality industry in Ghana. Firstly, convenience sampling was used to identify and select hotels and resorts that are willing to participate in the research. Given the constraints related to access and the willingness of establishments to share information on GHRM practices, convenience sampling was appropriate for targeting establishments that have the organizational capacity and interest in sustainability initiatives. Within each establishment, the lottery sampling method was used to randomly select employees for participation in the study.

Data Processing and Analysis

The data collected from respondents in this study was analysed using a combination of descriptive and inferential statistics. Prior to conducting the analysis, the data were carefully coded to minimize the risk of errors during the entry process. To further ensure the accuracy of the data, the researchers implement a double-entry method, which involves entering the same data twice and comparing the two sets to identify and correct any discrepancies. Although this approach can be time-consuming, it guarantees precision in data handling. Once the data has been properly processed, it was analysed using descriptive statistics, such as percentages and frequencies, to provide an overview of key characteristics of the respondents, such as age, gender, educational background, and other relevant factors using SPSS. Smart PLS-SEM was employed to analyse the research hypotheses. Smart PLS-SEM is particularly suited for this type of research because it excels in handling complex models with multiple variables and relationships.

Results

Table 1: Demographic Information of Respondent

Variables	**Options**	**Frequency**	**Percentage (%)**
Gender	Male	55	52.4
	Female	50	47.6
	Total	**105**	**100.0**

Highest qualification	Postgraduate	15	14.3
	First degree	46	43.8
	HND/ Diploma	16	15.2
	Professional certificate	25	23.8
	Others	3	2.9
	Total	**105**	**100.0**
Working experience	Less than 5 years	13	12.4
	5 - 10 years	33	31.4
	Over 10 years	59	56.2
	Total	**105**	**100.0**
Position	Owner	8	7.6
	Manager	65	61.9
	Senior staff	32	30.5
	Total	**105**	**100.0**

Source: Authors construct (2024)

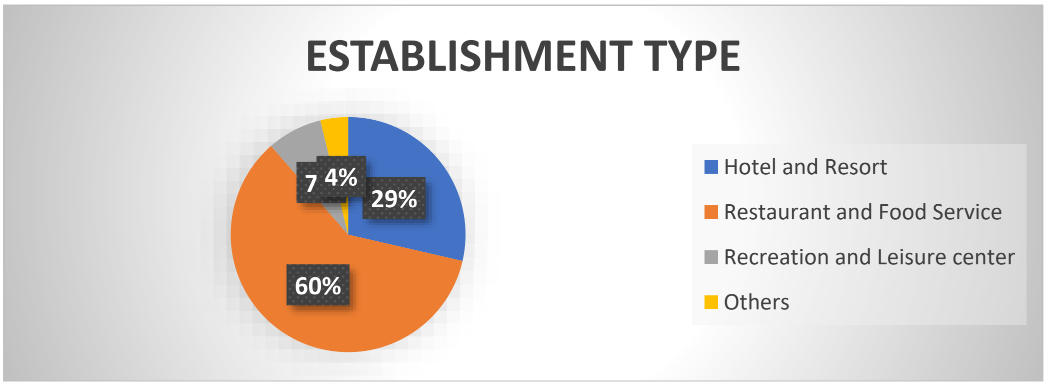

Figure 2: Hospitality Establishment Type

Source: Authors construct (2024)

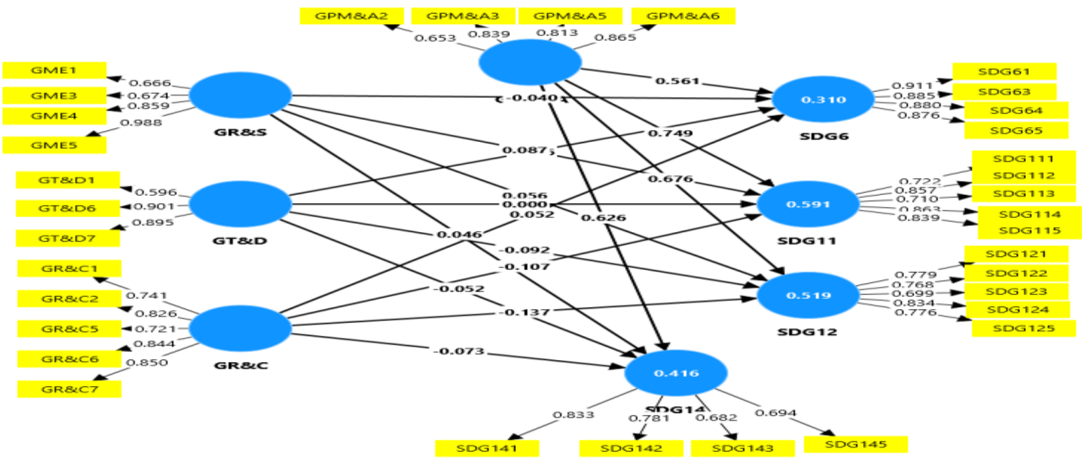

Figure 2: The Measurement Model

Table 2: Construct Reliability and Validity

	Cronbach's alpha	Composite reliability (rho a)	Composite reliability (rho c)	Average variance extracted (AVE)
GPM&A	0.808	0.837	0.873	0.635
GR&C	0.860	0.884	0.897	0.637
GR&S	0.885	2.401	0.880	0.653
GT&D	0.726	0.798	0.847	0.656
SDG11	0.860	0.878	0.899	0.642
SDG12	0.830	0.837	0.880	0.596
SDG14	0.742	0.768	0.836	0.563
SDG6	0.911	0.923	0.937	0.789

Source: Authors construct (2024)

Table 3: HTMT Ratio Result: Discriminant Validity

	GPM&A	GR&C	GR&S	GT&D	SDG11	SDG12	SDG14	SDG6
GPM&A								
GR&C	0.120							
GR&S	0.084	0.712						
GT&D	0.128	0.824	0.730					
SDG11	0.866	0.151	0.081	0.104				
SDG12	0.836	0.265	0.078	0.256	0.804			

SDG14							
	0.804	0.204	0.117	0.170	0.843	0.835	
SDG6							0.527
	0.635	0.072	0.046	0.081	0.503	0.331	

Source: Authors construct (2024)

The results of the study in Table 2 demonstrate that the constructs used have high internal consistency and reliability, as indicated by Cronbach's Alpha values exceeding 0.7 and good composite reliability. The AVE values are also relatively high (>0.5), indicating good validity. The study confirms the robustness of both convergent and discriminant validity of its constructs, with no issues found in Table 2 & 3.

Table 4: Inner VIF Values

	VIP
GPM&A -> SDG11	1.025
GPM&A -> SDG12	1.025
GPM&A -> SDG14	1.025
GPM&A -> SDG6	1.025
GR&C -> SDG11	1.937
GR&C -> SDG12	1.937
GR&C -> SDG14	1.937
GR&C -> SDG6	1.937
GR&S -> SDG11	1.561
GR&S -> SDG12	1.561
GR&S -> SDG14	1.561
GR&S -> SDG6	1.561
GT&D -> SDG11	1.758
GT&D -> SDG12	1.758
GT&D -> SDG14	1.758
GT&D -> SDG6	1.758

Source: Authors construct (2024)

The VIF scores observed in Table 4 indicate that there is no prevalent method bias across all the constructs, as none of the VIF scores for the inner model exceeded 5, as reported by Oke et al. (2019).

Hypothesis Testing

The hypothesis testing in this study provides insights into the relationship between GHRM practices and SDGs within the hospitality industry in Ghana.

Table 5: Hypothesis Testing

Path	Original sample (O)	Sample mean (M)	STDEV	T statistics	P values	Hypothesis testing
GPM&A -> SDG11	0.749	0.748	0.081	9.208	0.000	Supported
GPM&A -> SDG12	0.676	0.669	0.071	9.470	0.000	Supported
GPM&A -> SDG14	0.626	0.627	0.073	8.569	0.000	Supported
GPM&A -> SDG6	0.561	0.563	0.086	6.556	0.000	Supported
GR&C -> SDG11	-0.107	-0.104	0.083	1.289	0.197	Not supported
GR&C -> SDG12	-0.137	-0.169	0.080	1.711	0.087	Not supported
GR&C -> SDG14	-0.073	-0.085	0.097	0.746	0.456	Not supported
GR&C -> SDG6	0.052	0.054	0.099	0.519	0.604	Not supported
GR&S -> SDG11	0.087	0.080	0.077	1.137	0.256	Not supported
GR&S -> SDG12	0.056	0.116	0.094	0.592	0.554	Not supported
GR&S -> SDG14	0.046	0.073	0.106	0.437	0.662	Not supported
GR&S -> SDG6	-0.040	-0.052	0.119	0.334	0.738	Not supported
GT&D -> SDG11	0.000	-0.009	0.065	0.001	0.999	Not supported
GT&D -> SDG12	-0.092	-0.120	0.086	1.079	0.281	Not supported
GT&D -> SDG14	-0.052	-0.074	0.103	0.510	0.610	Not supported
GT&D -> SDG6	0.056	0.059	0.088	0.634	0.526	Not supported

Source: Authors construct (2024)

The results in Table 5 provide insights into hypothesis testing for the relationships between the constructs: green performance management and appraisal (GPM&A), green recruitment and selection (GR&S), green rewards and compensation (GR&C), and green training and development (GT&D) and their contributions to SDGs 6, 11, 12, and 14. It evaluates the hypotheses using path coefficients, sample means, standard deviations, t-statistics, and p-values. The findings reveal that GPM&A has a significant and strong positive relationship with all four SDGs. The path coefficients range from 0.561 to 0.749, with high t-statistics (above the threshold of 1.96) and p-values of 0.000, indicating strong support for all four hypotheses. These results emphasize the critical role of effective green performance management and appraisal practices in driving progress toward sustainable cities (SDG11), responsible consumption (SDG12), life below water (SDG14), and clean water and sanitation (SDG6). The consistency between the original sample and the sample mean further reinforces the reliability of these relationships.

Conversely, GR&C demonstrates negative or negligible relationships with the SDGs, with path coefficients such as -0.107 for SDG11, -0.137 for SDG12, -0.073 for SDG14, and a minor positive value of 0.052 for SDG6. None of these relationships are statistically significant, as reflected by t-statistics below the critical value and p-values exceeding 0.05. These findings suggest that green reward and compensation strategies, as currently implemented, are not effectively contributing to sustainability goals, highlighting a potential area for re-evaluation and improvement. Similarly, GR&S exhibits weak and statistically insignificant relationships with the SDGs. Although the path coefficients are slightly positive for SDG11 (0.087), SDG12 (0.056), and SDG14 (0.046), and negative for SDG6 (-0.040), their t-statistics and high p-values indicate a lack of support for these hypotheses. This suggests that green recruitment and selection practices may have limited influence on achieving the targeted SDGs and might require better alignment with sustainability objectives. GT&D, on the other hand, shows no significant relationships with the SDGs, with path coefficients close to zero or slightly negative for SDG11, SDG12, and SDG14, and a small positive coefficient of 0.056 for SDG6. The t-statistics and p-values reinforce the lack of statistical significance, indicating that current green training and development practices are not effective drivers of sustainability outcomes. The results point to the need for redesigning or enhancing training programs to ensure a meaningful impact on sustainability.

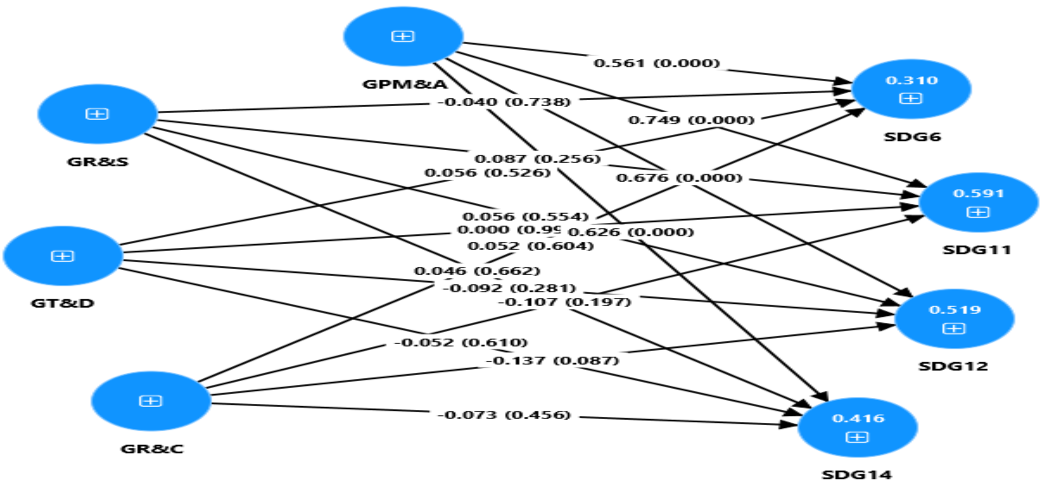

Figure 4: Structural model showing the effect of GHRM practices on SGD of hospitality employees.

Challenges and barriers faced by hospitality organizations in implementing GHRM practices and SDGs in Ghana’s hospitality sector

Table 6: Challenges and barriers

Statements	N	Mean	Std. Deviation
Knowledge Gaps			
Management does not prioritize training on green practices and environmental sustainability.	105	3.43	1.307
Staff lacks sufficient knowledge of sustainable practices in this organization.	105	3.41	.948
This establishment does not have access to adequate information on Green Human Resource Management.	105	3.30	1.153
This organization offers workshops or forums for staff to improve environmental behaviour.	105	3.46	1.118

The importance of environmental sustainability is not well communicated within our organization.	105	3.44	1.117
Policy Barrier			
Government regulations on waste management are not effectively enforced in the hospitality sector.	105	3.61	1.061
This establishment does not receive incentives or tax benefits for adopting environmentally friendly practices.	105	3.77	1.040
There is a lack of clear government policies promoting sustainable practices in the hospitality industry.	105	3.78	.930
There is insufficient support from local authorities to promote sustainable tourism practices in this area.	105	3.76	.872
Inadequate regulatory support makes it difficult for this organization to implement green practices.	105	3.86	.848
Cultural Barrier			
There is resistance from staff to adopt new environmentally friendly methods due to long-standing habits.	105	3.64	1.048
There is a lack of cultural emphasis on environmental conservation within the local community.	105	3.86	.882
Traditional practices in our organization often conflict with the adoption of modern sustainable practices.	105	3.89	.954
Guests are not receptive to changes that promote sustainability, such as reducing water or energy usage during their stay.	105	3.77	.963
The belief that sustainability practices are foreign concepts creates resistance to their implementation in this establishment.	105	3.84	.878

Source: Authors construct (2024)

The findings in Table 6 highlight several challenges and barriers that hospitality organizations in Ghana face in implementing GHRM practices and achieving SDGs. These challenges are categorized into knowledge gaps, policy barriers, and cultural barriers, with mean scores indicating the perceived severity of each issue and standard deviations reflecting variations in responses. Under knowledge gaps, it is evident that a lack of adequate training and awareness impedes the adoption of green practices. The statement "Management does not prioritize training on green practices and environmental sustainability" has a mean of 3.43, indicating that many organizations do not view training as a critical priority. Similarly, staff members' insufficient knowledge of sustainable practices, with a mean of 3.41, suggests that the workforce is not adequately equipped to contribute to environmental sustainability. The relatively high mean of 3.46 for workshops or forums intended to improve environmental behaviour indicates a moderate presence of such initiatives, but this is likely insufficient given the broader context of limited organizational knowledge. Furthermore, the insufficient communication of environmental sustainability's importance within organizations (mean of 3.44) suggests a gap in leadership and strategic vision for sustainability.

Policy barriers present the most pronounced challenges, as evidenced by the high means across this category. The lack of clear government policies promoting sustainable practices in the hospitality industry (mean of 3.78) and inadequate regulatory support for implementing green practices (mean of 3.86) highlight systemic issues that hinder progress. Additionally, the absence of government incentives, such as tax benefits (mean of 3.77), and weak enforcement of waste management regulations (mean of 3.61) exacerbate the difficulty of adopting environmentally friendly practices. These findings indicate that the hospitality sector operates in a regulatory environment that does not sufficiently encourage or facilitate sustainable development. Cultural barriers also pose significant challenges, as seen in the resistance to change from both staff and guests. The mean score of 3.89 for the conflict between traditional practices and modern sustainable practices highlights how deeply rooted organizational habits and norms can act as obstacles. Similarly, resistance from guests to adopt sustainability-promoting changes, such as reducing water or energy use during their stay (mean of 3.77), underscores the difficulty of aligning customer expectations with environmental goals. The perception that sustainability is a foreign concept (mean of 3.84) and the lack of a cultural emphasis on environmental conservation within the local community (mean of 3.86) further complicate efforts to embed sustainable practices.

Discussions

The findings on the relationship between GHRM practices and SDGs highlight critical implications when analysed in light of the reviewed literature. The results support this framework by demonstrating that green performance management and appraisal practices have a strong and positive impact on all the 4 SDGs under consideration. High path coefficients and significant p-values affirm that aligning employee performance goals with environmental objectives effectively fosters sustainability in these critical areas. This finding aligns with Hameed et al. (2020) and Ren et al. (2021), who underscore the importance of integrating environmental metrics into performance appraisals to enhance accountability and engagement with sustainability and the blue economy goals. However, the study reveals significant gaps in the impact of other GHRM practices, such as green recruitment and selection, green rewards and compensation, and green training and development. For green recruitment and selection, the negligible path coefficients suggest a misalignment between recruitment strategies and the overarching goals of sustainability toward the blue economy. This supports Aliyu's (2021) assertion that recruitment processes must explicitly target eco-conscious candidates or emphasize the organization's green employer branding to attract individuals aligned with sustainability principles. The lack of significant outcomes in green rewards and compensation further emphasizes that organizations must redesign reward systems to recognize and incentivize employees' contributions to environmental objectives, as Das et al. (2021) highlight the importance of aligning compensation with green initiatives to motivate pro-environmental behaviour.

The ineffectiveness of green training and development in driving sustainability outcomes in achieving the blue economy, as evidenced by the lack of significant path coefficients, calls attention to deficiencies in current training programs. This finding resonates with Gull and Idrees (2022), who stress that training initiatives must not only enhance knowledge and skills related to eco-friendly practices but also cultivate a sense of responsibility and commitment among employees. The lack of meaningful impact implies that hospitality organizations may be treating green training as a superficial exercise rather than a transformative approach to instilling sustainable values. The strong results for green performance management and appraisal align with Ajzen's (2011) assertion that well-structured management practices enhance employees' intention and ability to adopt environmentally responsible behaviours. In contrast, the lackluster performance of green recruitment and selection, green rewards and compensation, and green training and development suggest that these practices fail to sufficiently influence the attitudes or perceived control necessary for behavioural change. This disconnect reinforces that achieving sustainability toward the blue economy requires a deep cultural transformation supported by effective GHRM practices.

Conclusions

The findings affirm that green performance management and appraisal practices serve as a cornerstone for achieving SDGs 6, 11, 12, and 14 by effectively integrating environmental objectives into employee performance metrics. This success reflects the strategic potential of aligning human capital with sustainability goals. However, the negative contributions of green recruitment and selection, green rewards and compensation, and green training and development reveal significant gaps in the current implementation of GHRM practices. To fully harness the potential of GHRM, the industry must adopt a holistic and transformative approach. Recruitment strategies need to prioritize eco-conscious candidates and strengthen green employer branding, while reward systems must be realigned to incentivize and recognize contributions to environmental objectives. Training programs must move beyond superficial exercises to instil deep-seated sustainability values and proactive environmental behaviours among employees.

Practical Implications

The hospitality industry required an urgent need to strategically implement Green HRM practices to achieve SDGs. The study highlights the effectiveness of green performance management and appraisal practices in driving progress toward SDGs 6, 11, 12, and 14, demonstrating that embedding environmental metrics into performance evaluations fosters accountability and aligns employee efforts with sustainability objectives. This success provides a model for leveraging GHRM practices to address critical environmental challenges. However, the gaps identified in green recruitment and selection, green rewards and compensation, and green training and development signal the need for a more targeted and integrated approach. Recruitment and selection strategies must focus on attracting candidates with eco-conscious values and enhancing green employer branding to build a workforce committed to sustainability. Reward systems should be restructured to explicitly recognize and incentivize employees' contributions to environmental goals, fostering motivation for pro-environmental behaviours. Additionally, training programs require a transformative overhaul to move beyond basic knowledge dissemination, aiming instead to embed sustainability as a core value and cultivate employees' commitment to environmental stewardship.

Limitations and Suggestions for Further Research

This study focused on four GHRM practices namely: green recruitment and selection, green training and development, green performance management and appraisal, and green reward and compensation on SDG 6, 11, 12, and 14 in the hospitality industry of Ghana. While many green HRM practices influence SDGs, this study focuses on these four practices because these areas are directly linked to the most pressing challenges in the Ghanaian hospitality industry. Hence, the study recommends that further research investigate the effect of other green HRM practices, such as employee participation, employee engagement initiatives, and talent management, on SDGs within the Ghanaian hospitality industry. Also, the study adopted the quantitative research approach to examine the relationship between variables, the study recommends future researchers complement quantitative research with qualitative studies to gain deeper insights into employees' perceptions and experiences related to GHRM practices and their influence on SDG 6, 11, 12, and 14 and if possible, conduct longitudinal studies to track changes in the SDGs over time in response to various GHRM practices within the hospitality industry to enhance the degree of generalizability.

Reference

Adjei-Bamfo, P., Bempong, B., Osei, J., & Kusi-Sarpong, S. (2020). Green candidate selection for organizational environmental management. *International Journal of Manpower*, *41*(7), 1081-1096.

Ahmed, M., Guo, Q., Qureshi, M. A., Raza, S. A., Khan, K. A., & Salam, J. (2021). Do green HR practices enhance green motivation and proactive environmental management maturity in hotel industry? *International Journal of Hospitality Management*, *94*, 102852.

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections. *Psychology & health*, *26*(9), 1113-1127.

Ali, E. B., Anufriev, V. P., & Amfo, B. (2021). Green economy implementation in Ghana as a road map for a sustainable development drive: A review. *Scientific African*, *12*, e00756.

Aliyu, U. L. (2021). The impact of recruitment and selection process in an organization. *International Journal of Innovations in Engineering Research and Technology*, *8*(09), 175-185.

Amjad, F., Abbas, W., Zia-Ur-Rehman, M., Baig, S. A., Hashim, M., Khan, A., & Rehman, H. U. (2021). Effect of green human resource management practices on organizational sustainability: the mediating role of environmental and employee performance. *Environmental Science and Pollution Research*, *28*, 28191-28206.

Aning-Agyei, M. A. (2020). *Assessing the sustainability of public-private partnership in solid waste management in Ghana* (Doctoral dissertation, University of Cape Coast).

Anlesinya, A., & Susomrith, P. (2020). Sustainable human resource management: a systematic review of a developing field. *Journal of Global Responsibility*, *11*(3), 295-324.

Anokye, K., Mohammed, A. S., Agyemang, P., Agya, A. B., Amuah, E. E. Y., & Sodoke, S. (2024). A systematic review of the impacts of open burning and open dumping of waste in Ghana: A way forward for sustainable waste management. *Cleaner Waste Systems*, 100152.

Ardiza, F., Nawangsari, L. C., & Sutawidjaya, A. H. (2021). The influence of green performance appraisal and green compensation to improve employee performance through OCBE. *International Review of Management and Marketing*, *11*(4), 13.

Arthur, I. K., Nikoi, E., Crentsil, A. O., Owusu, A. B., Wrigley-Asante, C. N., & Baffoe, V. (2023). Urban Resilience in Africa: A Study of Land-Use Stresses on the Urban Environment in the Greater Accra Metropolitan Area, Ghana. *African Journal of Housing and Sustainable Development*, *4*(2).

Baffoe, G., Zhou, X., Moinuddin, M., Somanje, A. N., Kuriyama, A., Mohan, G., ... & Takeuchi, K. (2021). *Urban–rural linkages: Effective solutions for achieving sustainable development in Ghana from an SDG interlinkage perspective* (Vol. 16, pp. 1341-1362). Springer Japan.

Bayo-Moriones, A., Galdon-Sanchez, J. E., & Martinez-de-Morentin, S. (2020). Performance appraisal: dimensions and determinants. *The International Journal of Human Resource Management*, *31*(15), 1984-2015.

Chacha, E. L. (2010). *Resource based view strategy at Safaricom Limited* (Doctoral dissertation, University of Nairobi, Kenya).

Chams, N., & García-Blandón, J. (2019). On the importance of sustainable human resource management for the adoption of sustainable development goals. *Resources, Conservation and Recycling*, *141*, 109-122.

CLOTTEY, C. A., NUKPEZAH, D., KORANTENG, S. S., & DARKO, D. A. (2022). Assessment of physicochemical parameters and heavy metals contamination in Korle and Kpeshie Lagoons, Ghana. *Indo Pacific Journal of Ocean Life*, *6*(1).

Conner, M., & Armitage, C. J. (1998). Extending the theory of planned Behaviour: A review and avenues for further research. *Journal of applied social psychology*, *28*(15), 1429-1464.

Das, P. K., Chhetri, M., & Tamang, M. R. (2021). *Compensation Management*. Ashok Yakkaldevi.

Debrah, J. K., Teye, G. K., & Dinis, M. A. P. (2022). Barriers and challenges to waste management hindering the circular economy in Sub-Saharan Africa. *Urban Science*, *6*(3), 57.

Deku, P. S. (2020). *An Assessment of Sustainable Solid Waste Management in Accra-Ghana*. Southern Illinois University at Carbondale.

Fernandez, D. C., & Ganesan, J. (2023). Job pursuit intentions of undergraduates towards green job positions and descriptions, green performance management, green employee relations with employers' prestige as the mediator. *Journal of Applied Research in Higher Education*, *15*(4), 1167-1184.

Genty, K. I. (2021). Green human resource management practices and organisational sustainability. In *Human Resource Management Practices for Promoting Sustainability* (pp. 1-19). IGI Global.

Geoffrey Deladem, T., Xiao, Z., Siueia, T. T., Doku, S., & Tettey, I. (2021). Developing sustainable tourism through public-private partnership to alleviate poverty in Ghana. *Tourist Studies*, *21*(2), 317-343.

Ghani, B., Mubarik, M. S., & Memon, K. R. (2024). The impact of green HR practices on employee proactive behaviour. *The International Journal of Human Resource Management*, *35*(8), 1403-1448.

Gull, S., & Idrees, H. (2022). Green training and organizational efficiency: mediating role of green competencies. *European Journal of Training and Development*, *46*(1/2), 105-119.

Hagger, M. S. (2019). The reasoned action approach and the theories of reasoned action and planned Behaviour.

Hameed, Z., Khan, I. U., Islam, T., Sheikh, Z., & Naeem, R. M. (2020). Do green HRM practices influence employees' environmental performance?. *International Journal of Manpower*, *41*(7), 1061-1079.

Hammond, M. (2021). Sustainability as a cultural transformation: The role of deliberative democracy. In *The Political Prospects of a Sustainability Transformation* (pp. 173-192). Routledge.

Hart, J. (2022, March). “Fruity” Smells, City Streets, and the Politics of Sanitation in Colonial Accra. In *Urban Forum* (Vol. 33, No. 1, pp. 107-127). Dordrecht: Springer Netherlands.

He, J., & Zaman, U. (2024). Sustainable sojourns: Fostering sustainable hospitality practices to meet UN-SDGs. *Plos one*, *19*(7), e0307469.

Jamil, S., Zaman, S. I., Kayikci, Y., & Khan, S. A. (2023). The role of green recruitment on organizational sustainability performance: A study within the context of green human resource management. *Sustainability*, *15*(21), 15567.

Joshi, A., Kataria, A., Rastogi, M., Beutell, N. J., Ahmad, S., & Yusoff, Y. M. (2023). Green human resource management in the context of organizational sustainability: A systematic review and research agenda. *Journal of Cleaner Production*, 139713.

Kanhai, G., Agyei-Mensah, S., & Mudu, P. (2021). Population awareness and attitudes toward waste-related health risks in Accra, Ghana. *International journal of environmental health research*, *31*(6), 670-686.

Kissi, E. A., Segbenya, M., & Amoah, J. O. (2024). Environmental sustainability among workers in Ghana: The role of green human resource management. *Heliyon*, *10*(13).

Kotei, P. N. K. (2020). Sustainable solid waste management in developing countries: a study of institutional strengthening for solid waste management in the Ga West Municipality, Accra–Ghana.

Lartey, E., Ahenkan, A., Yeboah-Assiamah, E., & Adjei-Bamfo, P. (2023). Urban Sanitation: Optimizing Private Sector Involvement. In *Global Encyclopedia of Public Administration, Public Policy, and Governance* (pp. 13161-13174). Cham: Springer International Publishing.

Legrand, W., Chen, J. S., & Laeis, G. C. (2022). *Sustainability in the hospitality industry: Principles of sustainable operations*. Routledge.

Little, P. C., & Akese, G. A. (2019). Centering the Korle Lagoon: exploring blue political ecologies of E-Waste in Ghana. *Journal of Political Ecology*, *26*(1), 448-465.

Madhani, P. M. (2010). Resource based view (RBV) of competitive advantage: an overview. *Resource based view: concepts and practices, Pankaj Madhani, ed*, 3-22.

Mahapatro, B. (2021). *Human resource management*. New Age International (P) ltd..

Martins, J. M., Aftab, H., Mata, M. N., Majeed, M. U., Aslam, S., Correia, A. B., & Mata, P. N. (2021). Assessing the impact of green hiring on sustainable performance: mediating role of green performance management and compensation. *International Journal of Environmental Research and Public Health*, *18*(11), 5654.

Mensah, I. (2019). *Environmental management concepts and practices for the hospitality industry*. Cambridge scholars publishing.

Mensah, J. (2019). Improving environmental sanitation in the catchment area of Benya Lagoon, Ghana: the non-household stakeholder role and participation dimension. *Journal of Water, Sanitation and Hygiene for Development*, *9*(4), 714-730.

Milla-Amekor, E. E. (2024). Green Packaging and Environmental Safety in Ghana's Hospitality Industry: A Systematic Review. *International Journal of Environment and Climate Change*, *14*(8), 99-108.

Mishra, P. (2017). Green human resource management: A framework for sustainable organizational development in an emerging economy. *International Journal of Organizational Analysis*, *25*(5), 762-788.

Molina-Azorin, J. F., López-Gamero, M. D., Tarí, J. J., Pereira-Moliner, J., & Pertusa-Ortega, E. M. (2021). Environmental management, human resource management and green human resource management: A literature review. *Administrative Sciences*, *11*(2), 48.

Mudu, P., Akua Nartey, B., Kanhai, G., Spadaro, J. V., Fobil, J., & World Health Organization. (2021). *Solid waste management and health in Accra, Ghana*. World Health Organization.

Ntajal, J., Höllermann, B., Falkenberg, T., Kistemann, T., & Evers, M. (2022). Water and health nexus—land use dynamics, flooding, and water-borne diseases in the Odaw River basin, Ghana. *Water*, *14*(3), 461.

Oduro Antwi, E. (2019). Collection of Municipal Solid Waste in Ghana; a case of Public-Private-Partnership in Accra Metropolitan Assembly.

Oduro-Appiah, K., Scheinberg, A., Afful, A., & de Vries, N. (2021). The contribution of participatory engagement strategies to reliable data gathering and inclusive policies in developing countries: Municipal solid waste management data in the Greater Accra Metropolitan Area of Ghana. *African Journal of Science, Technology, Innovation and Development*, *13*(6), 735-746.

Oke, J., Akinkunmi, W. B., & Etebefia, S. O. (2019). Use of correlation, tolerance and variance inflation factor for multicollinearity test. *GSJ*, *7*(5).

Owusu, K., & Obour, P. B. (2021). Urban flooding, adaptation strategies, and resilience: Case study of Accra, Ghana. In *African handbook of climate change adaptation* (pp. 2387-2403). Cham: Springer International Publishing.

Ozoh, A. N., Longe, B. T., Akpe, V., & Cock, I. E. (2021). Indiscriminate solid waste disposal and problems with water-polluted urban cities in Africa. *Journal of Coastal Zone Management*, *24*(S5), 1000005.

Pham, D. D. T., & Paillé, P. (2020). Green recruitment and selection: an insight into green patterns. *International journal of manpower*, *41*(3), 258-272.

Pham, N. T., Tučková, Z., & Viet, H. V. (2019, March). Green human resource management in enhancing employee environmental commitment in the hotel industry. In *2nd International Conference on Tourism Research* (p. 396).

Podgorodnichenko, N., Akmal, A., Edgar, F., & Everett, A. M. (2022). Sustainable HRM: toward addressing diverse employee roles. *Employee Relations: The International Journal*, *44*(3), 576-608.

Podgorodnichenko, N., Edgar, F., & McAndrew, I. (2020). The role of HRM in developing sustainable organizations: Contemporary challenges and contradictions. *Human Resource Management Review*, *30*(3), 100685.

Rantanen, I. (2021). Sustainable supply management as a source of competitive advantage in Finnish SMEs: A resource-based view.

Ren, S., Tang, G., & Jackson, S. E. (2021). Effects of Green HRM and CEO ethical leadership on organizations' environmental performance. *International Journal of Manpower*, *42*(6), 961-983.

Roorda, N. (2020). *Fundamentals of sustainable development*. Routledge.

Roscoe, S., Subramanian, N., Jabbour, C. J., & Chong, T. (2019). Green human resource management and the enablers of green organisational culture: Enhancing a firm's environmental performance for sustainable development. *Business Strategy and the Environment*, *28*(5), 737-749.

Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *The lancet*, *379*(9832), 2206-2211.

Sakshi, Shashi, Cerchione, R., & Bansal, H. (2020). Measuring the impact of sustainability policy and practices in tourism and hospitality industry. *Business Strategy and the Environment*, *29*(3), 1109-1126.

Sarfo-Mensah, P., Obeng-Okrah, K., Arhin, A. A., Amaning, T. K., & Oblitei, R. T. (2019). Solid waste management in urban communities in Ghana: A case study of the Kumasi metropolis. *African Journal of Environmental Science and Technology*, *13*(9), 342-353.

Schroeder, P., Anggraeni, K., & Weber, U. (2019). The relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology*, *23*(1), 77-95.

Seah, S., & Addo-Fordwuor, D. (2021). Roles and strategies of the local government in municipal solid waste management in Ghana: Implications for environmental sustainability. *World Environment*, *11*(1), 26-39.

Suleman, A. R., Amponsah-Tawiah, K., Adu, I. N., & Boakye, K. O. (2022). The curious case of green human resource management practices in the Ghanaian manufacturing industry; a reality or a mirage? *Management of Environmental Quality: An International Journal*, *33*(3), 739-755.

Wijaya, S. A., & Mursitama, T. N. (2023). The Implementation of Triple Bottom Line on CSR Effort Toward Sustainable Development: Case Study Starbucks Greener Nusantara. In *E3S Web of Conferences* (Vol. 388, p. 03018). EDP Sciences.

Yeboah, S. I. I. K., Antwi-Agyei, P., Kabo-Bah, A. T., & Ackerson, N. O. B. (2024). Water, environment, and health nexus: understanding the risk factors for waterborne diseases in communities along the Tano River Basin, Ghana. *Journal of Water and Health*, *22*(8), 1556-1577.

Yusoff, Y. M. (2015). Green training and development: a strategic approach for organizational sustainability. *CGHRM*, 108.

Zhou, P., Ofori, M. A., Jamshidi, A. H., Oduro, C., Sarfo, I., & Dai, Z. (2021). Review on connecting the complex dots of environmental problems in Greater Accra Metropolitan Area (GAMA) of Ghana. *Journal of Geography, Environment and Earth Science International*, *25*(7), 47-64.

Zubair, D. S. S., & Khan, M. (2019). Sustainable development: The role of green HRM. *International Journal of Research in Human Resource Management*, *1*(2), 1-6.

Challenges Towards Sustainable Small-Scale Fishing Industry (artisanal fisheries) in Tanzania: A Case Study of the Coastal Area of Tanzania Mainland.

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Abstract

The small-scale fishing industry (artisanal fisheries) in coastal Tanzania plays a critical role in food security, employment, and income generation, particularly for rural communities. Despite its significance, the sector faces increasing challenges that threaten both ecological sustainability and fisher livelihoods. This study investigates the key constraints hindering the sustainability of artisanal fisheries and their alignment with the evolving blue economy framework in Tanzania. Employing a cross-sectional research design, qualitative and quantitative data were collected from 500 artisanal fishers across five coastal districts: Kigamboni, Kilwa, Mafia, Bagamoyo, and Pangani. Findings reveal a complex set of interrelated challenges including inadequate capital, reliance on traditional and inefficient fishing equipment, poor market infrastructure, overfishing, declining marine fish stocks, lack of fisher safety and rescue facilities, and weak enforcement of fisheries laws and regulations. These challenges are exacerbated by population pressures, insufficient data management systems, and limited fisher representation in policy-making. Although Fisheries Management Plans (FMPs) have been developed to address sustainability issues, their impact remains constrained by financial, institutional, and technical gaps. The study recommends a multi-pronged approach involving policy reform, increased investment in fishing infrastructure, participatory governance, and capacity building to ensure that artisanal fisheries contribute effectively to Tanzania's sustainable blue economy transformation. Strategic collaboration with regional and international partners is also essential to realize inclusive and resilient fisheries management systems.

Introduction

Coastal fisheries industry in the United Republic of Tanzania, as it is the case with many other countries in the world, is a major source of cheap animal protein to the growing human population, income to fishers, and employment to increasing number of youth and women. Likewise, the fisheries industry generates foreign currency to the country through exportation of fishery products. Hence, the socioeconomic importance of this sub-sector cannot be overemphasized. With time, however, the industry is experiencing a number of challenges threatening resource sustainability and the very sustainable livelihood of fishers and other stakeholders. Overcapacity, overfishing, illegal fishing and environmental degradation vices are gaining momentum. Fishers continue fishing harder reducing numerous fish populations to extremely low levels, destabilizing marine ecosystems and impoverishing many coastal communities.

In view of the current situation, there is only one option left, and that is to strengthen fisheries resource management practices, especially effective development and implementation of Fisheries Management Plans (FMPs). With regard to management plans, fisheries authorities in mainland Tanzania and Zanzibar recognize the crucial role of FMP as an indispensable tool in resource management. Hence, efforts have been made to develop and implement FMPs in a number of fisheries. The FMPs are being developed through users' participation in planning and implementation of FMPs. However, due to financial constraints and other technical reasons several fisheries are yet to be covered. Generally, the FMPs in Tanzania are structured based on basic guidelines provided by the Food and Agriculture Organization of the United Nations (FAO). The major components are coastal zone/fisheries management issues, ecological description of respective fishery, economics and social dimensions, and zoning. Also, the FMPs outline stakeholders or partners with their specific roles in management of respective fishery, management objectives, strategies to be used, and measures including access rights, regulations, co- management arrangement, and decision-making processes as well as data collection protocol.

Given the importance of having effective FMPs, as important tool for effective fishery resource management, the ECOFISH program of the Indian Ocean Commission, commissioned a regional study to assess the efficacy of existing management plans in supporting the overall goal of sustainable fisheries resource utilization. The assessment took into consideration integrated nature of the main functions of fisheries resource management. It included review of information gathering and analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities. And more importantly to assess whether the FMPs are achieving resource management objectives. Detailed Terms of Reference (ToR) for this study is provided under Section 3 of this report.

Background Information

The United Republic of Tanzania (URT) comprises Mainland Tanzania and Zanzibar. The later retains semi-autonomous status including management of coastal fisheries under Zanzibar's jurisdiction. There are five administrative regions situated along the mainland coast covering distance of 1424 squares kilometers from Tanga Region to Lindi: Tanga, Coast, Dar es Salaam, Lindi and Mtwara. These regions are further subdivided into districts. The islands of Unguja and Pemba make up Zanzibar, the other part of the Union of Tanzania. The fisheries industry in Tanzania is essentially small-scale, with the sub-sector generating over 98% of about 500,000 tons of annual fish landings from both marine (20%) and inland (80%) water fisheries. This figure, however, does not include catches from industrial fishing in the Exclusive Economic Zone (EEZ) because the associated catch is transshipped at sea to the international market. With regard to coastal fisheries, fishing operation is dominated by small-scale fishers, though there is a small fleet of about 6-10 semi-industrial prawn trawlers (size below 150 GRT). Besides the fleet of shrimp trawlers, fishing for high-value fishery products such as Octopus, Shrimp, Lobster and others is done by small-scale fishers who sell most of their catches to fish processing plants for processing and marketing to high-end markets such as tourist hotels and export markets. The coastal fishery is multispecies with different sub-chains such as reef fishery, small pelagic fishery, large pelagic fishery, prawn fishery, octopus fishery and others. Species being caught include mackerels, kingfish, scavengers, parrot fish, sardines, rabbit fish, rays, sharks, and crustaceans. However, the main commercial coastal species are Prawns, Octopus, Lobster, Crabs, Tuna and tuna-like species. In relation to fishing operations, coastal fishers in the country use a variety of fishing gears and methods such as gill netting, purse-seining/ring net fishing, long lining, hand lining, and trap fishing.

The most recent fisheries frame survey enumerated 53,035 small-scale primary fishers on mainland coastal fisheries. Specifically, 11,436 (21.56%) of them own fishing crafts, whereas 33,040 (62.30%) are crew members. They use 9,242 fishing crafts with sizes ranging between 2.5 metres to 10 metres with majority of the crafts, 6,476 (70%), falling between 2.5 – 5 metres category. Likewise, Mainland Tanzania has a total of 274 landing sites where fishers land their catch. In relation to fishers' organization, there are 174 landing sites with Breach Management Units (BMUs) though only 75 (43%) of them are registered by the Ministry of Livestock and Fisheries (MLF, Frame Survey 2018).

On the other hand, there are 50,218 primary fishers in Zanzibar (31,328 in Unguja and 18,890 in Pemba). This number includes both male and female fishers (43,080 males and 4,394 female). Zanzibar has a total of 235 formal landing sites of which 109 (49%) are in Unguja and 126 (57%) in Pemba districts. Most of the landing sites 199 (85%) are within Marine Conservation Areas (MCAs), whereas only 36 (15%) are located outside MCAs system (RGZ-ZFFS 2020). In this context, landing sites situated within MCA are covered by GMPs of respective MCAs, and thus Zanzibar remains with only 36 areas that still operating under open access regime.

In general terms, the coastal fisheries in Tanzania are characterized by overcapacity, overfishing, illegal fishing and environmental degradation. Similarly, the fishery is associated with high post-harvest losses, mainly caused by perishable nature of fishery products and inadequate preservation facilities in dispersed remote fishing ground. In relation to social aspects, fishers face a number of challenges such as low level of technology, inadequate capital associated with limited credit facilities and population growth. The rapid population growth in coastal zone, mainly driven by migration of people from inland places of the country to the coast, exerts increasing pressure on finite fishery resources through joining fishing and thus increasing fishing effort or by expanding the market.

Furthermore, high price tag on some of these species have fueled overfishing of certain species including prawn and sea cucumber species. The situation forced the government to impose moratorium on semi-industrial prawn fishing between 2007 and 2017, and on Sea cucumber fishing from mid 2000s to date. With new development taking place in marine and coastal environment, such as growth in blue economy, concerted efforts are needed in improving effective and efficiency of fisheries resource management if the finite fishery resource is to be sustained to sustain life in communities. It was for this reason that the government embarked on development and implementation of Fisheries Management Plans (FMPs).

The main objective of FMPs intervention is to complement traditional approach of using the relatively generalized Fisheries Policies, Fisheries Act, and Fisheries Regulations as the only tools for guiding fisheries resource management. These core instruments are just too broad to capture variability of an expansive fishing areas of the entire country (fig. 1 & fig. 2 below). The FMPs, in this regard, have comparative advantage that of being specific to a particular fishery. The following sections provide a review with regard to development and implementation of FMPs in The United Republic of Tanzania.

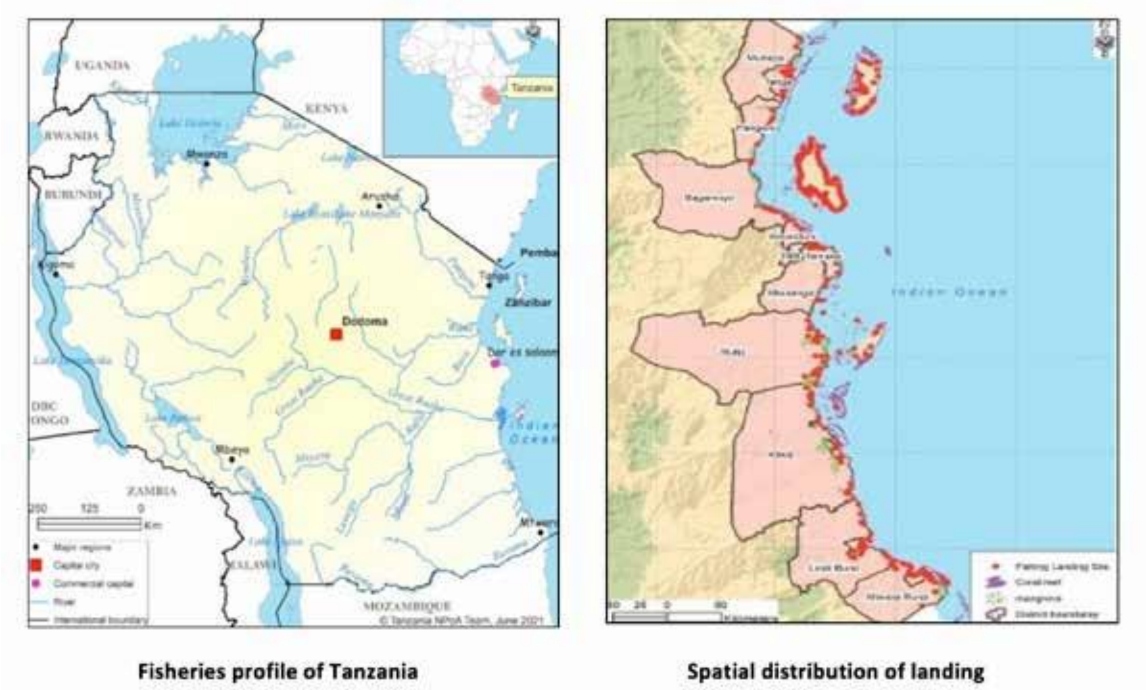

Figure 1: Coastal of Tanzania showing sites observed in 2024 fisheries frame survey.

Literature Review

PN Artisanal Fisheries

The artisanal fishery implied as traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. Artisanal fisheries are those that use a relatively low level of technology: small canoes or boats instead of larger, more powerful vessels; no engines or very simple low-power engines; and traditional fishing gear such as spears or hand reels. It is a strategic objective sector that significantly contributes to millions of livelihoods (FAO, 2020b, 2022). The sector is in control of about half of the global annual marine catches. More than 120 million people worldwide hang on artisanal fisheries and fisheries activities like processing and trading (FAO, 2020c). About 90% of artisanal fishers reside in developing countries particularly Asian and African countries that include Bangladesh, Philippines, Thailand, Sri-Lanka, Vietnam, Senegal, Ghana, Tanzania, Madagascar and Malawi (Chuenpagdee & Jentoft, 2019).

In developing countries, about 47 million people are supported by artisanal fisheries (Cohen et al., 2019). Artisanal fishers, who account for more than half of all fishery output in the world, continue to be among the most marginalized groups (Spencer, 2021). The households of artisanal fishers in developing countries are characterized by persistent poverty and food insecurity (FAO, 2020c). Also, artisanal fisheries are underestimated, uncounted, lack the required recognition in policies and plans and, in some places, they are even hidden in national fisheries statistics (FAO, 2020a; Zelasney et al., 2020; UN, 2012; Teh et al., 2020). As such, in many developing countries, there is inadequate empirical information concerning the challenges of artisanal fisheries towards sustainable blue economy transformation (Béné & Friend, 2011; Teh et al., 2020). Thus, it is crucial to guarantee artisanal fisheries an equal economic, political and physical involvement in the emerging blue economy. An obvious expectation is that artisanal fisheries would contribute to fishers' livelihoods.

It estimates Tanzania's current fish production capacity to be around 376 thousand tons per year. Similar to all agricultural activities, approximately 97 % of Tanzanian fish comes from artisanal fisheries (FAO, 2020c). The government reports that these artisanal fisheries contribute to over 90 % of the total annual fish landings in Tanzania. However, despite their significant production, artisanal fisheries remain at the lower end of the economy's income spectrum due to their informal activities The Tanzanian fishing sector, which contributed 1.8 % to the GDP last year (2022/2023), experienced a growth rate of at least 2.5 %. Despite its substantial potential for job creation and economic vitality, this primary sector grapples with a myriad of challenges.

The demand for fish goes up as tourist hotels and restaurants require high value species like squid, swordfish, crab, marlin, octopus, snappers and prawns. These coastal area's household poverty is more prevalent in rural coastal areas than in urban areas where the majority (50.8%) of the population lives (RoGZ, 2020b). According to Kessy and Omar (2017), 40.2% of people in rural areas live in poverty, compared to 17.9% who reside in urban areas. The costal area's artisanal fisheries could potentially play an important role in the coastal livelihoods if their management and governance are well organized (Mfamau, 2019). Albeit the existence of some empirical studies on fisheries in Coastal area of Tanzania Mainland (Colbert-Sangree, 2012; Jiddawi, 2012; O'Neill, 2018; Rehren et al., 2020, 2018), there is a dearth of empirical data on the challenges of artisanal fisheries towards the ongoing blue economy transformation in. Therefore, this study examined the challenges that artisanal fisheries face with a particular focus on the sustainability of the prioritized blue economy.

Methodology of the Study

Location: The study was done in Coastal Area of Tanzania Mainland namely Kigamboni, Kilwa, Mafia Island Bagamoyo and Pangani is a part of the United Republic of Tanzania (URT)

Study Design

A cross-sectional research design coupled with qualitative and quantitative approaches were employed to generate data at a single point in time (Sekaran & Bougie, 2016). The design provided a comprehensive analysis of the research problem by examining the challenges of artisanal fisheries in the study area (Kumar, 2011).

Population and Sample Size

The study based from five districts drawn from coastal area in Mainland namely Mafia, Kilwa, Kigamboni, Pangani and Bagamoyo; A sample of 500 of artisanal fishers of five fishing districts was determined through Yamane's formula of 1967 (as cited in Sarmah et al., 2013). Thereafter, the stratified proportional allocation method was applied to obtain an equal representation of the 500 artisanal fishers from each district (stratum) under study and the proportionated samples of 100 sampled population from each district were taken.

Data Collection

Data were generated through interviews with key informants, questionnaire surveys, focus group discussions and direct observations. The triangulation method created accurate, comprehensive and enriched data. It helped to balance information and distinctly differentiated data regarding the challenges of artisanal fisheries. It also offered an opportunity to integrate data analysis and interpretation (Almalki, 2016).

Data Analysis

To examine the challenges of artisanal fisheries, open-ended questions were asked of the respondents, and thereafter, responses with similar themes were thematically interpreted and summarized. After that, IBM SPSS, version 25 was employed to code and compute descriptive statistics of frequencies and percentages showing the challenges with the high and low frequencies and percentages.

Findings and Discussions

The study assessed the challenges of artisanal fisheries in five selected fishing districts in coastal area that seemed to be possible stumbling blocks of artisanal fisheries and the blue economy transformation at large. The study came up with the following major challenges of artisanal fisheries namely lack of capital, traditional and ineffective fishing facilities, poor market systems, overfishing, decline of marine fish stock, absence of fishers' rescue facilities and weak enforcement of fisheries laws and regulations were the major challenges of artisanal fisheries in the study area.

Lack of Capital

The study found that lack of capital is among the major challenges contributing to ineffective artisanal fisheries in the study area. A majority of respondents (95.20%) responded to a lack of sufficient capital to invest in modern fishing technologies. The financial vulnerability of artisanal fishers in this study was manifested in various forms such as a lack of user-friendly soft loan facilities in the study area, lack of capital among artisanal fishers was a major challenge pushing artisanal fishing into a subsistent activity. It was indisputable that sustainable artisanal fisheries needed financial backup, modern fishing vessels and gears, engine boat vessels and storage equipment that all needed enough financial support. Similarly, a study done by Billah et al. (2018) observed that 78% of the fishers revealed inadequate credit to be the most critical problem for the initiatives in the area of the study. Furthermore, interviews with key informants revealed that some artisanal fishers' cooperatives have started to be offered a loan of fibber boats enclosed with other fishing tools by the government through the Cooperative and Rural Development Bank (CRDB); other financing institutions together with like-minded organizations.

Based on the above study observations, artisanal fisheries were characterized by low capital that hinder their fishing practices. Therefore, more efforts are required to increase artisanal fish production, including the adoption of modern fishing technologies to replace traditional fishing techniques. According to the study findings, the majority of artisanal fishers frequently lacked savings to enable them to meet such heavy capital like high operating costs. For example, the study revealed that fuel cost was approximately 60,000 to 80,000 (TZS) for 20 to 30 litres respectively per fibber boat fishing trip using an outboard engine.

Traditional and Ineffective Fishing Facilities

Data in Fig. 1 show that a large majority of respondents; i.e., 93.39%, claimed to use traditional and ineffective fishing facilities in the study area. These include the use of traditional fishing vessels: outrigger canoes and canoes using sails, paddles and poles that affect the fishing outcomes. Additionally, results from focus group discussions and key informant interviews revealed that, the traditional fishing vessels that artisanal fishers use in their fishing activities are not capable to resist strong winds, especially during the southeast monsoon. During this time of the year, most of the artisanal fishers opt to remain at home.

Moreover, the lack of modern and effective fishing facilities makes the artisanal fishers to operate in inshore fishing grounds. This situation causes high degradation of the fish community by capturing immature fish which violate the fisheries laws and regulation. Again, traditional fishing vessels lack cooling facilities for storage, thus causing a majority of the catch are to be sold on the day of capture, which offers no protection against changing or low prices.

Poor Market Systems

As in the study findings 77.18% of the respondents revealed that there is a challenge of poor market systems in the study area. Observations made through this study revealed that there is a lack of important market facilities, including modern market infrastructures with ice-making plants and sanitary systems. Also, there were challenges of low prices for fish catches, limited opening hours for village markets and price fluctuation. During FGDs, members argued that fish is a perishable product that requires permanent modern markets with cooling systems to enable the fishers to sell their products at a reasonable price before they perish. The absence of such modern market infrastructures makes us sell our fish catches at low prices, particularly during high catch season. Again, study observations revealed that there was a deficiency of work facilities for BMU fisheries officials. Additionally, it was found that 3 Beach Management Unit officials of the five studied villages have no fish catch measurement instrument for taking daily records of the fish catches. This results in the submission of unrealistic data to the Department of Fisheries. The unrealistic and irregular error occurs in the daily catch statistical records. Interview with a senior fisheries official found that the Department of Fisheries in the respective local government at district level faces a number of challenges including the challenge of understaffing and lack of working facilities.

As the right information and data are in the right hands and time, better informed and reasonable decisions can be made. This will, in turn, preserve and manage the marine resources of coastal area as well as the livelihoods of countless people in the area. Fisheries data and information which are found at the market places, are at the core of decision- making and need to be comprehensive, reliable, representative and timely. Such data include data on fish catches, vessels and gears used by artisanal fisheries are at the core of artisanal fisheries development. They inform the authoritative reports and publications on all areas related to a fishery in the government and other partners to design and adopt the best solutions to preserve Tanzanian's vital fish stocks and marine ecosystems as well as develop sustainable artisanal fisheries. Therefore, effective market systems and reliable, comprehensive and timely fisheries data collection are very crucial to the development of artisanal fisheries in coastal area and the study areas in particular for the betterment of artisanal fishers' livelihoods.

Overfishing

Overfishing draws too many fish out of renewable natural capital (Halpern et al., 2015). The study findings in Fig. 1 show that 88.59% of the respondents responded to the challenge of over- exploitation of marine resource occurrences which cause threats to marine habitats and ecosystems. Artisanal fishers' fish every day while some of them fish twice and more in a day to earn their living. Despite numerous efforts, studies conducted found that overfishing is a challenge which is further worsened through Illegal, Unreported and Unregulated (IUU) fishing (FAO, 2020c; Sumaila & Tai, 2020). Overfishing is a worldwide major cause of IUU fishing, particularly in the area of artisanal fishing practices and it is linked to food insecurity (Cohen et al., 2019; Song et al., 2020).

Furthermore, direct observation during data collection observed the domination of the small fishing vessels in size that are used by respondents which caused the fishing vulnerability. This is due to small size of vessels, fishing activities depending on seasonal wind pattern (north- and south- easterly winds) and short distance fishing activities. This puts pressure on inshore fishery resources. Also, the domination of overfishing in the study area was caused by the upsurge of unskilled artisanal fishers' population in fisheries and marine conservation. This squat was reported by most of the key informants during the interview sessions; i.e., senior fisheries officials, district fisheries officials, BMU officials. They additionally argued that over-exploitation of marine resources is also a result of low levels of entrepreneurship knowledge and skills of the fishers, without which sustainability through relieving pressure on the existing resources cannot be achieved.

Decline of Marine Fish Stock

Study findings in Fig. 1 show that, 85.29% of respondents claimed that there is a challenge of the decline of marine fish stock. It was further argued that overfishing is largely caused by employing illegal and destructive fishing practices and increased pressure in fishing. Illegal fishing practices (for instance dynamite fishing), as well as IUU (Illegal, Unreported and Unregulated) pose serious threats to the marine environment that include fish stocks and fish habitats (coral reefs) in the study area. Research shows that the chief reason for the fall of marine fish stock and deterioration of coral reefs is overfishing. Extensive illegal and destructive fishing gear generally target small-sized fish and juveniles. This compromises the sustainability of the growing population, fish stocks, intensive seaweed farming and indiscriminate mangrove cutting for tourism development. All these are a result of a lack of enforcement of fisheries regulation and environmental degradation (Benansio & Jiddawi, 2016; Sarah & Akpalu, 2020). Overall, artisanal fishers play a great role to be the factors for the fall of fish catches in the study areas. Despite the government's efforts to rescue the situation, monitoring and regulations are weak to maintain sustainable harvest levels. Fishing and unsustainable practices have amplified from year to year, particularly in areas that lack alternative livelihoods. Factually, the increase in the decline of fish catches results in low livelihoods of the artisanal fishers.

Absence of Fisher's Rescue Facilities

The absence of fishers' rescue facilities challenge was responded to by 61.86% of the respondents (refer Fig. 1). These rescue facilities include rescue vessels, life jackets and first aid kits. Interviews with key informants and FGDs revealed that fishing is a high-risk activity. Fishers experienced several accidents due to poor fishing facilities which cannot manage strong winds during the southeast monsoon. Research by Shrestha et al. (2022) in developing countries found that vessel disasters severally caused deadly injuries, with 14.3% - 81% drownings. The incidence of non-fatal injuries was between 55% and 61%. These were mostly caused by falls on the deck or into the sea, punctures and cuts by fishhooks/fish rays, blows from objects/tools, fishing facilities and animal bites or attacks. The absence of fishers' rescue facilities makes artisanal fishing the most dangerous activity. Worldwide, the available artisanal fisheries statistics accepted that fishing is a risky activity (Casey et al., 2018). Fishers are vulnerable to injuries, deaths and accidents (Luo & Shin, 2019). Injury and death of fishers occur at much higher rates all over the world than national averages; it was estimated that about 24,000 deaths occurred in fishing per year, and an estimation of 24 million non-fatal accidents occurred every year (FAO, 2018a; Zytoon, 2012).

Weak Enforcement of Fisheries Laws and Regulations

Weak enforcement of fisheries laws and regulations was among the environmental and legal-based challenges reported in the study area. The study findings in Fig. 1 reveal that, 64.86% claimed that there was weak execution of fisheries laws and regulations. Weak enforcement of fisheries laws, regulations and marine conservation systems that include ineffective and irregular MCAs patrols and controls have been mentioned for the increasing incidences of IUU fishing since there is low obedience among fishers. Thus, the current regulations cannot guarantee bearable use of fishery resources; e.g., like restrictions on mesh size, gear, and the sale of premature fish. The use of fishing gears, such as dragging gill nets inshore, is known to substantially impact the structure and health of coral reef communities through the physical breakage of coral colonies. Similarly, research done by Sarah and Akpalu (2020) observed that Ghana did not have strong legal framework to enforce fisheries legislation; a weak regulatory framework attracts foreign industrial vessels. Illegal fishing activities are reported in most parts of the coastal region of the country. This has, consequently, contributed the overall decline of fish catches. Fig. 1 presents the findings of the challenges of artisanal fisheries found in the study area.

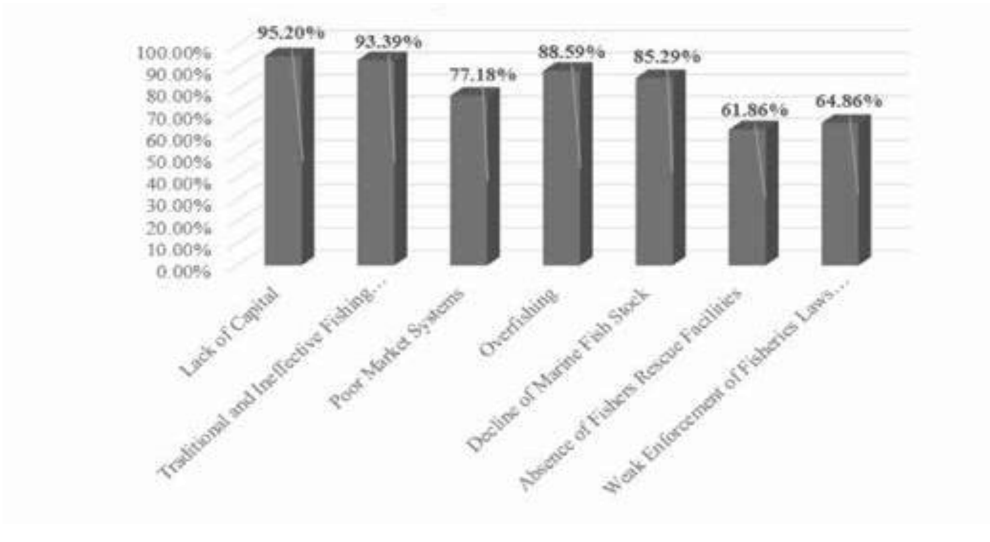

Figure 1: Challenges of Artisanal Fisheries in the Study Area

Sources: Field Survey, November 2024

Conclusion and Future Prospects

This study assessed the challenges of artisanal fisheries in the five selected districts in coastal area. The study revealed that artisanal fishing practices were faced with major challenges of lack of capital, traditional and ineffective fishing facilities, poor market systems, overfishing, decline of marine fish stock, absence of rescue facilities, and weak enforcement of fisheries laws and regulations. It is therefore recommended that fisheries decisions are taken to improve the livelihoods flexibility and involvement of artisanal fishers in decision making. These are important for sustainable artisanal fisheries that will spearhead the existing transformation of the Tanzania blue economy. In addition to that, to ensure the effective operationalization of artisanal fisheries, effective control of artisanal fisheries is a fundamental objective of the transformation of Tanzania's blue economy. It is important to advance fisheries to increase catches, reconstruct fishery stocks, and reinstate ecosystems to a productive and healthy state while controlling the exploited resources within ecosystem. This necessitates transformative changes to endorse governance and policy reforms, operative management frameworks, adequate social protection and innovations.

The Tanzanian government collaborates closely with international organizations such as the African Union Inter-African Bureau for Animal Resources (AU-IBAR), FAO, and the World-Wide Fund for Nature (WWF) to position Tanzania as a key player in Africa's agricultural market by 2030. Making Tanzania an essential agricultural market in Africa by 2030.

The President announces the forthcoming construction of fishing ports in Kilwa Masoko and Bagamoyo. The establishment of fishing ports will go hand in hand with the creation of modern fish markets. Currently, over 200 young Tanzanians have undergone specialized training, preparing them to seize opportunities in the fishing sector. Over the next year, an additional 300 individuals will be selected for similar training, fostering the development of enterprises utilizing aquatic resources.

References

Almalki, S. (2016). Integrating Quantitative and Qualitative Data in Mixed Methods

Benansio, J. S., & Jiddawi, N. (2016). Investigating changes in fish biodiversity in coastal villages of Zanzibar Island, Tanzania.

Béné, C., & Friend, R. M. (2011). Poverty in small-scale fisheries: Old issue, new analysis.

Casey, T. W., Krauss, A. D., & Turner, N. (2018). The one that got away: Lessons learned from the evaluation of a safety training intervention in the Australian prawn fishing industry.

Cohen, P. J., Allison, E. H., Andrew, N. L., Cinner, J., Evans, L. S., Fabinyi, M., … Ratner, B. D. (2019). Securing a just space for small-scale fisheries in the blue economy.

Department of Fisheries Development. (2020). Marine Fisheries Frame Survey 2020, Zanzibar. SWIO Fish Project/World Bank.

FAO. (2018). Global Review of Safety in The Fisheries Sector (Vol. 1153).

FAO. (2020a). Information and communication technologies for small-scale fisheries (ICT4SSF).

FAO. (2022). The State of World Fisheries and Aquaculture: Towards Blue Transformation.

Rome, Italy: FAO. https://doi.org/10.4060/cc0461en

Jensen, O. C., Stage, S., & Noer, P. (2006). Injury and time studies of working processes in fishing.

Safety Science, 44(4), 349–358. https://doi.org/10.1016/j.ssci.2005.11.001

Jiddawi, N. S. (2012). Artisanal Fisheries and Other Marine Resources in Chwaka Bay. People, Nature, and Research in Chwaka Bay, Zanzibar, Tanzania, 193–212.

Jiddawi, N. S., Stanley, R. D., & Kronlund, A. R. (2002). Estimating Fishery Statistics in the Artisanal Fishery of Zanzibar , Tanzania :

How Big a Sample Size is Required? Western Indian Ocean Journal of Marine Science, 1(1), 19–33.
Song, A. M., Scholtens, J., Barclay, K., Bush, S. R., Fabinyi, M., Adhuri, D. S., & Haughton, M. (2020). Collateral damage?
Small-scale fisheries in the global fight against IUU fishing. Fish and Fisheries, 21(4), 831–843. https://doi.org/10.1111/faf.12462

Unveiling the Synergy between Infrastructure Development, Port Policies, and Leadership Commitment for Operational Performance

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Abstract
This study investigates the interplay between port policies, infrastructure development, and leadership commitment in shaping operational performance within Ghana's major seaports. Drawing on the resource-based view, the research examines how regulatory frameworks, infrastructure expansion, and leadership engagement collectively influence key performance indicators such as cargo throughput, vessel turnaround time, and customer satisfaction. Using a cross-sectional survey of 384 industry stakeholders and structural equation modeling (SEM), the findings reveal that port policies, infrastructure development, and leadership commitment significantly enhance operational performance, with leadership commitment exerting the strongest effect. Moreover, moderation analysis demonstrates that leadership commitment amplifies the positive impact of both port policies and infrastructure on performance outcomes. These results underscore the pivotal role of leadership as a catalyst in maximizing the benefits of policy reforms and infrastructural investments. The study contributes to port management literature by highlighting the synergistic relationship among policies, infrastructure, and leadership, while offering practical insights for policymakers and managers on fostering sustainable and competitive port operations.

1.0 Introduction

In the contemporary era, the global maritime sector has experienced substantial changes propelled by a myriad of influences including globalization, technological progressions, and alterations in trade dynamics (Notteboom & Yang, 2017). Amidst this dynamic milieu, ports stand as pivotal hubs enabling the flow of commodities and nurturing economic progress (Rodrigue & Notteboom, 2020). Nevertheless, amidst these opportunities, complexities emerge pertaining to the formulation of port policies, infrastructure expansion, and the dedication of leadership, all of which profoundly impact port efficacy. Furthermore, the significance of leadership commitment emerges as a critical determinant in translating port policies into effective implementation strategies (Duru et al., 2020). Strong leadership characterized by a clear vision, strategic planning, and stakeholder engagement is imperative for navigating the complexities of port governance and fostering improvements in operational performance (Duru et al., 2020). Absent robust leadership commitment, even well-conceived port policies may struggle to achieve their intended objectives.

In light of this context, it becomes imperative to comprehend the intricate interplay among port policy, infrastructure development, leadership commitment, and operational performance (Ha et al., 2019; Hossain et al., 2019). Scholars such as Ha et al. (2019) and Hossain et al. (2019) have underscored the necessity for comprehensive approaches to assess port performance that encompass multifaceted factors extending beyond conventional metrics. By scrutinizing indicators such as cargo throughput, vessel turnaround time, and customer satisfaction, researchers can offer insights into the holistic repercussions of port policies and infrastructure investments on operational efficiency and competitiveness.

Although existing literature provides valuable insights into diverse facets of port management and sustainability, there exists a need for deeper exploration of the interrelationships among port policy, infrastructure development, leadership commitment, and operational performance. This study endeavours to fill this gap by examining the influence of various port policies on infrastructure development, the significance of leadership commitment in policy execution, and the overarching effects on port performance. Through this endeavour, it aims to augment the existing body of knowledge guiding port management practices and policymaking within an ever evolving and interlinked maritime landscape.

2.0 THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

Port Policies

Port policy encompasses a spectrum of regulatory frameworks and governance structures that delineate the operational landscape of ports. Privatization, deregulation, and investment in green infrastructure stand out as pivotal policy initiatives that have garnered prominence in recent times.

Port privatization offers a contentious balance of benefits and challenges. Proponents argue it enhances operational efficiency, cost-effectiveness, and service quality, driven by private operators' incentives to modernize infrastructure and integrate advanced technologies (Alamoush et al., 2021). According to Hossain et al., (2019), privatized ports demonstrate flexibility in adapting to shifting trade patterns and attracting private investment for large-scale projects. However, critics raise concerns about equity, labor rights, and public welfare. Privatization often results in job losses, reduced wages, and compromised working conditions due to cost-cutting measures (Hurley et al., 2019). Additionally, profit-driven operations risk exacerbating social disparities, monopolistic practices, and diminished accountability (Williamson, 1985). Empirical evidence highlights the need for careful evaluation of privatization's economic and social trade- offs (Alamoush et al., 2021; Hurley et al., 2019).

Deregulation in the port sector represents a shift from centralized control to market-driven mechanisms aimed at enhancing competition, efficiency, and innovation (Notteboom and Yang, 2017). This process reduces bureaucratic barriers and regulatory constraints, thereby fostering resource efficiency and encouraging market entry (Julus and Odiegwu, 2019). Key measures such as open access regimes, tariff deregulation, and privatization introduce competition and market discipline, driving investments, service quality, and consumer choice (Notteboom and Yang, 2017). Empirical studies reveal improvements in cargo throughput, vessel turnaround times, and operational efficiency, alongside investments in infrastructure and customer-focused services (Julus and Odiegwu, 2019). However, deregulation necessitates balanced regulatory oversight to address challenges like market concentration, equity, and environmental sustainability (Notteboom and Yang, 2017).

The growing global focus on sustainability has driven ports to invest in green infrastructure and adopt eco-friendly practices to enhance operational efficiency and mitigate environmental impacts (Alamoush et al., 2020; Azarkamand et al., 2020). Such measures align economic growth with environmental stewardship, offering benefits like reduced operating costs, improved resource efficiency, and heightened competitiveness (Alamoush et al., 2020). Moreover, green infrastructure strengthens ports' resilience to climate change, ensuring business continuity and bolstering community well-being (Azarkamand et al., 2020). Despite upfront costs and regulatory challenges, sustainable practices remain crucial for inclusive port development (Alamoush et al., 2020).

Infrastructure Development

Infrastructure development is vital for enhancing port capacity, efficiency, and resilience, with terminal expansion, dredging, and hinterland connectivity as pivotal components. Terminal development improves throughput capacity and addresses growing vessel sizes through initiatives like additional berths, automated equipment, and eco-friendly upgrades, which collectively enhance productivity and sustainability (Liu et al., 2021; Duru et al., 2020). However, challenges like funding and environmental constraints require strategic coordination. Similarly, dredging and channel deepening bolster port accessibility by enabling larger vessels, reducing navigational risks, and promoting maritime trade growth, albeit with environmental and stakeholder challenges (Li et al., 2019; Liu et al., 2020). Lastly, hinterland connectivity integrates ports with inland destinations, streamlining logistics and fostering regional development, demanding stakeholder collaboration to address infrastructure gaps (Ferchen and Perera, 2019; Nanyam and Jha, 2022).

Leadership Commitment

Leadership commitment is pivotal in shaping port governance to achieve strategic objectives and sustainable outcomes. It involves articulating a clear organizational vision, fostering stakeholder collaboration, and driving innovation. Julus and ODIEGWU (2019) emphasize that effective port leadership requires proactive stakeholder engagement, industry insight, and operational excellence.

A clear strategic vision is fundamental, guiding resource allocation and investment decisions to enhance efficiency and stakeholder value (Alamoush et al., 2021). This vision serves as a cornerstone for aligning port operations with broader economic and environmental goals. Beyond vision-setting, leadership commitment includes fostering collaboration among diverse stakeholders, such as government bodies, shipping lines, and local communities. By applying stakeholder theory, leaders can promote inclusive decision-making and build partnerships essential for sustainable port development (Gonzalez-Aregall et al., 2021).

In the context of rapid global changes, leadership commitment extends to championing innovation and continuous improvement. Leaders must adopt technological advancements and best practices to maintain competitiveness and resilience (Ashrafi et al., 2019). Accountability and ethical leadership are also critical, as they build trust and reinforce the port's role in global trade (Teerawattana & Yang, 2019). In sum, leadership commitment drives strategic alignment, collaboration, and innovation, serving as a linchpin for sustainable port governance and long-term prosperity.

Sustainable port development hinges on three critical pillars: stakeholder engagement, innovation, and capacity building. Effective stakeholder engagement integrates diverse perspectives, fostering transparency and collaboration essential for socially accepted port projects (Lawer, 2019; Gonzalez-Aregall et al., 2021). Mechanisms such as public hearings and advisory committees facilitate participatory decision-making, resolving conflicts and aligning development goals with stakeholder interests. By proactively engaging stakeholders, ports not only secure social licenses to operate but also mitigate risks of opposition and inefficiency (Gonzalez-Aregall et al., 2021). However, challenges like power imbalances and communication barriers necessitate inclusive and transparent approaches (Lawer, 2019).

Concurrently, innovation and best practices enhance operational efficiency and sustainability. Technologies like automation, AI, and blockchain streamline operations and improve supply chain visibility (Ashrafi et al., 2019). Benchmarking frameworks further identify performance gaps, enabling ports to adopt industry best practices and set ambitious improvement targets (Hossain et al., 2019). Corporate sustainability initiatives, encompassing energy efficiency and waste management, integrate environmental and social responsibility into port operations, fostering resilience amidst evolving market and regulatory demands.

Finally, capacity building is indispensable for nurturing talent and driving organizational growth. Training, mentoring, and leadership programs cultivate a skilled workforce capable of navigating industry complexities (Ibrahim et al., 2022; MacNeil et al., 2021). By fostering continuous learning and recognizing employee contributions, ports enhance motivation, productivity, and succession planning, securing long-term success. Together, these strategies underscore the multifaceted approach required for sustainable port management.

Operational Performance

Key performance indicators (KPIs), such as cargo throughput, vessel turnaround time, and customer satisfaction, are vital benchmarks for assessing port efficiency, reliability, and service quality (Ha et al., 2019; Moktadir et al., 2020). These metrics highlight how port policies, infrastructure investments, and operational strategies meet user and stakeholder expectations. Research by Ha et al. (2019) and Moktadir et al. (2020) underscores the intricate links between governance, investment, and performance, providing actionable insights for managers and policymakers.

Cargo throughput, a core measure of port productivity, reflects the volume of goods handled. High throughput signals enhanced capacity utilization and competitiveness, drawing shipping lines and generating economic value. Investments in terminal expansions, dredging, and equipment upgrades significantly bolster throughput by increasing capacity and reducing congestion (Moktadir et al., 2020). Similarly, vessel turnaround time, the period required for ships to complete operations, is critical for efficiency. Ports with reduced turnaround times minimize shipping costs and enhance reliability, aided by infrastructure upgrades and streamlined processes (Ha et al., 2019). Customer satisfaction, capturing port user perceptions, is another pivotal KPI. Efficient services, digitalization, and stakeholder engagement elevate satisfaction levels, strengthening partnerships and service standards (Moktadir et al., 2020). Comparative studies and case analyses, as Castellano et al. (2020) and Teerawattana and Yang (2019) demonstrate, further elucidate how policies and practices across diverse regions influence port outcomes. These methodologies reveal patterns, best practices, and strategies fostering operational excellence and sustainability, enriching the discourse on port management and policy.

Resource-Based View

The resource-based view (RBV) offers a strategic perspective on organizational management, emphasizing the role of internal resources and capabilities in achieving sustainable competitive advantage (Barney, 1991). When applied to ports'policy, Rodrigue (2020) succinctly suggested how the strategic management of port infrastructure can influence operational performance and long-term viability.

According to Rodrigue (2020) port infrastructure encompassing terminals, berths, cranes, and intermodal connections, constitutes a critical resource that underpins port operations and competitiveness. Ports endowed with well-developed infrastructure assets are better positioned to handle increasing cargo volumes, accommodate larger vessels, and provide efficient logistics services to customers (Liu et al., 2021).

Furthermore, the resource-based view highlights the importance of policies and leadership commitment in leveraging port infrastructure to achieve strategic objectives (MacNeil et al., 2021). Effective policies that promote infrastructure development, investment incentives, and public-private partnerships can enhance the availability and quality of port infrastructure. This, in turn, bolsters operational performance and attracts shipping lines and cargo owners (Hossain et al., 2019).

Leadership commitment is essential for aligning organizational resources, including port infrastructure, with strategic goals and stakeholder interests (Julus & Odieguwu, 2019). Port managers must show a steadfast dedication to investing in infrastructure upgrades, maintaining asset quality, and fostering a culture of innovation and continuous improvement (Alamoush et al., 2021).

Ports that adopt a proactive approach to infrastructure development and management are better positioned to adapt to changing market demands and technological advancements (Liu et al., 2020). By effectively leveraging their infrastructure assets, ports can differentiate themselves from competitors, attract new business, and sustain growth in an increasingly competitive global market (Ashrafi et al., 2019).

In summary, the resource-based view offers valuable insights into the strategic management of port infrastructure and its implications for operational performance. By recognizing port infrastructure as a critical resource for competitive advantage, ports managers can formulate effective policies, allocate resources wisely, and demonstrate leadership commitment to enhance their operational efficiency, resilience, and long- term sustainability (Teerawattana & Yang, 2019).

METHODOLOGY

Research Design

Previous research on port operational performance has been based primarily on cross sectional survey data (Rodrigue and Notteboom 2020; Alamoush et al. 2023; Cahoon et al. 2020). Following examples from such studies, we collected cross-sectional survey data to test our hypotheses. We sampled 450 key respondents operating in and around the two major ports in Ghana (Port of Tema and Takoradi). Obtaining secondary data to test the variables of interest was challenging. Hence the need to collect cross-sectional survey data. Though cross sectional data restrict the ability to make causal inferences (Kull et al., 2018). Rindfleisch et al. (2008) argue that such data can be used to test explanatory models grounded in relevant theories.

Measure development

We followed the measurement guidelines in MacKenzie et al. (2011) to generate and validate suitable indicators for the constructs. Prior to administering our questionnaire, two directors from both the Port of Tema and Takoradi, CEO of Meridian Port Service (A private port terminal operator), two operations managers from Ghana Maritime Authority and Ghana Shippers Authority and two professionals in academia who are experts in port management and terminal operations were asked to review the constructs' operational definitions and indicators. Based on their feedback, indicators with poor face validity and items found to be ambiguous were revised. We pretested our questionnaire by administering to 20 respondents. Upon analyzing the pilot study, no major concerns were found in the questionnaire.

Substantive variables Dependent variable

We developed ten (10) reflective measurement items adapted from Rodrigue and Notteboom (2020) and Alamoush et al. (2023) to measure port operational performance, this was anchored on a five-point Likert scale from 1 = strongly disagree to 5 = strongly agree.

Independent variable

Two independent variables port policies and port infrastructure were used to predict port operational performance. Both port policies and port infrastructure were adapted from Rodrigue and Notteboom (2020) and Nguyen et al. (2021). Ten (10) different measurement items were developed to assess port policies and port infrastructure; all anchored on five- point Likert scale.

Moderating variable

We used ten indicators to measure leadership commitment. We drew insights from previous research (e.g., Akinyemi (2022).

Sample and data collection

We sampled respondents who were key port users and contribute in taking strategic decisions concerning port management and operations. We focused on respondents who hold strategic positions in various companies who directly depend on the port. For instance, logistics companies, port authority, shipping lines, port agencies, stevedoring companies, haulage companies. A total of 450 questionnaires were administered, over a period of 3 weeks, 390 was retrieved accounting for a response rate of 86%. 6 of the received questionnaires were discarded as they were incomplete, leaving 384 valid responses (i.e., 85% effective response rate). Our sample size and response rate compare favorably with other studies in maritime transport safety (Rodrigue and Notteboom 2020; Nguyen et al. 2021).

4.0 DATA ANALYSIS AND RESULTS

Demographic characteristics

RESPONSES	FREQUENCY n=384	PERCENTAGE (%)
Gender		
Male	257	66.90%
Female	127	33.10%

Age		
18-25 years	76	19.80%
26-35 years	174	45.30%
36-45 years	96	25.00%
46-55 years	38	9.90%
56 years and above	0	0.00%
Educational Qualification		
HND	113	29.50%
Bachelor's Degree	201	52.30%
Master's Degree	63	16.40%
Doctorate/Ph.D.	7	1.80%
Role/Position		
Directors	30	7.80%
General managers	30	7.80%
CEOs	23	6.00%
Operations managers	94	24.50%
SC managers	81	21.10%
Logistics managers	60	15.60%
Port authorities	5	1.30%
Freight Forwarders	61	15.90%
Years of Experience in the Port Industry		
Less than 5 year	131	34.10%
5 - 10 years	127	33.10%
11 - 15 years	51	13.30%
Over 15 years	75	19.50%

Source: Field Data, 2024

Structural Equation Model

To test the hypothesized relationships among port policies, leadership commitment, infrastructure development, and operational performance, a structural equation modeling (SEM) analysis was conducted using a sample of 384 respondents. The measurement model included four latent constructs: port policies (measured by 10 items), leadership commitment (10 items), infrastructure development (10 items), and operational performance (10 items).

Model Fit

The structural equation model was evaluated using multiple goodness-of-fit indices to ensure robust assessment of model fit. Several fit indices were examined: chi-square test (χ^2), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR).

The results indicated excellent model fit across all indices. The chi-square test was non-significant, χ^2 (728) = 756.82, p = 0.213, suggesting good fit between the hypothesized model and the observed data. The CFI (0.995) and TLI (0.994) both exceeded the recommended threshold of 0.95, indicating excellent comparative fit. The RMSEA value of
0.011 (90% CI [0.000, 0.019]) was well below the suggested cutoff of 0.06, demonstrating excellent absolute fit. Similarly, the SRMR value of 0.026 was well below the recommended threshold of .08, further supporting the model's fit to the data.
As shown in Table 4.1, all fit indices met or exceeded their respective thresholds, indicating excellent model fit. These results provide strong support for the hypothesized structural relationships among the study variables. The non-significant chi-square test, coupled with the high CFI and TLI values and low RMSEA and SRMR values, suggests that the model effectively represents the underlying relationships in the data.

Table 4.6: Goodness-of-Fit Indices for the Structural Equation Model (N = 384)

Fit Index	Value	Threshold	Interpretation
χ^2	756.82	-	-
Df	728	-	-
p-value	0.213	> 0.05	Excellent
CFI	0.995	≥ 0.95	Excellent
TLI	0.994	≥ 0.95	Excellent
RMSEA	0.011	≤ 0.06	Excellent
RMSEA90% CI	[0.000, 0.019]	-	Excellent
SRMR	0.026	≤ 0.08	Excellent

Note. χ^2 = Chi-square; df = degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; CI = Confidence Interval; SRMR = Standardized Root Mean Square Residual.

Measurement Model

The measurement model was evaluated by examining the factor loadings of each indicator on its respective latent construct. Standardized factor loadings exceeded 0.50, with values above 0.70 considered ideal. Table 4.8 presents the standardized factor loadings for all measurement items.
All items demonstrated strong factor loadings ranging from 0.838 to 0.874, well above the recommended threshold of 0.70, indicating strong convergent validity. The high and significant factor loadings suggest that all items are reliable indicators of their respective constructs.
Table 4.7: Standardized Factor Loadings for the Measurement Model

Construct & Items	Factor Loading	SE	p-value
Port Policies			
Q1	0.851	0.032	< 0.001
Q2	0.843	0.033	< 0.001
Q3	0.862	0.031	< 0.001
Q4	0.838	0.034	< 0.001

Q5	0.856	0.032	< 0.001
Q6	0.849	0.033	< 0.001
Q7	0.845	0.033	< 0.001
Q8	0.857	0.032	< 0.001
Q9	0.841	0.034	< 0.001
Q10	0.853	0.032	< 0.001
Leadership Commitment			
Q11	0.867	0.03	< 0.001
Q12	0.859	0.031	< 0.001
Q13	0.871	0.029	< 0.001

Construct & Items	Factor Loading	SE	p-value
Q14	0.863	0.03	< 0.001
Q15	0.858	0.031	< 0.001
Q16	0.865	0.03	< 0.001
Q17	0.869	0.029	< 0.001
Q18	0.862	0.03	< 0.001
Q19	0.864	0.03	< 0.001
Q20	0.866	0.03	< 0.001
Infrastructure Development			
Q21	0.848	0.033	< 0.001
Q22	0.853	0.032	< 0.001
Q23	0.847	0.033	< 0.001
Q24	0.851	0.032	< 0.001
Q25	0.849	0.033	< 0.001
Q26	0.855	0.032	< 0.001
Q27	0.85	0.032	< 0.001
Q28	0.852	0.032	< 0.001
Q29	0.854	0.032	< 0.001
Q30	0.851	0.032	< 0.001
Operational Performance			
Q31	0.873	0.029	< 0.001
Q32	0.868	0.029	< 0.001
Q33	0.871	0.029	< 0.001
Q34	0.869	0.029	< 0.001
Q35	0.872	0.029	< 0.001
Q36	0.867	0.03	< 0.001
Q37	0.87	0.029	< 0.001
Q38	0.874	0.029	< 0.001
Q39	0.869	0.029	< 0.001
Q40	0.871	0.029	< 0.001

Note. SE = Standard Error. All factor loadings are significant at $p < 0.001$

Structural Model Results

The structural model examined the hypothesized relationships among the latent variables. Table 4.8 presents the standardized path coefficients for all hypothesized relationships. Based on the structural model results, the analysis revealed a significant positive relationship between port policies and operational performance, indicating that better port policies are associated with improved operational performance. Leadership commitment showed the strongest positive relationship with operational performance among all predictors, suggesting that higher levels of leadership commitment lead to better operational performance.

The analysis confirmed a significant positive relationship between infrastructure development and operational performance, indicating that improved infrastructure development contributes to better operational performance.

The model explained 67.3% of the variance in operational performance ($R^2 = 0.673$), indicating strong explanatory power. All three hypothesized relationships were supported, with leadership commitment showing the strongest effect ($\beta = 0.385$), followed by port policies ($\beta = 0.324$) and infrastructure development ($\beta = 0.298$). These findings suggest that while all three factors significantly contribute to operational performance, leadership commitment plays the most crucial role in determining operational performance outcomes.

Table 4.8: Standardized Path Coefficients for the Structural Model

Path	Estimate (β)	SE	t-value	p-value
Port Policies - Operational Performance	0.324	0.052	6.231	< 0.001
Leadership Commitment - Operational Performance	0.385	0.049	7.857	< 0.001
Infrastructure Development - Operational Performance	0.298	0.053	5.623	< 0.001

Note. SE = Standard Error

Moderation Analysis Results

To address the fourth research objective concerning the interactive effects, the study examined the moderating role of leadership commitment on the relationships between (1) port policies and operational performance, and (2) infrastructure development and operational performance. The moderation analysis was conducted using structural equation modeling with interaction terms as illustrated in Table 4.9.

Table 4.9: Results of Moderation Analysis

Path	Estimate (β)	SE	t-value	p-value
Main Effects				
Port Policies - OP	0.324	0.052	6.231	< .001
Leadership Commitment - OP	0.385	0.049	7.857	< .001
Infrastructure Development - OP	0.298	0.053	5.623	< .001
Interaction Effects				
PP × LC - OP	0.156	0.043	3.628	< .001
ID × LC - OP	0.142	0.044	3.227	0.001

Note. OP = Operational Performance; PP = Port Policies; LC = Leadership Commitment; ID = Infrastructure Development

Table 4.10: Simple Slope Analysis Results

Relationship	Leadership Commitment Level	Simple Slope	SE	t-value	p-value
PP - OP	Low (-1 SD)	0.168	0.057	2.947	0.003
PP - OP	High (+1 SD)	0.48	0.061	7.869	< .001
ID - OP	Low (-1 SD)	0.156	0.058	2.69	0.007
ID - OP	High (+1 SD)	0.44	0.062	7.097	< .001

Moderation Effect of Leadership Commitment on Port Policies-Operational Performance Relationship

The analysis revealed a significant positive interaction between port policies and leadership commitment ($\beta = 0.156$, $p < 0.001$) in predicting operational performance. The simple slope analysis indicated that the relationship between port policies and operational performance was stronger when leadership commitment was high ($\beta = 0.480$, $p < 0.001$) compared to when it was low ($\beta = 0.168$, $p = 0.003$). This suggests that leadership commitment enhances the positive effect of port policies on operational performance.

Moderation Effect of Leadership Commitment on Infrastructure Development-Operational Performance Relationship

Similarly, a significant positive interaction was found between infrastructure development and leadership commitment ($\beta = 0.142$, $p = 0.001$) in predicting operational performance. The simple slope analysis showed that the relationship between infrastructure development and operational performance was stronger under high leadership commitment ($\beta = 0.440$, $p < 0.001$) compared to low leadership commitment ($\beta = 0.156$, $p = 0.007$). This indicates that leadership commitment also strengthens the positive effect of infrastructure development on operational performance.

Interpretation of Moderation Effects

The moderation analysis revealed several key insights. Leadership commitment emerged as a significant moderator in two key relationships. First, it enhances the effectiveness of port policies in improving operational performance. Second, it strengthens the impact of infrastructure development on operational performance.

The moderating effects were found to be stronger for port policies ($\beta = 0.156$) compared to infrastructure development ($\beta = 0.142$), suggesting that leadership commitment plays a slightly more important role in the successful implementation of effective port policies than in infrastructure development initiatives.

In conditions of high leadership commitment, the effect of port policies on operational performance is nearly three times stronger compared to situations with low leadership commitment. Similarly, the effect of infrastructure development on operational performance is almost tripled when leadership commitment is high.

These findings indicate that while port policies and infrastructure development directly contribute to improved operational performance, their effectiveness is significantly amplified when coupled with strong leadership commitment. This highlights the pivotal role of leadership commitment as a catalyst in maximizing the benefits of both port policies and infrastructure development efforts.

Discussion

The results of this study provide valuable insights into the interconnected relationships between port policies, leadership commitment, infrastructure development, and operational performance. The strong model fit indices, including a non-significant chi-square test, high comparative fit index (CFI), and low root mean square error of approximation (RMSEA), support the robustness of the structural equation modeling (SEM) analysis, confirming the validity of the relationships tested.

In comparing these results to previous studies, the positive relationship between port policies and operational performance resonates with findings from Onwuegbuchunam et al. (2021), who examined Nigerian seaports. Their research also highlighted the role of sound port policies in improving operational outcomes, noting that well-structured policies can mitigate operational inefficiencies. Similarly, Nguyen et al. (2021) found a positive correlation between port policy implementation and performance in Vietnamese seaports, suggesting that policy reforms tailored to port-specific needs can have a substantial impact on performance outcomes. The present study extends these conclusions by showing that the effect of port policies is further strengthened when leadership commitment is high. This finding builds upon existing knowledge by demonstrating the critical moderating role of leadership, which echoes the conclusions of Akinyemi (2022). Akinyemi's review of African port leadership pointed out that leadership commitment not only drives policy success but also fosters a culture of accountability and operational excellence. Thus, the current study confirms the importance of leadership as a reinforcing mechanism that ensures the successful application of port policies, particularly in diverse operational environments.

The results also demonstrate a significant positive relationship between infrastructure development and operational performance, which is consistent with studies such as Liu et al. (2021) in China and Munim and Schramm (2023) on a global scale. These scholars emphasized the critical role that modern infrastructure plays in enhancing port efficiency, reducing bottlenecks, and improving cargo handling capacities. In this study, the SEM results revealed that infrastructure development contributed meaningfully to performance improvements, though the impact was slightly weaker than leadership commitment's role.

The moderation analysis highlights that leadership commitment not only improves the direct relationship between policies and performance but also significantly amplifies the effect of infrastructure development. This supports the view presented by Cahoon et al. (2020), who emphasized that leadership's influence is pivotal in realizing the full potential of infrastructural investments. Effective leadership can align infrastructure projects with strategic objectives, thus maximizing their impact on performance. This interaction effect between leadership and infrastructure development has been observed in Canadian ports as well, where leadership played a crucial role in bridging the gap between infrastructure upgrades and performance outcomes (Ashrafi et al., 2019).

However, while leadership commitment's moderating effect on infrastructure development is significant, the results of this study show a slightly stronger moderation effect on the relationship between port policies and operational performance. This implies that leadership commitment may play a more vital role in policy implementation than in the success of infrastructure development. This finding contrasts with earlier work by Ferchen and Perera (2019), who found that in Chinese infrastructure projects, leadership's role was more critical in ensuring that infrastructure developments aligned with operational goals. The differences could be attributed to the specific contexts of the studies; in more regulated environments such as China, infrastructure projects may be more directly influenced by government leadership compared to ports operating under market-driven frameworks.

The high explanatory power of the model ($R^2 = 0.673$) further underscores the substantial role that port policies, leadership commitment, and infrastructure development play in operational performance. This finding is supported by Rodrigue and Notteboom (2020), who noted that well-integrated port strategies tend to explain a significant proportion of performance variance in diverse settings. Moreover, the study's findings reinforce the conclusion that leadership commitment is the most influential factor among the predictors, as demonstrated by its largest path coefficient ($\beta = 0.385$). This corresponds with the observations of Alamoush et al. (2023), who concluded that leadership is often the driving force behind sustainable port performance.

In summary, the results of this study contribute to the literature by confirming the importance of port policies, leadership commitment, and infrastructure development in enhancing operational performance. The findings suggest that leadership commitment not only has a direct effect but also amplifies the effects of both port policies and infrastructure development, particularly in fostering an environment where these initiatives can thrive. These insights align with and extend previous research, adding depth to the understanding of how leadership can act as a catalyst in port operations. While policies and infrastructure are essential, their effectiveness is significantly enhanced when supported by committed leadership.

Managerial implications

The study findings suggest the need to develop leadership training programs focusing on strategic alignment, operational excellence, and change management to improve the application of port policies and infrastructure utilization.

Managers must engage in participatory leadership practices that involve employees, contractors, and other stakeholders in decision-making to build trust and foster a culture of accountability.

Port managers must acknowledge that infrastructure development projects are closely tied to specific operational performance goals coupled with commitment from leadership. It is again, important to emphasize that senior managers and leadership teams must be assigned to oversee key policy initiatives and ensure strategic alignment among policies, infrastructure and leadership.

Policy implications

In the quest to enhance performance at port, port authorities and policymakers must be encouraged to design policies that directly address key inefficiencies in port operations, with clear objectives linked to measurable outcomes. This means that performance-based policy frameworks must be developed to drive the achievement of operational goals. Infrastructure-responsive policies plan is required to align long term strategic objectives of the port. Policies must incorporate mechanisms that recognize and reinforce the role of leadership in their execution. For example, policies could mandate leadership oversight in infrastructure projects or establish accountability measures for leaders during policy implementation.

Limitations and Areas for Future Research

The research relied on cross-sectional data, capturing relationships at a single point in time. This approach limits the ability to establish causal inferences or observe how relationships between port policies, leadership commitment, and operational performance evolve over time. Future researchers could consider longitudinal studies to track the direction of policies and infrastructure development that is creating the required performance. This would provide deeper insights into the interactive effect of port policies, infrastructure and performance and their long-term impact.

While the study focused on internal drivers of performance (e.g., policies, leadership, infrastructure), external factors such as global trade disruptions, geopolitical risks, and technological advancements were not explicitly modeled, potentially leaving out key determinants of port performance. Further studies could integrate external variables such as global supply chain disruptions, trade policy shifts, or emerging technologies like automation and artificial intelligence, assessing their moderating or mediating effects on operational performance.

Expanding the analysis to include different leadership styles (e.g., transformational, transactional, servant leadership) could provide more granular insights into the specific leadership behaviors that maximize the effectiveness of policies and infrastructure investments.

REFERENCES

Alamoush, A. S., Ballini, F., & Ölçer, A. I. (2020). Ports' technical and operational measures to reduce greenhouse gas emission and improve energy efficiency: A review. Marine Pollution Bulletin, 160, 111508.

Alamoush, A. S., Ballini, F., & Ölçer, A. I. (2021). Revisiting port sustainability as a foundation for the implementation of the United Nations Sustainable Development Goals (UN SDGs). Journal of Shipping and Trade, 6, 1-40.

Alamoush, A. S., Ballini, F., & Dalaklis, D. (2023). Port leadership and sustainable port performance: A systematic literature review. Sustainability, 15(3), 2506.

Akinyemi, Y. C. (2022). Port leadership and performance in Africa: A systematic review and future research agenda. Maritime Policy & Management, 49(3), 344-364.

Ashrafi, M., Acciaro, M., Walker, T. R., Magnan, G. M., & Adams, M. (2019). Corporate sustainability in Canadian and US maritime ports. Journal of Cleaner Production, 220, 386-397.

Azarkamand, S., Wooldridge, C., & Darbra, R. M. (2020). Review of initiatives and methodologies to reduce CO2 emissions and climate change effects in ports. International journal of environmental research and public health, 17(11), 3858.

Balla, M., Fernández-González, A., Sanchez-Carricondo, R., & Fernández-Pérez, R. (2022). Port performance indicators and their relationships: A systematic literature review. Maritime Policy & Management, 49(5), 716-736.

Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of management, 17(1), 99-120.

Cahoon, S., Pateman, H., & Chen, S. L. (2020). Port leadership in innovation: Challenges andopportunities. In Sustainable Shipping(pp. 245-268). Springer, Cham.

Castellano, R., Ferretti, M., Musella, G., & Risitano, M. (2020). Evaluating the economic and environmental efficiency of ports: Evidence from Italy. Journal of Cleaner Production, 271, 122560.

Clarkson, M. E. (1995). A stakeholder framework for analyzing and evaluating corporate social performance. Academy of management review, 20(1), 92-117. Duru, O., Galvao, C. B., Mileski, J., Robles, L. T., & Gharehgozli, A. (2020). Developing a comprehensive approach to port performance assessment. The Asian Journal

of Shipping and Logistics, 36(4), 169-180.

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. Academy of management review, 14(1), 57-74.

Fama, E. F., & Jensen, M. C. (1983). Separation of ownership and control. The journal of law and Economics, 26(2), 301-325.

Ferchen, M., & Perera, A. (2019). Why unsustainable Chinese infrastructure deals are a two-way street. Carnegie-Tsinghua center for global policy, 22.

Freeman, R. E. (2010). Strategic management: A stakeholder approach. Cambridge university press.

Gonzalez-Aregall, M., Cullinane, K., & Vierth, I. (2021). A review of port initiatives to promote freight modal shifts in Europe: evidence from port governance systems. Sustainability, 13(11), 5907.

Ha, M. H., Yang, Z., & Lam, J. S. L. (2019). Port performance in container transport logistics: A multi-stakeholder perspective. Transport Policy, 73, 25-40.

Hossain, T., Adams, M., & Walker, T. R. (2019). Sustainability initiatives in Canadian ports. Marine Policy, 106, 103519.

Hurley, J., Morris, S., & Portelance, G. (2019). Examining the debt implications of the Belt and Road Initiative from a policy perspective. Journal of Infrastructure, Policy and Development, 3(1), 139-175.

Ibrahim, M., Saputra, J., Adam, M., & Yunus, M. (2022). Organizational culture, employee motivation, workload and employee performance: A mediating role of communication. WSEAS Transactions on Business and Economics, 19, 54-61.

Jensen, M. C., & Meckling, W. H. (2019). Theory of the firm: Managerial behavior, agency costs and ownership structure. In Corporate governance (pp. 77-132). Gower.

Julus, L. C., & ODIEGWU, C. L. (2019). Effect of liner shipping on container terminal performance of Apapa and Onne ports in Nigeria. Transportation Research Part A: Policy and Practice, 49, 285-301.

Lawer, E. T. (2019). Examining stakeholder participation and conflicts associated with large scale infrastructure projects: the case of Tema port expansion project, Ghana. Maritime Policy & Management, 46(6), 735-756.

Kull, T. J., Kotlar, J., & Spring, M. (2018). Small and medium enterprise research in supply chain management: The case for single-respondent research designs. Journal of Supply Chain Management, 54(1), 23–34. https://doi.org/10.1111/ jscm.12157

Li, Y., Zhang, X., Lin, K., & Huang, Q. (2019). The analysis of a simulation of a port–city green cooperative development, based on system dynamics: A case study of Shanghai port, China. Sustainability, 11(21), 5948.

Liang, Y., Wang, K., & Zhu, X. (2022). Evaluating port performance using factor analysis and structural equation modeling: An application to Asian ports. Maritime Policy & Management, 49(6), 848-866.

Liu, J., Wang, X., & Guo, J. (2021). Port efficiency and its influencing factors in the context of pilot free trade zones. Transport Policy, 105, 67-79.

Liu, Z., Schindler, S., & Liu, W. (2020). Demystifying Chinese overseas investment in infrastructure: Port development, the Belt and Road Initiative and regional development. Journal of Transport Geography, 87, 102812.

MacNeil, J. L., Adams, M., & Walker, T. R. (2021). Development of framework for improved sustainability in the Canadian Port Sector. Sustainability, 13(21), 11980.

Mitchell, R. K., Agle, B. R., & Wood, D. J. (1997). Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. Academy of management review, 22(4), 853-886.

Moktadir, M. A., Kumar, A., Ali, S. M., Paul, S. K., Sultana, R., & Rezaei, J. (2020). Critical success factors for a circular economy: Implications for business strategy and the environment. Business strategy and the environment, 29(8), 3611-3635.

Munim, Z. H., & Schramm, H. J. (2023). Port development and economic growth: Panel evidence from global panel data. Maritime Economics & Logistics, 25(1), 1-21. Nanyam, V. N., & Jha, K. N. (2022). Conceptual Model for the Operational Performance of the Container Terminals in India. Journal of Waterway, Port, Coastal, and

Ocean Engineering, 148(4), 04022011.

Nguyen, L. C., Notteboom, T., & Gheisari, M. (2021). The impact of port policy and infrastructure development on operational performance: A study of Vietnamese seaports. Maritime Policy & Management, 48(4), 508-528.

North, D. C. (1990). Institutions, institutional change and economic performance.

Cambridge university press.

Notteboom, T., & Yang, Z. (2017). Port governance in China since 2004: Institutional layering and the growing impact of broader policies. Research in transportation business & management, 22, 184-200.

Onwuegbuchunam, D. E., Okeke, K. O., & Igboanusi, C. (2021). Port policies and operational performance: Evidence from Nigerian seaports. Research in Transportation Business & Management, 41, 100663.

Panayides, P. M., Athanasios, A. P., & Aouad, T. (2021). Port governance and performance: A systematic literature review. Transport Reviews, 41(5), 586- 618.

Peteraf, M. A. (1993). The cornerstones of competitive advantage: a resource-based view. Strategic management journal, 14(3), 179-191.

Rindfleisch, A., Malter, A. J., Ganesan, S., & Moorman, C. (2008). Cross-sectional versus longitudinal survey research: Concepts, findings, and guidelines. Journal of Marketing Research, 45(3), 261–279. https://doi.org/10.1509/jmkr.45.3.2

Rodrigue, J. P., & Notteboom, T. (2020). Ports and economic development. Port economics, management and policy.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic Management Journal, 18(7), 509-533.

Teerawattana, R., & Yang, Y. C. (2019). Environmental performance indicators for green port policy evaluation: case study of Laem Chabang port. The Asian Journal of Shipping and Logistics, 35(1), 63-69.

Williamson, O. E. (1985). firms, markets, relational contracting. The economic institutions of capitalism.

Harnessing Renewable Energy for Sustainable Blue Economy Development

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ABSTRACT

The transition to renewable energy is essential for sustainability in Ghana's blue economy, particularly in fisheries, aquaculture, ports, and coastal tourism. This study explores how renewable energy integration can mitigate environmental impacts and ensure economic viability. Key objectives include: (1) assessing current energy consumption in coastal Ghana, (2) evaluating renewable energy technologies for cost-effectiveness, scalability, and emission reductions, (3) analyzing global case studies of successful adoption, and (4) proposing policies to promote renewable energy. A mixed-methods approach combines quantitative data on fuel use, energy intensity, renewable capacity, and carbon emissions with qualitative insights from interviews with experts, policymakers, and stakeholders. Technologies such as offshore wind, solar, tidal, and wave energy are evaluated for their potential economic and environmental benefits. The study also considers biodiesel alternatives (Jatropha oil, Sunflower oil, Algal oil) for logistics in the sectors under review. Challenges include high initial costs for ports, technical limitations in fisheries (e.g., solar-powered vessels), limited local expertise, and inconsistent energy supplies affecting processing and tourism. Drawing on global and local case studies, the research identifies scalable renewable energy models. Policy recommendations include financial incentives, mandates, investments in R&D, public-private partnerships, and supportive regulatory frameworks to accelerate renewable energy adoption. These strategies aim to meet global climate goals while enhancing the economic and environmental resilience of Ghana's coastal communities.

Keywords: Aquaculture, blue economy, coastal tourism, fisheries, ports, renewable energy.

INTRODUCTION

The blue economy encompasses the sustainable use of ocean and coastal resources for economic growth, improved livelihoods, and marine ecosystem health (Underwood & Stempel, 2022). In Ghana, key sectors such as fisheries, aquaculture, maritime transport, and coastal tourism form the foundation of the blue economy, contributing significantly to the country's socioeconomic development (Ministry of Fisheries and Aquaculture Development, 2021). However, the heavy dependence on non-renewable energy sources in these sectors raises critical environmental, economic, and sustainability concerns (Knodt et al, 2023; Hagan & Amissah, 2022). Ghana's location along the Gulf of Guinea makes its blue economy central to the livelihoods of millions, with fisheries and aquaculture playing a vital role (Energy

Commission of Ghana, 2020). These sectors employ over 2 million people and rely on energy-intensive processes, such as diesel-powered artisanal fishing vessels and electricity-dependent refrigeration and processing facilities (FAO, 2016; Ministry of Fisheries and Aquaculture Development, 2021).

Similarly, aquaculture operations require substantial energy for water pumping, aeration, and temperature control, with costs exacerbated by the reliance on fossil fuels (Energy Commission of Ghana, 2020). Ports like Tema and Takoradi are also energy- intensive hubs, consuming large amounts of diesel and electricity for cargo handling, refrigerated storage, and lighting (Ministry of Fisheries and Aquaculture Development, 2021). Coastal tourism, another expanding sector, requires significant energy for accommodations, water desalination, and hospitality services. With tourism poised for further growth, energy inefficiencies pose a risk to sustainable expansion (United Nations, 2020). The reliance on fossil fuels in Ghana's blue economy brings numerous challenges. High energy costs and exposure to volatile fuel prices impact operational efficiency, while greenhouse gas emissions contribute to climate change (Hagan & Amissah, 2022). These challenges emphasize the urgent need to transition to renewable energy solutions that can stabilize costs, reduce environmental impacts, and align with Ghana's climate commitments under the Paris Agreement (United Nations, 2020). Renewable energy technologies such as solar, wind, and marine energy hold promise for powering Ghana's blue economy sustainably. Solar energy, given Ghana's abundant sunlight, can be utilized for aquaculture water pumping, fisheries refrigeration, and lighting in coastal tourism facilities (Energy Commission of Ghana, 2020). Coastal wind energy can support port operations and maritime activities, while marine energy from tides and waves offers long-term potential to complement the renewable energy mix (Cavagnaro et al, 2020). The integration of renewables can mitigate climate change impacts, enhance energy security, and support Ghana's Renewable Energy Master Plan, which aims for a 10% renewable energy share in electricity generation by 2030 (Energy Commission of Ghana, 2020).
Transitioning to renewables not only aligns with Ghana's Nationally Determined Contributions (NDCs) but also offers economic benefits for coastal communities vulnerable to climate change (United Nations, 2020). Despite the advantages, several barriers hinder the widespread adoption of renewable energy in Ghana's blue economy. High upfront costs, limited technical expertise, and inadequate policy frameworks are major obstacles (Ministry of Fisheries and Aquaculture Development, 2021). For instance, deploying solar and wind systems requires significant investment in infrastructure and capacity-building. Integrating renewables into existing operations, such as fishing vessels and port activities, poses technical challenges that demand targeted research and development (Hagan & Amissah, 2022). Addressing these barriers presents opportunities for innovation and collaboration. Public- private partnerships (PPPs), international development assistance, and advancements in renewable technologies can drive the adoption of clean energy solutions (FAO, 2016). Government initiatives like the National Energy Transition Framework and policies that incentivize renewable energy investments are critical for overcoming financial and technical hurdles (Ministry of Energy, 2022). Global collaboration can further accelerate Ghana's transition to a sustainable blue economy. This research explores renewable energy's potential to power Ghana's blue economy efficiently and sustainably. It examines current energy consumption patterns, evaluates renewable technologies, and identifies integration pathways for fisheries, aquaculture, ports, and tourism. By providing actionable insights and policy recommendations, the study aims to enhance livelihoods, preserve marine ecosystems, and bolster Ghana's climate resilience (United Nations, 2020). Ultimately, the goal is to foster a sustainable blue economy that aligns with national and global climate action goals (Energy Commission of Ghana, 2020).

RESEARCH METHODOLOGY

This section outlines the approach and methods used to investigate the integration of renewable energy, specifically offshore wind, solar, tidal, wave energy and biodiesel into Ghana's blue economy. The section looked at the historic energy consumption for all the four key sectors of the blue economy Thereafter, the future demand fuels and electricity consumption were modelled to determine possible GHG emissions into the future for all the four sectors of the blue economy. The methodology comprises the following steps.

Data Collection: Data collection was carried out using surveys, interviews, and site visits. The main sources of data are Ghana Port and Harbour Authority, Ministry of Fisheries and Aquaculture Development (MOFAD), Fisheries Commission and Ministry of tourism

Surveys: Distributed to stakeholders within the blue economy, including fishermen, aquaculture operators, port authorities, and tourism operators, to gather insights into their energy requirements.

Interviews: Conducted with policymakers, renewable energy experts, and business leaders to understand barriers and opportunities for renewable energy adoption.

Site Visits: Conducted at fishing ports, aquaculture farms, and coastal facilities to assess real-world energy needs and identify suitable locations for renewable energy installations.

Technical and Economic Feasibility Assessment: The technical and economic feasibility of implementing renewable energy in blue economy projects was evaluated. This include assessment of renewable energy potential, available technologies, and site- specific conditions. Also, estimating installation costs, operational savings, greenhouse emissions savings and return on investment (ROI) to determine the financial viability of renewable energy integration.

Case Study Analysis: Case studies and success stories of renewable energy integration in blue economy sectors, both within and outside Ghana, were analyzed. These examples provided insights into best practices, lessons learned, and critical factors for effective implementation, such as stakeholder engagement and technological considerations.

Policy Recommendations and Strategy Development: Based on findings from the previous steps, policy recommendations and strategies were developed to address barriers to renewable energy adoption. These included suggestions to enhance regulatory frameworks, incentivize investments, and promote sustainable energy practices across Ghana's blue economy.

Scope of the Study

The study is specifically focused on the coastal areas of Ghana. Ghana's coastline spans several regions, each with unique features. Greater Accra Region, known for its capital city, Accra, and bustling urban beaches like Labadi Beach. Central Region, which is famous for historical landmarks like Cape Coast Castle and Elmina Castle, as well as scenic beaches. Western Region is also home to some of Ghana's most pristine beaches, including those in Takoradi, Axim, and Busua. Volta Region also known for its coastal lagoons, rivers, and scenic beaches, such as those in Ada and Keta.

Specific areas where this work focused on are Ghana port (Tema port and Takoradi port), Aquaculture (key ares are Kpeve, Kpong, and Akosombo, Asuogyaman District, lake volta adjacent areas, Tema, Kumasi, Nzema East and Shama, Winneba and Cape Coast, Tano River), Fisheries (key areas are Tema, Jamestown (Accra), Teshie and Nungua, Cape Coast, Elmina, Winneba, Anomabo, Takoradi, Axim, Dixcove, shama, Keta, Anloga, Ada, Half Assini) and Coastal tourism (key areas are Labadi Beach (Accra), Bojo Beach, Jamestown, Cape Coast, Elmina, Anomabo, Winneba, Takoradi, Busua Beach, Axim, Dixcove, Keta, Ada Foah, Half Assini)

RESULTS AND DISCUSSION

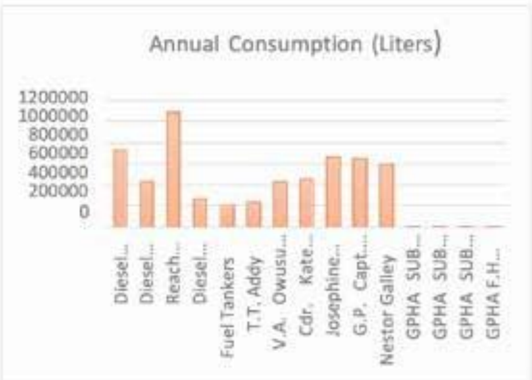
Fuel Energy Consumption for Ghana Port Operation

Energy consumption at the Ghana Ports and Harbours Authority (GPHA) involves both electrical and fuel energy across its two main ports namely, Tema and Takoradi. These energy sources power port operations, equipment, facilities, and infrastructure. Fuel consumption is essential for heavy-duty machinery, transport, and backup power in the port, particularly for activities where electricity isn't viable due to high power requirements or operational demands. The primary fuel sources used are diesel and marine fuel. The data from Ghana Port and Harbour Authority provided details of fuel consumption at Ghana's port operations across various equipment categories, including cranes, forklifts, tugboats, pilot boats, salvage boats, patrol boats, mooring launches, and generatorsThe Reach Stackers have the highest daily fuel consumption, likely indicating their intensive use or higher operational demand. The data lists six tugboats with fuel consumption ranging from 645 to 1,823 liters per day. The Josephine Asante tugboat has the highest daily consumption (1,823 liters), while the T.T. Addy has the lowest at 645 liters. Variation in fuel consumption suggests different usage intensities or power capacities among the tugboats. Patrol Boats: Consumption varies, with Joseph Adorkor using 193 liters and Cletus Adugbire using 93 liters. Pilot Boats: Consumption ranges from 80 to 482 liters, with the Adjei Kumi Sam being the highest consumer at 482 liters, while others, like Osagyefo and Frederick Damalie, consume less (90 and 80 liters, respectively). The difference in fuel consumption may reflect variations in operational distances or the frequency of missions for each vessel. The data also lists several generator sets, varying in capacity (250 KVA to 1.7 MVA), with fuel consumption per year ranging from 507.76 liters (GPHA F.H Security) to 7,882.83 liters (GPHA Reefer Terminal). Larger capacity generators, such as the 1.7 MVA at GPHA Sub #6, generally have higher annual fuel needs. However, some lower-capacity generators like the 550 KVA at the Reefer Terminal exhibit high annual consumption, which could indicate sustained usage. Among equipment, Reach Stackers use the most diesel daily, with vessels, the Josephine Asante tugboat is the largest consumer and for generator sets, GPHA Reefer Terminal has the highest annual consumption.

Annual Energy Consumption Estimate

The annual energy consumption for Ghana Port Operation refers to the total amount of energy required over a year for all operations at the port, including equipment, vessels, and generators. It is calculated based on the daily diesel consumption values provided and converted into energy using diesel's energy content. Figure 3.2 depicts the annual fuel usage by equipment type. Diesel fuel has an approximate energy content of 10 kWh per liter. This is used to convert diesel consumption (in liters) into energy (in kilowatt- hours, kWh). The annual Diesel

Projected Annual Energy Consumption



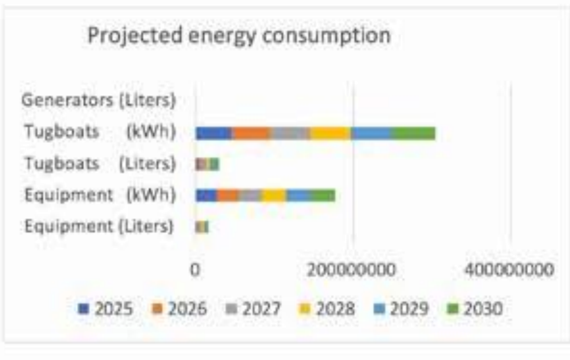


Figure 3.2: Annual fuel usage by equipment type Figure 3.3: Projected energy consumption

from 2025 -2030

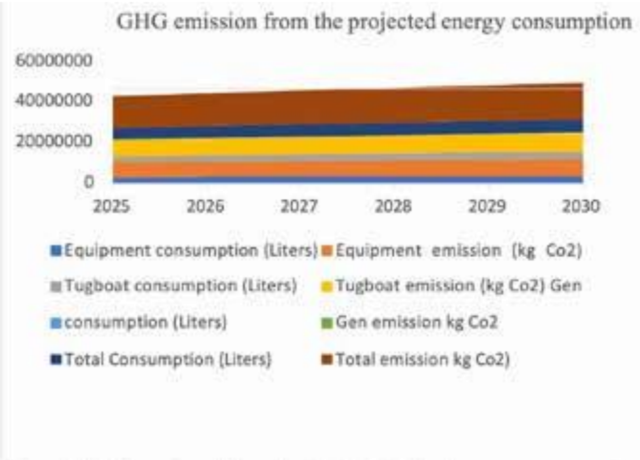
Consumption for each item = Daily Consumption (liters) × 365. Annual Energy Consumption (kWh) for each item = Annual Diesel Consumption × 10. By summing up the energy consumption for equipment, vessels, and generators, the grand total is 58,145,046kWh/year(≈58.1GWh/year).

The projected annual energy consumption refers to the total energy requirement for Ghana Port operations, derived from the projected diesel consumption for various categories: Figure 3.3 projected energy consumption from 2025 -2030 Equipment, Tugboats, and Generators. It is calculated by converting diesel consumption into energy (kilowatt- hours, kWh) using diesel's energy content. Projected annual energy consumption is given by the expression, Base Annual Consumption×(1−h) 2025. The projected annual diesel consumption from 2025 to 2030 reveals key insights into energy demand trends for Ghana Port operations across Equipment, Tugboats, and Generators. The 3% annual growth rate applied to all categories results in a consistent increase in diesel consumption over the six-year period. The total diesel consumption grows from approximately 5.84 million liters (58.39 GWh) in 2025 to 6.77 million liters (67.69 GWh) in 2030, representing a 16% increase over the projection period.

Projected Greenhouse Gas Emissions

Using the emissions factor of 2.68 kg CO_2 per liter of diesel, GHG emissions increase proportionally with energy consumption. Figure 4 gives projected emission from 2025 -2030. The total emission grows from approximately 15.64 million kg CO_2 (15,640 metric tons) in 2025 to 18.14 million kg CO_2 (18,140 metric tons) in 2030, representing a 16% increase over the projection period, mirroring the rise in diesel consumption.

Energy Consumption in Fishing Sector of Ghana



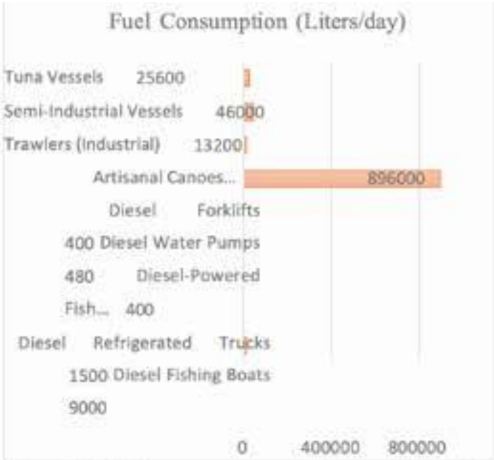


Figure 3.4: Projected emissions from 2025-2030 in the port sector. Figure 3.5: Daily energy consumption per day in the fishing sector

The daily energy consumption is the sum of the fuel consumption for all equipment listed in the dataset. Figure 3.5 shows daily energy consumption per day. Each equipment type contributes a specific amount to the overall daily fuel usage. The total daily energy consumption is 992,580 liters per day.

Projected Energy Consumption (2025–2030)

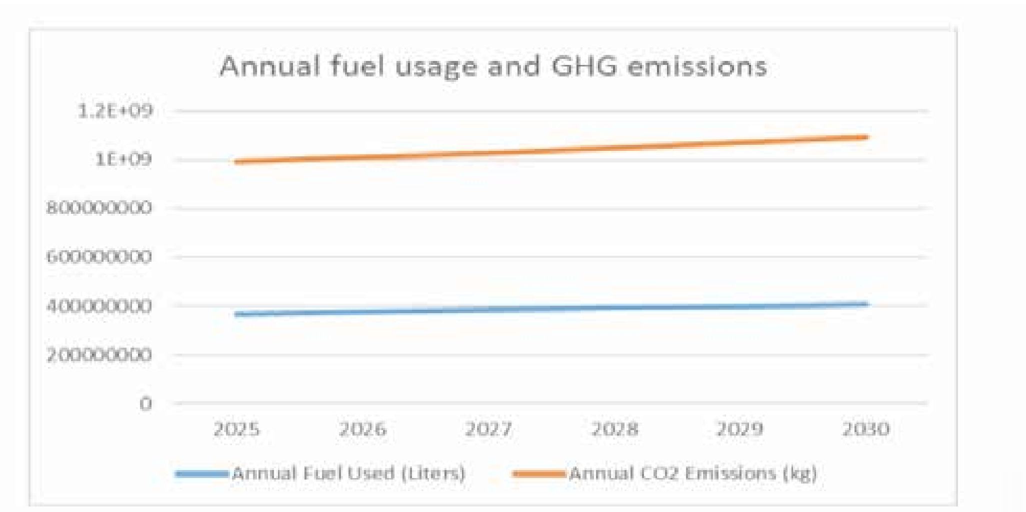
To forecast future energy consumption, the annual growth rate is assumed to be 2%. This rate accounts for increased activity, growth in operations, or population changes in the fishing community. The base year is 2024, with daily consumption of 992,580 liters. Future Consumption = Current Consumption × (1−h) 2025. Table 1 shows daily and annual usage in the fishing sector while Figure 3.6 depicts annual GHG emission for fishery sector. The daily consumption grows from 1,012,431 liters/day in 2025 to 1,117,806 liters/day in 2030. This reflects a steady rise in energy demand, driven by the assumed growth rate. By 2030, the daily consumption is projected to increase by about 12.6% compared to 2024 levels. By 2030, daily energy consumption increases by approximately 12.6% compared to 2024 levels. Also, by 2030, annual CO_2 emissions will rise to 1.092 million tons, an increase of around 12.6% from 2024.

Energy Consumption in the Aquaculture Sector of Ghana

Table 1: Daily and annual fuel usage in fishing sector

Year	Daily energy consumption (Liters)	Annual fuel use (Liters)
2025	1012431	369535315
2026	1032680	376923200
2027	1053333	384432469
2028	1074400	392064456
2029	1095888	399820578
2030	1117806	407702439

Figure 3.6: Annual GHG emission for fishery sector



The total daily energy consumption for the aquaculture equipment provided is calculated by summing up the average fuel consumption (in liters/day) for each equipment type. Figure 3.7 shows the daily energy consumption for aquaculture sector. The total daily energy consumption is 58800liters/day, representing the amount of fuel required to operate all the equipment on an average day.

Projected Energy Consumption (2025–2030)

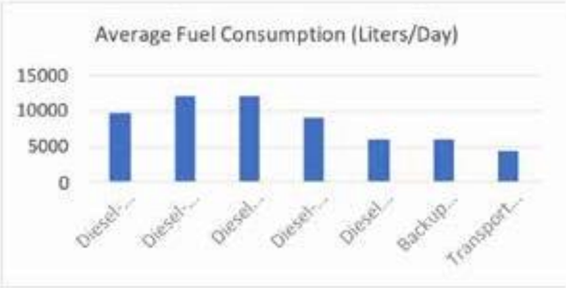
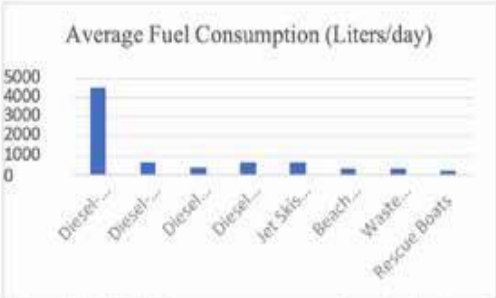


Figure 3.7: Daily energy consumption for Aquaculture Sector, Figure 3.8: Forecast of energy consumption and GHG emission in the Aquaculture sector



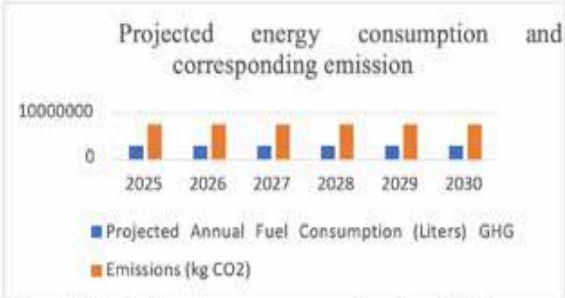


Figure 3.9: (a) Daily energy consumption in the Coastal Tourism

Figure 3.10: Projected energy consumption from 2025 to 2030 in the Coastal Tourism

To predict the daily energy consumption from 2025 to 2030, work assumed an annual growth rate of 2%.This reflects a gradual increase in fuel usage, potentially due to expansion in operations, additional equipment, or increased usage. The formula for calculating each year's projected daily consumption is given by the expression, Future Consumption =Current daily Consumption×Current Consumption × (1−h) 2025. Figure 3.8 shows the forecast of energy consumption and GHG emission. The predicted daily consumption increases each year due to the 2% growth assumption. By 2030, the daily consumption is expected to reach approximately 66,217 liters/day, which is about 12.5% higher than the current daily consumption of 58,800 liters/day. This pattern provides insights into planning for fuel supply, operational costs, and potential environmental impacts over the next decade. To estimate greenhouse gas (GHG) emissions, work considered an emission factor that relates fuel consumption to the amount of GHG emitted. For diesel fuel, a commonly used emission factor is 2.68 kg of CO_2 per liter of diesel burned. The expression for GHG emissions from 2025 to 2030 is given by GHG Emissions (kg/day) = Daily Consumption (liters)×2.68.

Energy Consumption in Coastal Tourism Sector of Ghana

The provided data outlines the average daily fuel consumption for various diesel- powered equipment. This data was used to calculate the total daily energy consumption and project annual energy consumption from 2025 to 2030. Figure 3.9 shows daily energy consumption in the tourism sector while Figure 3.10 shows the projected energy consumption from 2025 to 2030. The total daily and annual fuel consumption are 7425liters/day and 2,709,125liters/year respectively. This total reflects the daily operational demand for diesel fuel by tourist boats, buses, forklifts, and other equipment. The greenhouse gas emissions are estimated using the

diesel emission factor of 2.68 kg CO_2 per liter. GHG Emissions (kg CO_2) = Fuel Consumption (liters)×2.68. The annual GHG Emissions is estimated to be 7,259,457kg CO_2/year. This means that the operations would release approximately 7,259 metric tons of CO_2 annually.
Total Daily and annual Fuel Consumption for the Four Sectors of Blue Economy The analysis provides insights into the current and projected energy consumption and corresponding greenhouse gas (GHG) emissions for the critical sectors (fisheries, aquaculture, ports, and coastal tourism) of the blue economy. The total energy consumption is 1,081,568 liters/day. This figure represents the sum of diesel usage across all listed equipment and vehicles operating daily at all the four sectors under study. Major contributors include artisanal canoes with outboard motors, trawlers, tuna vessels, and other high-consuming units. Similarly, the total annual energy consumption is 394,807,952 liters/year. This is derived by adding annualized daily consumption (daily total × 365 days) to directly provided annual consumption figures. It highlights the immense energy demand of the port's operations over a year.

Future Energy Consumption and GHG Emissions

A 3% annual growth rate reflects an expected increase in operations of all the four critical sectors of the blue economy, population, or industrial activities, leading to higher energy needs. From 406 million liters in 2025 to 471 million liters in 2030, consumption grows steadily each year. Also, diesel consumption translates into significant emissions due to diesel's emission factor (2.68 kg CO_2 per liter). Emissions rise from 1.09 billion kg CO_2 in 2025 to 1.26 billion kg CO_2 in 2030, reflecting the environmental impact of increasing energy use. Table 2 gives detail analysis of the future consumption and the GHG emission patterns.
Feasibility and Benefit of Adoption of Replacing Diesel with Biodiesels

Table 2: Projected Energy Consumption and GHG Emissions (2025–2030)

Year	Energy Consumption (liters/year)	GHG Emissions (kg CO2/ year
2025	406,652,191	1,089,827,872
2026	418,851,757	1,122,522,708
2027	431,417,309	1,156,198,389
2028	444,359,829	1,190,884,341
2029	457,690,623	1,226,610,871
2030	471,421,342	1,263,409,197

To evaluate the feasibility and benefits of replacing diesel with biodiesels such as Jatropha oil, Sunflower oil, and Algal oil biodiesel for all the four sectors of the blue economy, certain key aspects is analysed: technological readiness, cost-effectiveness, scalability, and emissions reduction potential.

Technological Readiness - Biodiesel Compatibility

With Jatropha Oil it is highly compatible with existing diesel engines after minimal modification. It has proven as a viable fuel in various applications; supported by adequate research and field tests. Sunflower Oil is readily usable in modified diesel engines; straight vegetable oil (SVO) also an option but requires pre-heating. It has higher viscosity than diesel, leading to potential clogging without blending. Algal Oil is a newer option and requires advanced production technology. It can be converted to biodiesel via transesterification, suitable for conventional diesel engines. Jatropha and Sunflower oils are immediately deployable with existing engine technology. Algal oil biodiesel is less mature, needing further innovation to optimize extraction and conversion.

Cost-Effectiveness - Production and Market Costs

Jatropha Oil has relatively low production cost and requires marginal land unsuitable for food crops. The estimated production costs range from $0.50 to $1.00 per liter, cheaper in regions where Jatropha grows naturally. Sunflower Oil has higher production cost due to competition with edible oil markets and intensive cultivation inputs. The costs are typically higher than Jatropha ($1.10–$1.50 per liter). Algal Oil has high production cost ($5–$10 per liter) due to energy-intensive cultivation, harvesting, and oil extraction processes. It shows sign of significant potential for cost reduction with technological advancements and economies of scale. Jatropha oil biodiesel is the most cost-effective option for immediate deployment. Algal oil is currently expensive but holds long-term potential.

Scalability - Supply Chain and Resource Availability

Jatropha Oil has high scalability in Ghana and other tropical regions. It can be cultivated on non-arable land, but the large-scale adoption may face limitations in seed production and processing infrastructure. The sunflower Oil has limited scalability in regions where Sunflower cultivation is not already widespread. It competes directly with food markets, leading to concerns about food security. With Algal Oil, theoretical scalability is vast; algae can be grown in ponds, wastewater, or photo-bioreactors. It is currently hindered by lack of infrastructure and high capital investment requirements. Jatropha oil is the most scalable in local contexts, while algal oil could be scalable globally if costs decrease.

Emissions Reduction Potential - Lifecycle GHG Emissions

The lifecycle emissions of Jatropha oil are 40%–80% lower than diesel due to carbon sequestration during Jatropha growth. It has significant reductions in particulate matter and sulfur oxide emissions. The Sunflower oil is similar to Jatropha, the lifecycle GHG emissions are reduced by 50%–80% compared to diesel. The blended fuels reduce engine wear and enhance efficiency. Algal Oil offers the lowest emissions (up to 90% reduction compared to diesel), as algae absorb large amounts of CO_2 during cultivation. It has a potential to produce biofuel with minimal land-use impact. All options dramatically reduce emissions compared to diesel, with Algal oil offering the greatest reduction potential.

Operational Benefits

It has lower GHG emissions, since all biodiesels offer cleaner combustion. The use of biodiesel reduces dependence on imported diesel, especially if locally produced. It promotes local agriculture and industrial growth.

Operational Challenges

It has initial cost of engine modifications for compatibility. It requires investment in biodiesel production and distribution infrastructure. There is seasonal variability in feedstock supply for Jatropha and Sunflower oils. Table 3 provides a summary of the feasibility and benefits of replacing diesel with biodiesel.

Alternative Scenarios for Greenhouse Gas Emissions Savings Using

Table 3: Feasibility and benefits of replacing diesel with biodiesels

Factor	Jatropha oil	Sunflower oil	Algal oil
Technological Readiness	High	Moderate	Low
Cost-Effectiveness	High	Moderate	Low
Scalability	High	Low	Moderate-High
Emissions Reduction	Moderate-High	Moderate	High

Biodiesel The replacement of diesel with biodiesel fuels from Jatropha oil, Sunflower oil, and Algal oil significantly reduces greenhouse gas (GHG) emissions. Below is an evaluation of GHG savings under different scenarios, considering the lifecycle emissions reductions provided by each biodiesel type.

Key Assumptions

Current Diesel Usage: Based on the four sectors (fisheries, aquaculture, ports, and coastal tourism) operations, total annual diesel consumption is approximately 394,807,952 liters/ year Emission Factor for Diesel: 2.68 kg CO_2 per liter of diesel. Emission Reductions: Jatropha oil: 0.6–1.6 (70%–85% reduction compared to diesel), Sunflower oil: 0.7–1.7 (65%–80% reduction) and Algal oil: 0.3–0.6 (85%–90% reduction). Table 4 shows alternative reduction for greenhouse gas emission savings. The emission reduction for Jatropha oil saved 426 to 821 million kg CO_2/year while sunflower oil saved 387 to 782 million kg CO_2/year. The algal oil saves 821 to 940 million kg CO_2/year, offering the largest reduction. Even the least effective alternative (Sunflower oil at a 65% reduction) saves over 380 million kg CO_2 annually. Transitioning entirely to Algal oil could cut emissions by up to 90%, a reduction of nearly 940 million kg CO_2.

Combined Strategy Scenarios Assumptions:

Table 4: Alternative Scenarios for Greenhouse Gas Emissions Savings

Fuel Type	Emission Factor (kg CO_2 /liter)	Annual Emissions (kg CO_2 /year)	Savings (%)	Savings (kg CO_2 /year)
Diesel	2.68	1,058,057,332	Baseline	-
Jatropha Oil	0.6–1.6	236,884,771–631,692,723	70%–85%	426,364,609–821,172,561
Sunflower Oil	0.7–1.7	276,365,566–671,172,519	65%–80%	386,884,812–781,691,766
Algal Oil	0.3–0.6	118,442,386–236,884,771	85%–90%	821,172,561–939,614,946

Fuel Requirement: Replace all diesel consumption (394,807,952 liters/year). Blending Ratios: Different shares of Jatropha, Sunflower, and Algal biodiesels are considered: Scenario 1: 50% Jatropha, 30% Sunflower, 20% Algal.

Scenario 2: 40% Jatropha, 40% Sunflower, 20% Algal.

Scenario 3: 30% Jatropha, 30% Sunflower, 40% Algal. Yields and Costs (per hectare/year): Jatropha: 1,500 liters, \$0.50–\$1.00/liter. Sunflower: 800 liters, \$1.10–\$1.50/liter. Algal Biodiesel: 40,000 liters, \$5.00–\$10.00/liter.

Table 5 shows combined strategy scenarios of the sources of biodiesel. Land requirements are highest for Scenarios 1 and 2 due to the larger share of Jatropha and Sunflower oils, which have lower yields. Scenario 3 requires the least land but shifts the cost burden to Algal biodiesel, which has high production costs. Scenario 1 is the most cost-effective, with total costs ranging from \$666M–\$1.22B/year. Scenario 3 is the most expensive, primarily due to the reliance on Algal biodiesel. Scenario 3 offers the highest GHG savings (80%) due to the larger share of Algal biodiesel. Scenario 1 strikes a balance, offering significant GHG savings (77.5%) at a lower cost.

Financial Viability of replacing diesel with Biodiesel

Table 5: Combined Strategy Scenarios

Scenario	Land (ha)	Cost ($/year)	GHG Savings (%)
Scenario 1	**Jatropha**: 131,603	**Jatropha**: $98.7M–$197.4M	77.5%
50% Jatropha	**Sunflower**: 148,052	**Sunflower**: $173.1M–$236.9M	
30% Sunflower	**Algal**: 1,974	**Algal**: $394.8M–$789.6M	
20% Algal	**Total**: 281,629	**Total**: $666.6M–$1,223.9M	
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Scenario 2	**Jatropha**: 105,283	**Jatropha**: $78.9M–$157.6M	75%
40% Jatropha	**Sunflower**: 197,404	**Sunflower**: $230.8M–$315.8M	
40% Sunflower	**Algal**: 1,974	**Algal**: $394.8M–$789.6M	
20% Algal	**Total**: 304,661	**Total**: $704.5M–$1,263M	
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Scenario 3	**Jatropha**: 78,962	**Jatropha**: $59.2M–$118.9M	80%
30% Jatropha	**Sunflower**: 148,052	**Sunflower**: $173.1M–$236.9M	
40% Algal	**Algal**: 3,948	**Algal**: $789.6M–$1,579.2M	
Total: 230,962	**Total**: $1,021.9M–$1,935M		

This aspect estimates the installation costs, operational savings, greenhouse gas (GHG) emissions savings, and return on investment (ROI) for using Jatropha, Sunflower, and Algal biodiesel to replace diesel. Table 6 shows a comprehensive table that demonstrates the financial viability of replacing diesel with Jatropha, Sunflower, and Algal biodiesel. This includes installation costs, annual savings, GHG emissions savings, monetized GHG savings, and ROI. The results show that Jatropha has annual savings of $276.4M (minimum cost scenario) to $79M (maximum cost scenario). With the corresponding GHG Savings of 821,172 tons of CO_2 (minimum emissions scenario). The return of investment (ROI) is 127% (maximum cost scenario) to 803.88% (minimum cost scenario). The sunflower biodiesel has annual savings of $39.5M (minimum cost scenario) to a loss of $118.4M (maximum cost scenario), while GHG savings is 781,692 tons of CO_2 (minimum emissions scenario). The ROI is 90.46% (minimum cost scenario) to -83.68% (maximum cost scenario). Algal biodiesel has annual Losses of $1.5B (minimum cost scenario) to $3.4B (maximum cost scenario). The GHG Savings is 939,614 tons of CO_2 (minimum emissions scenario), while ROI is -367.91% (minimum cost scenario) to -434.87% (maximum cost scenario). Jatropha biodiesel is the most financially viable option due to its low production costs and moderate GHG emission factor. The substantial cost savings and high ROI in the minimum cost scenario make it ideal for large-scale adoption. Sunflower biodiesel offers moderate GHG savings but struggles with cost-effectiveness. The minimum cost scenario yields a positive ROI, but high production costs in the maximum scenario lead to financial losses. Algal biodiesel achieves the highest GHG savings, reducing emissions by up to 90%, but is extremely costly due to its high production and infrastructure requirements. Negative ROI in both scenarios highlights that algal biodiesel is not financially viable with current technology. Long-term investments in research and development are needed to lower costs and make it competitive.

Integrating Offshore Renewable Energy Sources into Ghana's Blue

Table 6: Biodiesel Financial Viability

Metric	Jatropha (Min)	Jatropha (Max)	Sunflower (Min)	Sunflower (Max)	Algal (Min)	Algal (Max)
Annual Diesel Consumption (liters)	394,807,952	394,807,952	394,807,952	394,807,952	394,807,952	394,807,952
Diesel Price ($/liter)	1.20	1.20	1.20	1.20	1.20	1.20
Biodiesel Cost ($/liter)	0.50	1.00	1.10	1.50	5.00	10.00
Diesel Cost Avoided ($)	473,769,542.40	473,769,542.40	473,769,542.40	473,769,542.40	473,769,542.40	473,769,542.40
Biodiesel Cost ($)	197,403,976.00	394,807,952.00	434,288,747.20	592,211,928.00	1,974,039,760.00	3,948,079,520.0
Annual Savings ($)	276,365,566.40	78,961,590.40	39,480,795.20	(118,442,385.6)	(1,500,270,217.6)	(3,474,310,477.6)
GHG Emissions Diesel (kg)	1,058,057,332	1,058,057,332	1,058,057,332	1,058,057,332	1,058,057,332	1,058,057,332
GHG Emissions Biodiesel (kg)	236,884,771	631,692,723	276,365,566	671,172,519	118,442,386	236,884,771
GHG Savings (tons)	821,172.56	426,364.61	781,691.77	386,884.81	939,614.95	821,172.56
Monetized GHG Savings ($)	41,058,627.90	21,318,230.25	39,084,588.50	19,344,240.50	46,980,747.50	41,058,627.90
Total Savings ($)	317,424,194.30	100,279,820.65	78,565,383.70	(99,098,145.10)	(1,453,289,470.1)	(3,433,251,849.7)
Installation Cost ($)	39,480,795.20	78,961,590.40	86,857,749.44	118,442,385.60	394,807,952.00	789,615,904.00
ROI (%)	803.88	127.03	90.46	(83.68)	(367.91)	(434.87)

Economy Sectors Integrating offshore wind, solar, tidal, and wave energy into fisheries, aquaculture, ports, and coastal tourism within Ghana's blue economy can significantly reduce emissions and operational costs. Offshore wind farms can supply electricity to onshore fish processing plants, cold storage facilities, and aquaculture operations. Co- locating offshore aquaculture cages beneath wind turbines optimizes ocean space usage, providing clean energy directly to the farms for equipment like aerators, pumps, and feeding systems. Ports can use offshore wind energy to power electric cargo cranes, shore power systems for docked ships, and electric vehicle (EV) charging stations. Also, the integration of offshore wind farms into microgrids for port operation can ensure low- carbon energy supply. In the case of coastal tourism, offshore wind farms can supply clean energy to coastal hotels, resorts, and tourism facilities. Tours of offshore wind farms can attract environmentally conscious tourists. Per the data available for fisheries, aquaculture, ports, and coastal on electrical equipment, the total daily and annual grid power consumption are 62,785.2 kW/day and 22,916,598 kWh/year.

Predicted Annual Grid Power Consumption (2025–2030)
Figure 3.11 estimates the total energy demand on the grid from 2025 to 2030. Using a 3% annual growth rate, we account for increased usage of existing equipment, potential addition of new equipment or facilities and gradual expansion of operations. Annual grid demand is expected to rise by about 3% each year, adding approximately 680,000– 800,000 kWh annually. By 2030, grid power consumption is expected to increase by about
million kWh, or approximately 20% more than 2025.

Feasibility and Benefits of Replacing Grid Power
A mix of offshore wind and solar offers the best near-term feasibility and scalability. Tidal and wave energy can complement as they mature technologically and become more cost-effective (Green et al, 2019). Replacing the 22.9 GWh/year grid power entirely with renewables can reduce annual emissions by 12,500–15,000 metric tons of CO_2, assuming grid power has an average emissions factor of 0.54 kg CO_2/kWh. The challenges are high upfront investment for infrastructure, the need for energy storage or complementary sources to manage intermittency (especially for solar and wind) and site- specific environmental and regulatory hurdles. The advantages are Near-zero operational emissions from renewables (Giannoumis, 2021), and reduced reliance on fossil fuels and volatile energy markets. Declining costs of renewables make them cost-competitive with traditional grid power. Table 6 shows the capital and operational expenditure assessment based on the data from the four sectors of the blue economy.
Successful Renewable Energy Strategies in the Blue Economy Sectors

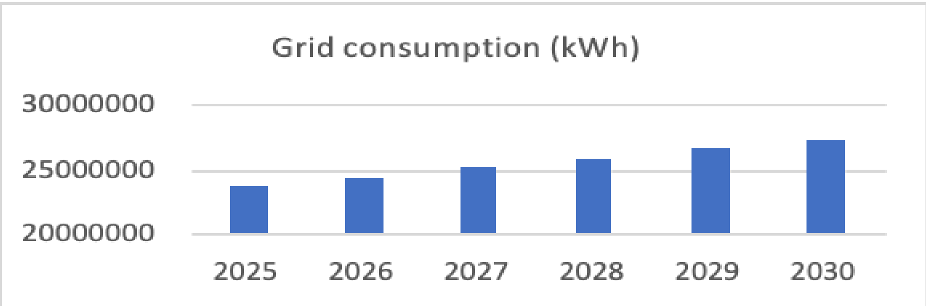

Figure 3.11: Predicted Annual Grid Power Consumption (2025– 2030)

Figure 6: Capital and operational expenditures renewable energy technology.

Energy Source	Required Capacity (MW)	CAPEX ($M)	OPEX ($M/year)	LCOE ($/MWh)	Annual Cost ($M)
Offshore Wind	5.8	20.3–29.0	0.41–0.87	75–110	1.72–2.52
Solar (Onshore)	13.1	10.5–15.7	0.11–0.31	30–60	0.69–1.37
Solar (Floating)	13.1	18.3–26.2	0.18–0.52	50–90	1.15–2.06
Tidal Energy	6.5	29.25–39.0	0.88–1.56	150–250	3.43–5.73
Wave Energy	7.5	37.5–75.0	1.13–3.75	200–500	4.58–11.45

Onshore Solar is the most cost-effective option with the lowest LCOE and CAPEX. However, it may require substantial land area and is weather-dependent. Offshore Wind provides reliable energy with moderate costs and high scalability. Tidal and Wave Energy are significantly more expensive and less mature but offer long-term potential. Floating Solar is promising but currently costlier than onshore solar.

Global case studies highlight innovative renewable energy adoption strategies across the fisheries, aquaculture, ports, and coastal tourism sectors, providing pathways for reducing emissions and enhancing sustainability in the blue economy. Table 7 depicts global case studies for adoption of renewable energy into various sectors of the blue economy which showcases innovative technologies, successful policies, and proven renewable energy solutions. Renewable energy adoption is most mature in ports (e.g., cold ironing in Germany) and least integrated into fisheries and aquaculture. Biodiesel is gaining traction in logistics, especially in countries like Ghana, to reduce reliance on diesel fuels. Large-scale offshore wind projects for aquaculture can exceed \$50M, while smaller solar or biodiesel projects for ports and fisheries are more affordable. Biodiesel costs remain high due to feedstock production needs. CO_2 reductions of up to 86% are possible with renewable integration, though initial costs and infrastructure readiness remain barriers This provides adaptable solutions that align with Ghana's unique challenges and opportunities, such as biodiesel adoption for logistics. Renewable energy integration remains in its early stages, with solar PV and wind showing potential to reduce emissions significantly (up to 86%) However, cost barriers (e.g., increased electricity costs by 34%) and seasonal challenges (e.g., short fishing seasons) slow adoption. Wave and offshore wind energy dominate renewable initiatives, particularly in Europe and Asia. These technologies address the energy demands of remote operations and align with environmental goals Co-locating aquaculture with offshore wind farms reduces costs and optimizes marine space usage. While promising, these projects face high capital costs, exceeding \$50M for large-scale systems. Ports are leading in renewable energy adoption through cold ironing and hybrid systems powered by solar and wind. Germany and the UAE showcase successful implementation. These systems cut operational emissions significantly and modernize logistics, but initial infrastructure investments remain a challenge. Renewable energy adoption in resorts (e.g., floating solar, wind) aligns with eco-tourism trends in the Caribbean and Maldives. Smaller-scale projects (\$500K–\$5M) achieve substantial branding and environmental benefits, attracting sustainability-focused travellers. Ghana's focus on biodiesel (e.g., Jatropha and Sunflower) for logistics shows significant emissions reductions (70%-85%). However, production costs (\$197M–\$395M annually) and land use requirements limit scalability.

Policy Recommendations to Facilitate Renewable Energy Usage in the

Table 7: Global case studies for adoption of renewable technology

Sector	Country	Technology Adopted	Biodiesel Integration	Project Cost (Estimates)	Key Insights
Fisheries	USA (Mississippi, Alaska)	Solar PV, Wind	Limited; focus on diesel replacement	\$1M–\$5M for solar installations	Solar/wind systems for catfish farming reduced CO_2 by 86% but increased electricity costs.
	Norway, Netherlands	Offshore wind, hybrid power	Exploring biodiesel in vessel engines	Varies; hybrid vessel retrofit \$2M	Co-location of offshore wind and aquaculture supports emissions reductions
Aquaculture	Japan, China	Floating Solar, Wave Energy	Trials on biodiesel for remote aquafarms	\$3M–\$8M for pilot-scale projects	Solar and wave energy address offshore needs while reducing emissions.
	UK	Wave Energy, Wind Farms	Not integrated	\$50M–\$100M for large-scale systems	Wave Hub Project powers aquaculture and tourism with renewable energy.
Ports	Germany	Cold Ironing, Hybrid Systems	Biodiesel adopted for port logistics	Solar systems ~\$10M; hybrid trucks ~\$1M/unit	Cold ironing and hybrid logistics reduce operational emissions.
	UAE (Jebel Ali)	Solar PV	Limited biodiesel for terminal equipment	\$20M–\$50M for large solar installations	Solar panels power cranes and port infrastructure.
Coastal Tourism	Caribbean (Jamaica, Aruba)	Solar, Wind	Limited	\$500K–\$2M per resort	Eco-tourism boosts with renewable-powered resorts.
	Maldives	Floating Solar	Trials in logistics for biodiesel-powered boats	\$2M–\$5M for installations	Floating solar offsets diesel dependency in island resorts.
Logistics	Ghana	Biodiesel (Jatropha, Sunflower)	Transitioning from diesel to biodiesel	\$197M–\$395M annually for biodiesel	Biodiesel logistics reduce emissions by 70%–85% while requiring substantial land.

Blue Economy Based on the data and global case studies, these policy recommendations target the fisheries, aquaculture, ports, coastal tourism, and logistics sectors. The focus is on reducing emissions, optimizing costs, and enhancing sustainability. Figure 11 (a) illustrates the proportion of energy consumption that each sector aims to offset with renewable energy sources while Figure 11 (b) reflects goals to reduce energy intensity through efficiency upgrades and the electrification of diesel-powered equipment. The renewable energy targets of 20% for fisheries and aquaculture, 50% for ports, and 30% for coastal tourism are set based on each sector's energy consumption patterns, operational requirements, and potential for renewable energy integration. Also, the efficiency and electrification targets are tailored to reflect the energy usage intensity, potential for improvements, and the operational constraints of each sector in Ghana's blue economy. These targets balance feasibility, economic considerations, and sustainability goals. Moderate targets reflect the fisheries and aquaculture sectors reliance on grid electricity for energy-intensive equipment like refrigeration and water pumps. Integrating renewable energy (e.g., solar or wind) for these sectors could support auxiliary equipment and reduce operational costs sustainably. Ports have the highest renewable energy target due to their significant energy demand, particularly from large equipment like electric cranes, shore power systems, and cold storage units. Ports are ideal for large-scale solar panel installations or wind turbines, given their open spaces and constant demand. Moderate renewable energy target for coastal tourism aligns with the sector's reliance on grid power for guest amenities like lighting, refrigeration, and air conditioning. Installation of solar panels and solar water heaters in resorts can significantly contribute to achieving this target.

Key Policy Recommendations:
Energy Audits and Efficiency Standards: Periodic energy audits must be conducting to identify high-consumption equipment and enforce minimum energy efficiency standards.
Renewable Integration: Investments in renewable energy must be encouraged (e.g., on- site solar installations) to offset grid power usage, especially for shore power systems and water pumps. Ports to reduce energy intensity by 15% through upgrades by 2030. Coastal tourism to target a 10% reduction in grid reliance by implementing solar solutions and LED lighting.
Incentives for Modernization: There should be a provision of tax benefits or subsidies for upgrading to energy-efficient technologies like LED lighting, efficient HVAC systems, and variable-speed motors. Convert 50% of diesel- powered forklifts and shuttle buses to electric by 2028.
Deploy electric boats in tourism and aquaculture sectors, aiming for a 30% replacement rate by 2030.
Demand-Side Management: Time-of-use tariffs must be introduced to shift energy usage to off-peak periods, minimizing strain on the grid.
Smart Energy Solutions: There should be IoT-enabled devices and energy management systems to optimize consumption patterns based on real-time data.
There should be promotion of the cultivation of Jatropha and Sunflower for biodiesel on underutilized lands to avoid food security conflicts. Subsidies must be provided for biodiesel production and use in logistics, particularly for heavy equipment like cranes, trucks, and vessels. Example: Ghana's focus on Jatropha biodiesel has the potential to reduce logistics emissions by 70%- 85%.
Conclusion

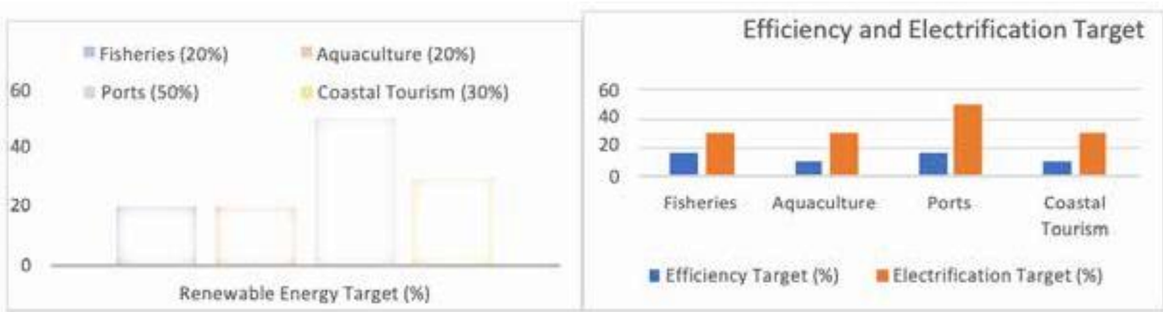

Figure 11: (a) Renewable energy target by sector, Efficiency and electrification by sector

This study underscores the significant impact and potential of renewable energy integration in Ghana's blue economy sectors namely, ports, fisheries, aquaculture, and coastal tourism. By transitioning from diesel-based operations to renewable energy sources like solar, wind, tidal, and biodiesel, Ghana can significantly enhance sustainability, reduce greenhouse gas (GHG) emissions, and optimize operational costs. Current diesel consumption across the four sectors totals approximately 394.8 million liters annually, resulting in emissions of 1.09 billion kg CO_2/year. By 2030, diesel consumption is projected to increase to 471 million liters/year, with emissions reaching 1.26 billion kg CO_2/year (16% increase). Replacing diesel with biodiesel can reduce emissions by 70%- 85% using Jatropha oil, saving 426 to 821 million kg CO_2/year. 85%-90% using Algal oil, saving up to 940 million kg CO_2/year. Combined biodiesel strategies, such as a mix of 50% Jatropha, 30% Sunflower, and 20% Algal oil, could achieve a balanced 77.5% emissions reduction. With regards to energy cost and savings, using biodiesel (e.g., Jatropha oil) instead of diesel yields annual savings of up to $276 million, with a return on investment (ROI) of 127%–803%, depending on production costs. With regards to renewable energy integration feasibility, replacing annual grid power consumption of 22.9 GWh in fisheries, aquaculture, ports, and coastal tourism with renewables can reduce emissions by 12,500–15,000 metric tons CO_2/year. Offshore wind energy (5.8 MW capacity) and solar energy (13.1 MW capacity) are the most viable options, offering moderate costs and high scalability. With regards to sector-specific goals, port has a target of 50% renewable energy adoption by 2030, reducing energy intensity by 15%. Fisheries and Aquaculture aim to achieve 20% renewable energy reliance and electrification of 30% of equipment by 2030. Coastal Tourism aim for 30% renewable energy reliance and 10% grid energy reduction by adopting solar and LED technologies. With regards to projected renewable costs and emissions impact, offshore wind and onshore solar have the lowest levelized costs of energy (LCOE) at $30–$110/MWh, while tidal and wave energy, though less mature, provide long-term benefits at higher costs.

References

Cavagnaro, R. J., Matthews, C., Hume, D., Raye, R., Copping, A., & Jenne, D. (2020). Enabling marine energy integration for ocean observing: Functional requirements. Global Oceans 2020: Singapore – U.S. Gulf Coast, 1–7. https://doi.org/10.1109/IEEECONF38699.2020.9389228

Energy Commission of Ghana. (2020). Ghana Renewable Energy Master Plan. Energy Commission.

FAO. (2016). The state of world fisheries and aquaculture 2016: Contributing to food security and nutrition for all. Food and Agriculture Organization of the United Nations.

Giannoumis, J., Dooley, L., & Cummins, V. (2021). A time and place for the sustainable blue economy: The dilemma of blue growth balancing commercial opportunities and environmental forces. OCEANS 2021: San Diego – Porto, 1–7. https://doi.org/10.23919/OCEANS44145.2021.9705960.

Green, R., Copping, A., Cavagnaro, R. J., Rose, D., Overhus, D., & Jenne, D. (2019). Enabling power at sea: Opportunities for expanded ocean observations through marine renewable energy integration. OCEANS 2019 MTS/IEEE Seattle, 1–7. https://doi.org/10.23919/OCEANS40490.2019.8962706.

Hagan, E., & Amissah, R. (2022). Renewable energy potential in Ghana's blue economy: A review. Journal of Sustainable Development Studies, 10(2), 23–45.

Knodt, S., Visbeck, M., & Biber, A. (2023). Sustainable blue economy: Transformation, value and the potential of marine ecosystems. OCEANS 2023 – Limerick,1–5.https://doi.org/10.1109/OCEANSLimerick52467.2023.10244621.

Ministry of Energy. (2022). National Energy Transition Framework. Government of Ghana..

Ministry of Fisheries and Aquaculture Development. (2021). Annual fisheries report 2021. Ministry of Fisheries and Aquaculture Development, Ghana.

Underwood, J., & Stempel, N. (2022). Open innovation and achieving balance for a sustainable blue economy. OCEANS 2022, Hampton Roads, 1–4. https://doi.org/10.1109/OCEANS47191.2022.9977111.

United Nations. (2020). The sustainable development goals report 2020. United Nations.