

Promoting information systems interoperability in enhancing compliance with maritime transport rules and regulations in Tanzania

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ABSTRACT

This study was conducted to investigate how information systems interoperability can enhance maritime transport compliance monitoring and evaluation in Tanzania, specifically to identify the challenges posed by non-interoperable information systems and to investigate the barriers to achieving interoperability in maritime transport compliance monitoring and evaluation. The Responsive Regulation Theory and the Socio-Economic Theory of Regulatory Compliance guided this research. The study employed a convergent or concurrent design using a mixed-methods approach (qualitative and quantitative research approaches). Simple random sampling was utilized to select 171 respondents using Yamane's formula for the quantitative component and eleven (11) participants through the purposive sampling technique for the qualitative component. The population comprised 300 individuals from Tanzania Shipping Agencies Corporation (TASAC) as the maritime transport regulator authority and regulated entities, from which, out of the 171 questionnaires issued, 160 were returned, resulting in a response rate of 93 percent, and based on data saturation and consultation with experts, in-depth semi-structured interviews with eleven (11) TASAC employees and compliance officers from regulated entities were used to collect qualitative data. Data were collected through questionnaires, interviews, and document analysis and analyzed using thematic analysis, descriptive analysis, and inferential analysis through ordered logistic regression. Delays in data retrieval, inconsistencies and inaccuracies across information sources, and inefficiencies in compliance reporting are among the critical challenges identified due to non-interoperable information systems. Furthermore, barriers such as information security risks, institutional information system fragmentation, and a lack of harmonized standards were found to significantly hinder the achievement of interoperability. The findings provide valuable insights for the Tanzania Maritime Regulatory Authority (TASAC), policymakers, and industry stakeholders on the need to have collaborative efforts for fostering secure, transparent, and efficient maritime operations through regulatory frameworks alignment, standardizing reporting procedures, integrating platforms such as the National Maritime Single Window (NMSW) and the Port Community System (PCS), and making governance structures more effective to ensure accountability and sustainability. By establishing an interconnected and secure digital environment, compliance monitoring and evaluation can become more efficient, transparent, and reliable.

Keywords: Compliance Monitoring, Evaluation, Information Systems Interoperability, Regulatory Service Delivery

I. INTRODUCTION

Regulations are rules not created explicitly by the parliament or the courts. When social, commercial, and political actors monitor and enforce these rules, it is considered regulation (Guidi et al., 2020). The regulatory system offered by governmental organizations and/or independent regulators comprises two fundamental elements, which are rulemaking and regulatory delivery (Mangalam, 2020). When the government provides services to businesses and individuals to ensure compliance with rules, this is termed regulatory service delivery. The key characteristics of good regulatory delivery are simplicity, efficiency, consistency, and transparency. Private companies mostly rely on the quality of regulatory service delivery to make investment decisions (Ali et al., 2019).

In the digital age, enhancing regulatory service delivery requires adopting artificial intelligence and other digital technologies. These tools can reduce burdens and protect the general public and consumers (Mangalam, 2020). A key enabler in this transformation is data sharing and interoperability among government agencies and stakeholders. When information can be directly obtained from stakeholders, repeated inspections and monitoring visits can be avoided, increasing operational efficiency (Organisation for Economic Co-operation and Development, 2014). Moreover, such data can support a variety of regulatory objectives when processed through modern analytics tools (Organisation for Economic Co-operation and Development, 2021).

However, the lack of interoperability between Information Technology (IT) Systems and software applications to communicate and exchange data accurately, effectively, and consistently poses risks for regulatory authorities like maritime transport regulatory authorities, as links between data fragments can be very difficult to identify (Jokhadze, 2020). Many legacy systems operated by Government departments in Tanzania, especially in the maritime industry, are



proprietary and non-standard, which means they are not interoperable at the business processes level and forced to operate in silos, which hinders regulatory service delivery (President's Office Public Service Management and Good Governance, 2022).

While Interoperability offer a wide range of advantages to the maritime transport sector by improving the efficiency and productivity of port operations (Kahyarara & Simon, 2018).it has been shown that legislative barriers, incompatible business processes and information models, and the diversity of technologies used in the public sector are major barriers to exchanging information and collaborating electronically (European Union, 2017).In addition, issues of data standardization, cybersecurity, and stakeholder adoption continue to be major challenges in achieving interoperability (Esther et al., 2025).

Although Interoperability standards and Application Programming Interfaces are widely used, with some level of interoperability within public, but not between, public and private facilities (Ndlovu et al., 2021). It is revealed that there is an interoperability challenge in e-government implementation related to information systems (Ronoh et al., 2018). Being a smarter maritime transport regulatory authority requires a more forward-thinking approach to using and integrating information, technology, and innovation in governing and delivering services (Mangalam, 2020).In response, Tanzania's government has invested in ICT to provide services to citizens and reform the public sector by making government services easy to access. Nevertheless, some public institutions, including institutions in the maritime industry, face limited automation and an unintegrated service provisioning approach (President's Office Public Service Management and Good Governance, 2022). The current study aims to identify challenges arising from this unintegrated service provisioning approach and barriers to achieving integrated regulatory service provision in the Tanzania maritime industry.

1.1 Statement of the Problem

In fulfilling its mandate, the Tanzania Shipping Agencies Corporation (TASAC), a maritime transport regulatory authority in Tanzania, has introduced several information systems to streamline billing, licensing, and certification processes, aiming to reduce time and paperwork. However, these systems do not directly share data or interoperate with those of regulated service providers and other government agencies, resulting in limited real-time monitoring and inefficient compliance oversight (TASAC, 2021).The lack of interoperability has led to repetitive tasks, human errors, and delays in decision-making, thereby increasing operational costs for TASAC and its stakeholders. Consequently, TASAC faces challenges in promptly detecting and addressing regulatory issues. This study aims to identify the challenges arising from non-interoperable information systems and investigate obstacles to achieving effective interoperability in monitoring and evaluating compliance with maritime transport regulations.

1.2 Research Objective

- i. The study focused on identifying challenges of non-interoperable information systems
- ii. Investigating barriers to achieving interoperability of information systems for effective maritime transport compliance monitoring and evaluation.

II. LITERATURE REVIEW

2.1 Theoretical Review

2.1.1 Responsive Regulation Theory

To achieve its objective, the study employed Responsive regulation theory (Ayres & Braithwaite, 1992), which claims that regulation should be responsive to the needs of regulators and those who are regulated. Various tools, such as persuasion, negotiation, and enforcement, should be used for achieving effective compliance. Once Information system interoperability is promoted, the regulator and the regulated can promptly identify trends and regulatory issues occurring in the maritime industry, making regulation more responsive rather than reactive. Delivering regulatory service in this manner allows the regulatee to quickly understand violations and take corrective action, reinforcing cooperative relationships through a negotiation approach without immediately escalating to punishment.

Interoperability enhances proactive service delivery by allowing different players to exchange information, carefully evaluate it, and plan from different perspectives. Providing services in a proactive way increases the utilization and thus experienced benefits to all stakeholders. Siloed information systems constitute a clear obstacle to improving trust in the public sector (The World Bank, 2022). In this view, System interoperability acts as a key enabler for regulations to be responsive to the needs of the regulator and regulatee through improved visibility and coordination among key maritime industry stakeholders, which reflects the core principle of Responsive regulation theory.

2.1.2 The Socio-Economic Theory of Regulatory Compliance

In addition, the study opted for the socio-economic theory of regulatory compliance (Sutinen et al., 1999), which suggests that various factors such as economic incentives, social norms, and the perceived legitimacy of the regulator, i.e. process efficiency and fairness, and outcome fairness and effectiveness, influence regulatory compliance. Interoperability contributes to significant efficiency gains, and the delivery of services and data becomes immediately available and usable to stakeholders, which leads to time saving as administrative data can be accessed more quickly, and back-office processing and handling time is also reduced (The World Bank, 2022).

When systems are interoperable, stakeholders from both public and private sectors have greater confidence in the impact of their investments. Integrated ecosystems assist regulators and those who are regulated to better address their complex needs; they also allow stakeholders to share costs and insights and lower various barriers such as data problems (Hatcher-Mbu, 2024). This strengthens the belief among maritime stakeholders that the regulator acts fairly and effectively. As a result, the regulatory service delivery becomes more legitimate in terms of efficiency, effectiveness, and fairness, as echoed in the socio-economic theory of regulatory compliance.

2.2 Empirical Review

2.2.1 Challenges of Non-Interoperable Information Systems

Regulators need significant resources to obtain more data and information from businesses and other resources (Black, 2010). In government, these data are always scattered among governmental entities, causing delays and coordination issues. The absence of an integrated management system for data sharing has made data collection and management tedious. Expenses and time required to comply have been major issues businesses face when adhering to regulations. Businesses always realize the benefits or purpose of the regulation when they are in their favor and do not see the bigger picture benefits to the public (Department of Business Energy & Industrial Strategy, 2020). In addition, data quality has posed a great challenge in compliance (Matsuo & Gorgento, 2017). Integrating services has been identified as the key emerging issue in regulating services (REPOA, 2022). As a result, the identification of compliance patterns becomes even more challenging; affected parties are not well considered, and regulators are suspected of being more worried about risks by being too procedural than experts (Lodge, 2015).

Technology integration has transformed monitoring, enforcement, and reporting to regulatory compliance. Due to increased regulations and regulatory reporting requirements, various technologies and solutions have been introduced, such as robotics and report automation (Ernst & Young, 2019). Matsuo and Gorgento (2017) urge companies to utilize their available data and derive new analytics that further their cost-effective, risk-based approach to compliance and provide more valuable compliance information. Regulatory technology (RegTech) is a technical solution for managing regulatory issues. It aims to support governments in making regulatory monitoring and enforcement more efficient (Bolton & Mintrom, 2023). Murrer and Sainsbury (2020) reveal that governments will have large data repositories and be capable of monitoring behavior in real-time through compliance software and Artificial Intelligence. This will make it easier for companies and individuals to fulfill compliance obligations and limit incidences of non-compliance. Companies have started implementing data-driven approaches to dynamically and continuously improve compliance programs through automation (KPMG, 2023). Without automation, compliance monitoring and evaluation faces issues of data inaccuracy, inconsistency, and delays in operations. Automation allows information to flow in real-time and seamlessly connects government authorities (Thomson Reuters, 2019).

2.2.2 Barriers to achieving Interoperability of Information Systems

Information system interoperability has several advantages in regulatory compliance: It strengthens issue identification and coordination, provides decision-makers with better information, improves the policymaking process, and boosts monitoring and assessment (Andres et al., 2024). While interoperability presents clear advantages for regulatory compliance, implementing interoperable systems can expose the compliance domain to cybersecurity risks. In addition, a few private integrators may dominate the process of facilitating integration due to proprietary nature of many emerging data networks though open standards could address this issue, but the balance between proprietary and open systems remains to be defined (Kirstein, 2018). Furthermore, companies are not ready to share data due to the effect of competitive intelligence despite the mutual value it can gain (Pan et al., 2023).

In addition, Digital trade facilitation solutions, such as Electronic Data Interchange (EDI) and electronic single windows, improve risk management for shipments and vessels prior to port arrival and enable real-time tracking, strengthening the readiness of government agencies. However, data access and sharing remain challenging for many businesses, as companies may be hesitant to disclose confidential commercial information. This reflects broader concerns over ICT security and the need to protect government networks and public platforms from cyber-attacks (UNCTAD, 2022). Although these technologies and systems offer substantial efficiency benefits for the maritime industry, they also introduce risks to critical operational systems essential to shipping. Such risks can stem from vulnerabilities in system design, integration, operation, or maintenance, as well as from both intentional and unintentional cyberthreats (International Maritime Organization, 2021).

III. METHODOLOGY

The study used a mixed methods approach (qualitative and quantitative research approaches) to achieve breadth and depth of understanding and validation. It adopted a convergent or concurrent design, which involves collecting both quantitative and qualitative data, analyzing both datasets, and then integrating the two sets of analyses to cross-validate or compare the findings. This study was conducted in the Dar-es-Salaam region, where most maritime transport services are provided. The study's population included 300 individuals, including TASAC employees (137) and Compliance officers from the regulated entities (164) within the maritime transport compliance domain (Port Terminal Operators, Shipping Agents, Inland Container Depots (ICD), 17 Empty Container Depots, Container Freight Stations, and Inland Container Depots Vehicle).

For this study, purposive sampling was used, and eleven (11) participants were involved in the qualitative component. However, this was based on data richness (saturation) and the range of viewpoints, experiences, and insights that various participants brought to the study. The quantitative component of the study used simple random sampling. According to Yamane's formula, a sample size can be calculated using the formula below.

$$n = N / [1 + N (e)^2]$$

Where:

n is the sample size

N is the population size

e is level of precision

Hence, a sample size of 171, which included TASAC employees and Compliance officers from regulated service providers, was used.

Based on data saturation and consultation with experts, in-depth semi-structured interviews with eleven (11) TASAC employees and compliance officers from regulated entities were used to collect qualitative data. The study also used the questionnaire for quantitative data collection. A prepared set of closed and open-ended questions was required to be filled in with answers; the questionnaire was administered online and collected to collect data from the respondent.

In both approaches, the study reviewed various documents as part of a secondary data collection technique, such as internal reports, technical documentation of TASAC's existing systems, regulations, and other operational documents that record compliance activities.

This study analyzed qualitative data through thematic analysis using Taguette software, which is a free, open-source, and user-friendly qualitative data analysis (QDA) tool. For the quantitative phase, data were analyzed through descriptive statistics and an Ordinal logistic regression model (Ordered model) using STATA-17 software and MS Excel. This study used methodological triangulation to ensure data reliability and validity using both quantitative and qualitative approaches. Data was collected from multiple sources, such as interviews, questionnaires, and document reviews, to cross-check and verify the consistency of findings. Key findings were sent to participants to validate the findings.

IV. FINDINGS & DISCUSSION

4.1 Findings

4.1.1 Background Information

The data Tables 1 to 3 below present the background information of the respondents who participated in the study, focusing on three key variables: respondent role in the shipping industry, years of experience, and the types of information systems used within their respective organizations for sharing compliance data. These variables provide important context for interpreting the findings related to information systems interoperability and compliance monitoring in the maritime transport sector.

Table 1

Descriptive Statistics on the Respondent Roles in the Shipping Industry

Role in the Shipping Industry	Freq.	Percent
Clearing and Forwarding Agent	15	9.38
Regulator	102	63.82
Port Authority	2	1.25
Dry port Operator (ICD, ECD, CFS, ICDV)	7	4.38
Ship Tallying Service Provider	1	0.63
Shipping Agent	33	20.63
Total	160	100

Table 1 indicates that regulators constitute the majority (63.82 percent) of respondents involved in the study, suggesting their central role in overseeing data sharing and enforcement. Shipping agents follow with 20.63 percent, reflecting their significant involvement in day-to-day compliance activities. Clearing and forwarding agents make up 9.38 percent, while other roles, such as dry port operators (4.38 percent), port authority (1.25 percent), and ship tallying service providers (0.63 percent), are less represented. This distribution highlights a strong regulatory presence and suggests that any interventions to improve interoperable information systems should prioritize the regulator and shipping agent needs for maximum impact.

Table 2

Descriptive Statistics on Years of Experience in the Shipping Industry

Years of Experience	Freq.	Percent
1-3 years	38	23.75
4-7 years	45	28.13
8-10 years	16	10.00
Less than 1 year	8	5.00
More than 10 years	53	33.13
Total	160	100

Table 2 shows that the majority of respondents (33.13 percent) have more than 10 years of experience in the shipping industry, indicating a strong presence of seasoned professionals. This is followed by those with 4–7 years of experience (28.13 percent) and 1–3 years (23.75 percent), suggesting a balanced mix of mid-level and early-career participants. Only 10 percent have 8–10 years of experience, and a small portion (5 percent) have less than 1 year, reflecting limited representation from newcomers. Overall, the distribution implies that insights and feedback on maritime compliance and information systems come from a workforce with considerable experience, which adds credibility to the findings.

Table 3

Type of Information Systems Used to Share Compliance Data

System Type	Freq.	Percent
Emails	46	29.01
Single Window System (SWS)	36	22.84
Electronic Data Interchange (EDI)	24	14.81
Manual System (Printed reports/forms)	18	11.42
Online Portals	22	13.58
Shared Databases	12	7.72
EMS and Tanzania Electronic Single Window (TANESW)	1	0.63
Total	160	100

Results from Table 3 above show that emails are the most commonly used system for sharing compliance data, accounting for 29.01 percent of responses, followed by the Single Window System (SWS) at 22.84 percent, and Electronic Data Interchange (EDI) at 14.81 percent. These figures suggest that while some organizations are adopting modern, integrated systems such as SWS and EDI, a substantial number still depend on traditional tools like email, which may lack the efficiency, security, and automation offered by more advanced platforms.

The continued reliance on manual and email-based systems may hinder real-time data sharing, increase the risk of errors, and reduce overall operational efficiency. Second, the limited use of centralized digital platforms like TANESW or e-Government systems suggests underutilization of national ICT investments. This points to a need for enhanced stakeholder engagement, capacity building, and policy enforcement to ensure a consistent and secure compliance data-sharing ecosystem across the maritime and transport.

4.1.2 Challenges of Non-Interoperable Information Systems in Maritime Transport Compliance Monitoring

Table 4 below presents the findings related to the challenges arising from non-interoperable information systems in maritime transport compliance monitoring and evaluation. Respondents from various roles within the shipping industry were asked to indicate the extent to which they experienced specific challenges associated with fragmented or poorly integrated systems. The analysis captured key areas such as information accuracy, data problems, delays, and detection of non-compliance issues. These challenges are significant as they hinder timely decision-making, reduce operational efficiency, and compromise the enforcement of maritime transport rules and regulations.

**Table 4***Issues Affecting Compliance Data Sharing and Maritime Enforcement*

Variable	Occurrence of Compliance Data and Enforcement Challenges (Percentage)					
	Always	Frequently	Never	Rarely	Sometimes	Total
Delays Sharing Compliance data	1	16	4	22	57	100
Data Problems in shared data	3	16	5	22	54	100
Accuracy in Information Shared	55	6	23	9	7	100
Untimely Maritime Enforcement	7	18	1	19	55	100

The majority of respondents (57%) reported that delays in sharing compliance data occur sometimes, while 22% indicated these delays rarely happen. A smaller portion reported frequent (16%) and never (4%) occurrences, with only 1% stating that delays always occur. This suggests that delays are an alternating but common issue in compliance data sharing. Similarly, data problems in compliance were reported to occur sometimes by 54% of respondents and rarely by 22%. Another 16% indicated frequent occurrences, while 5% reported no such problems (quality and integrity), and 3% experienced them always. This pattern shows that data issues are generally present but not overwhelmingly persistent.

Despite these challenges, A majority of 55% reported that compliance information shared is always accurate (correct and reliable), indicating strong confidence in the reliability of shared data. However, 23% stated accuracy never occurs, which is a concerning minority highlighting potential gaps in data integrity. Smaller proportions reported frequent (6%), rare (9%), or sometimes (7%) accuracy issues. In addition to data-related challenges, non-interoperability was reported to hinder timely enforcement, sometimes by 55% of respondents, with 19% indicating rare hindrance. Another 18% experienced this issue frequently, and 7% reported it always occurs. Only 1% stated this challenge never occurs, suggesting that interoperability issues are a notable barrier to effective maritime enforcement.

During the interview, one critical challenge highlighted in maritime compliance monitoring imposed by non-interoperable systems was the slow and inefficient retrieval of information due to the need to access multiple, unintegrated systems or manually contact various stakeholders. One of the respondents stated that,

“Retrieving the necessary information for monitoring takes a long time. We have to contact different stakeholders manually or log in through different systems, which slows the entire process and can result in delayed enforcement actions”.

In addition, according to a respondent who works as a senior compliance monitoring officer at TASAC,

“There is a delay in receiving compliance data from stakeholders, as it depends on email, and we are forced to evaluate manually the reports received from terminal operators, which is time-consuming and sometimes contains errors”.

Communication through email and the manual handling of reports increases the likelihood of human error, hence may compromise data integrity and limit the ability to quickly analyze trends or detect anomalies. These highlight the need for automated, interoperable information systems that can facilitate real-time data exchange and reduce dependence on fragmented and labor-intensive processes.

It was also found that data access delay, data inaccuracy, and unreliability are among challenges in sharing performance data and operational statistics in the current practices, and information is often delayed in being updated, and incorrect information is present in key systems. One of the interviewees responded that,

“Performance statistics are often submitted late, and even when submitted, they cannot be reliably used, as they have at times been found to misrepresent the actual situation on the ground.”

Furthermore, one more interviewee stated that,

“The information in the systems is not updated on time in cargo clearance, and sometimes we find wrong information regarding vessel arrival in the ICD systems.”

During the study, it was also found that stakeholders are required to submit compliance reports to various government agencies with the same compliance reporting requirements, which creates additional operating costs. One respondent urged that,

“Our Company has to submit the same information to various government agencies for compliance, while the same information could be obtained from another government department.”

Another challenge encountered was the failure to detect forged documents and to verify documents issued by other government entities, such as business licenses. One compliance monitoring office from the regulatory authority declared that,

“During licensing, we are not able to identify forged documents and verify important information such as business licenses, which could be verified directly from other government systems”.

In addition, one of the respondents stated that:

“We often find discrepancies between different sets of records. This makes it difficult to establish a single source of truth and undermines the integrity of our compliance assessments since data is entered and stored in isolated systems.”

The above findings point out that there is a critical weakness in compliance monitoring since, without real-time access to reliable external systems, regulatory authority and other stakeholders are left to rely on manual, potentially manipulated submissions. The absence of digital linkages with relevant databases results in delays and inaccuracies in operations, increases the risk of fraudulent approvals, undermines regulatory integrity, and poses risks to maritime safety and legitimacy.

4.1.3 Barriers to Achieving Interoperability of Information Systems for Effective Maritime Transport Compliance Monitoring

Table 5 below presents the findings related to Objective 2, which aimed to investigate the key barriers to achieving interoperability of information systems for effective compliance monitoring and evaluation in the maritime transport sector. Respondents were asked to rate the extent to which various technical, organizational, and legal factors hinder the interoperability of information systems in the maritime industry.

Table 5
Ordered Logistic Regression Coefficients

Dep. Variable	y	Log-Likelihood			-166.82	
Model	Ordered Model	AIC			347.6	
Method	Maximum Likelihood	BIC			369.2	
No. Observations	160					
Df Residuals	153					
Df Model	7					
	Coef.	Std err	z	P> z	[0.025	0.975]
Legal issues	0.1499	0.172	0.873	0.383	-0.187	0.486
Organization issues	0.7564	0.217	3.483	0.000	0.331	1.182
Technical issues	0.7133	0.202	3.523	0.000	0.316	1.110
0/1	-1.9984	0.785	-2.545	0.011	-3.537	-0.459
1/2	1.1960	0.216	5.538	0.000	0.773	1.619
2/3	1.1324	0.098	11.524	0.000	0.940	1.325
3/4	0.5772	0.178	3.241	0.001	0.228	0.926

An ordinal logistic regression model was employed for outcomes on an ordered scale, i.e., Never < Rarely < Sometimes < Frequently < Always. The ordered outcome is the frequency of key interoperability barriers, with predictors Legal issues, issues within the organization, and technological problems. The result reveals that the organization issues with the coefficient = 0.756 and $p < 0.001$, and technical issues with coefficient = 0.713 and $p < 0.001$ are statistically significant in increasing the odds of reporting higher frequency as key interoperability barriers, while legal issues with coefficient = 0.150, $p = 0.383$ is not statistically significant. In addition, the cut point parameters indicate that the ordered categories are not interpreted substantively; their significance just shows the model can distinguish adjacent response levels. Furthermore, lower values of Log-L = -166.82, AIC = 347.6, and BIC = 369.2 indicate a relatively better fit comparison across models.

During the interview, Security implications were noted as one of the barriers to achieving the integration of information systems in the maritime sector. One of the interviewees from the Shipping Agency company claimed that,

“Commercial data such as freight rates that affect competition in the market can be stolen, as there is a significant risk of data breaches, hacking, or other malicious attacks through system integration”.

Shipping Agents are concerned with this risk as it creates fear that sharing their system access could compromise their market advantage or expose business secrets. Another challenge found was that information systems currently in use are not stable and reliable. One of the interviewees claimed that,

“One key challenge we face in the maritime industry is that some of the systems in use are not consistently stable. We experience frequent downtimes, slow processing speeds, and prolonged technical problems”.

Another factor noted for not achieving system interoperability in the maritime industry was a technological gap. One interviewee expressed that,

“There are some stakeholders, such as Clearing and Forwarding Agents, who still lack dedicated information systems for their specific operational needs. Instead of using digital platforms, they often rely on manual processes, spreadsheets, or generic tools that are not designed for seamless integration with other maritime systems”.

This absence of automated tools limits the ability to exchange data in a timely, structured, and automated manner. It also creates bottlenecks in the compliance monitoring process, since information is often manually transferred or reformatted before it can be used by other stakeholders.



It was also pointed out that there is a governance-related challenge in achieving interoperability within the maritime industry. As noted during the interviews, one respondent said that,

“Initiatives to ensure the integration and interoperability of systems in the maritime industry were not undertaken. This is partly attributed to the nature of the Port Community itself, which comprises multiple institutions and stakeholders (both public and private) mandated by various acts of Parliament. As a result, they do not fall under the regulatory jurisdiction of a single entity”.

During the interview, the fragmented stakeholder coordination was declared as a key institutional barrier to system interoperability in the maritime sector. One of the interviewees stated that,

“There is no clear policy mandating all stakeholders to use a unified or interoperable system. Without regulatory enforcement or strategic direction from authorities, different organizations continue using their preferred systems, resulting in fragmentation.” and he added that, *“There is poor coordination among maritime stakeholders, as each is focused on its own priorities.”*

This autonomy results in a disconnected digital environment, where data is siloed and integration efforts are increasingly difficult. Additionally, a siloed mindset further obstructs collaboration, standardization, and investment in shared solutions

4.2 Discussion

Overall, the findings highlight that internal organizational issues and technological problems are all recognized as significant barriers to achieving interoperability to enhance regulatory compliance. While none of these barriers are universally persistent, they appear frequently to warrant attention and emphasize the need for improved infrastructure and management practices to support regulatory adherence. Legal and regulatory complexities also pose notable, though somewhat less frequent, challenges that may require clearer frameworks or guidance

Both quantitative and qualitative findings show that the fragmented information systems and delayed or inaccurate data transmission limit regulators' ability to detect non-compliance in real time or apply proportionate and timely enforcement measures. This aligns with the Department of Business (2020) that the absence of an integrated management system for data sharing has made data collection and management tedious, causing delays and coordination issues. This undermines the responsive nature of regulation, as enforcement actions become delayed and reactive rather than preventive in response. From another perspective, when businesses are burdened with redundant submissions, outdated communication methods, and uncoordinated regulatory processes, stakeholders view compliance as inefficient, frustrating, and unfair. This reduces voluntary compliance, especially when the system is seen as unreliable,

In addition, the fragmented nature of compliance infrastructure implies that without regulatory mechanisms that can respond responsively, the regulator's ability is limited in influencing change or enforcing interoperability standards. Similarly, the findings underscore that compliance cannot be achieved by rules alone. Socio-economic conditions, such as limited technological capacity among stakeholders, institutional misalignment, and lack of support, also hinder adherence to compliance rules and regulations.

This study extends the work of the European Union (2017) by showing that incompatible business processes, information models, and the diversity of technologies used are among the key barriers in exchanging information and collaborating electronically, as information systems in the public sector were set up independently of each other and not in a coordinated way. Furthermore, the integration of processes, systems. People and structures form a comprehensive and interdependent foundation for achieving effective information systems interoperability in maritime transport, compliance monitoring, and evaluation.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusions

This study reveals that information system interoperability is significant in ensuring effective compliance monitoring and evaluation in maritime transport. The results indicate that non-interoperable information systems cause delays, data problems, and inaccuracies in shared compliance information and untimely enforcement, which makes regulatory oversight less effective. Furthermore, the study shows that organizational and technological issues, such as information security and the absence of dedicated systems among some key stakeholders, remain significant barriers in achieving system interoperability for enhancing effective compliance monitoring and evaluation. The study aligns with earlier studies that systems interoperability provides decision-makers with better information and improves monitoring and assessment. The study highlights that there is a need to implement systems interoperability across maritime stakeholders, as it is a key enabler in regulatory service delivery. Addressing these identified challenges and barriers requires coordinated efforts among maritime stakeholders from both public and private sectors.

5.2 Recommendations

The study recommends that a mechanism be developed for maritime transport stakeholders in Tanzania to effectively interlink their information systems. In addition, there is a need to provide technical and financial support to stakeholders with limited digital capacity. The mechanism to be developed has to ensure that processes and structures among stakeholders are aligned so that real-time data sharing can be achieved smoothly. Policymakers should ensure that laws and regulations, i.e., institutional mandates across maritime transport stakeholders, are aligned and harmonized. Future studies should focus on how emerging technologies such as blockchain and Artificial intelligence can ensure effective compliance monitoring and evaluation in the maritime industry.

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