



Mechanisms for the adoption of port automation to enhance cargo handling in Malindi port Zanzibar

Tasnim Yussuf Maalim¹
Abbas Mohamed Omar²

¹tasnimyussuf@gmail.com

²abasamo@gmail.com

²<https://orcid.org/0000-0001-6701-5336>

¹National Institute of Transport, ²Zanzibar University, Zanzibar, ^{1,2}Tanzania

Recommended Reference: Maalim, T. Y., & Omar, A. M. (2026). Mechanisms for the adoption of port automation to enhance cargo handling in Malindi Port Zanzibar. *African Quarterly Social Science Review*, 3(2), 441–451.

<https://doi.org/10.51867/AQSSR.3.2.39>

ABSTRACT

This study examines the mechanisms behind the adoption of port automation technologies to improve cargo handling operations in Zanzibar. Specifically, it assesses the current state of cargo handling processes, evaluates staff and managerial perceptions and readiness for automation, and identifies key barriers to the implementation of automated systems. A cross-sectional research design was employed, utilizing a convergent parallel mixed-methods approach. The study was guided by the Technology Acceptance Model. The study population comprised 152 individuals, including port staff, customs declaration officers, shipping agency personnel, authorized clearing and forwarding, and shipping line agencies based in Zanzibar. The sample size was 108 individuals who were selected through purposive sampling and simple random methods. The response rate was 90, equal to 85.7%. Data were collected through structured questionnaires and face-to-face interviews. Quantitative data was analyzed using descriptive statistical methods with the aid of Jamovi statistical software, and qualitative data was analyzed using thematic analysis. The findings reveal that 63% of respondents perceive cargo handling processes as only partially automated, while 93% report persistent operational inefficiencies, including berthing delays and yard congestion. Although some information and communication technology (ICT) infrastructure is in place, only 45.5% of participants consider it adequate to support effective port operations. Furthermore, 80% of respondents highlight insufficient ICT training and an underdeveloped policy framework as significant challenges. The study concludes that, despite existing efforts to advance cargo handling automation, implementation remains constrained by interconnected barriers, including technological limitations, financial constraints, institutional fragmentation, and policy inadequacies. It recommends increased investment in integrated ICT systems, the development of targeted digital literacy programs for port personnel, and the establishment of a comprehensive national port automation policy with clear implementation strategies and institutional accountability.

Keywords: Cargo Handling, Malindi Port, Port Automation, Zanzibar

I. INTRODUCTION

The adoption of automation in cargo handling is increasingly recognized as a vital step toward improving port efficiency. Nguyen et al. (2022), refer port automation as the application of advanced technologies such as automated cranes, robotics, sensors, data analytics, and remote-controlled vehicles to optimize operations and reduce human intervention in the handling, storage, and transportation of cargo within port facilities. It encompasses systems that automate container loading and unloading, inventory tracking, gate operations, and communication processes (Chen et al., 2022). Collectively, these innovations contribute to enhance operational speed, accuracy, safety of port activities and shorten vessel turnaround times (Tsagkaris & Moschovou, 2025). Globally, the level of port automation varies significantly between developed and developing countries. In high-income countries such as the Netherlands, Singapore, and South Korea, major ports like Rotterdam and Busan have successfully deployed fully automated terminals that operate with minimal human involvement (Nikolaieva, et al., 2024). These ports have implemented cutting-edge technologies, including AI-powered logistics systems, autonomous vehicles, and digital twin modeling, to streamline operations and ensure high performance (Chen et al., 2022).

Building on this global perspective, it is evident that the successful adoption of port automation is not solely a function of technological availability, but rather a product of coordinated investments in infrastructure, human capital, regulatory frameworks, and institutional capacity (Rodrigue & Notteboom, 2021). In advanced port systems, automation is typically supported by robust digital ecosystems, strong public-private partnerships, and continuous innovation strategies that facilitate the integration of emerging technologies into existing operations (Rusinov et al., 2021).



Contrarywise, in many developing countries in Africa, automation efforts are either in their infancy or absent altogether. For instance, Ali et al. (2022) reported that ports in Nigeria, Ghana, and Mozambique continue to rely on manual labor, facing persistent challenges related to low productivity and cargo delays. While some countries in East Africa have initiated modernization efforts, the overall level of technological integration remains uneven. For example, partial automation initiatives have been reported in countries such as South Africa, Kenya, and Rwanda, where selected terminals have incorporated digital systems and mechanized equipment to improve operational performance (Jobran & Kara, 2022). In Kenya, the Port of Mombasa has introduced elements of terminal operating systems and electronic cargo tracking, whereas South Africa has implemented more advanced container handling technologies in selected ports. Although some progress has been made, such as the partial automation of port terminals, wide gaps remain in terms of technology access, financial capacity, and institutional readiness (Nganda, 2021).

In response to these disparities, Tanzania has initiated several reforms aimed at modernizing its port infrastructure and improving cargo handling efficiency. The Tanzania Ports Authority (TPA) has implemented digital solutions such as the Port Community System, which integrates port users and facilitates real-time data exchange among stakeholders (TPA, 2023). Additionally, development of new port terminals, including improvements at Dar es Salaam Port, the installation of electronic cargo tracking systems and efforts to digitize customs procedures reflect the government's commitment to enhancing operational transparency and efficiency (World Bank, 2021).

Despite national-level progress, Zanzibar Port continues to lag in the adoption of automation technologies. The study by Oyewole and Olufemi (2020) and Yese (2020) reported that the port remains on manual systems, facing recurrent issues of congestion, slow cargo turnaround, and limited handling capacity. Existing studies further highlight persistent infrastructural and institutional constraints hindering automation efforts (Bakari & Subriadi, 2020; Issa & Masanja, 2022). However, while these studies identify key challenges, they offer limited empirical insight into the specific mechanisms that drive automation adoption within the Zanzibar context. Given the port's strategic role in regional trade and tourism, this gap underscores the need for systematic investigation into the technological, financial, organizational, and policy-related factors shaping automation adoption. This study therefore, seeks to address this gap by examining the mechanisms for advancing port automation in Zanzibar.

1.1 Research Objectives

- i. To assess the current state of cargo handling operations at the Zanzibar port
- ii. To determine the staff and management perceptions and readiness toward the adoption of port automation technologies.
- iii. To identify the barriers hindering the adoption of automation in cargo handling in Zanzibar port.

II. LITERATURE REVIEW

2.1 Theoretical Review

The theoretical foundation for this study is attached in Technology Acceptance Model (TAM). This framework provides a lens for understanding the adoption of port automation by examining both individual behavioral factors and organizational/institutional influences. The Technology Acceptance Model, originally developed by Davis (1989), is widely used to explain and predict user acceptance of technology. The model posits that two primary factors influence an individual's intention to use a new technology: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU refers to the degree to which a person believes that using a particular system will enhance their job performance, while PEOU refers to the degree to which the system is perceived as free of effort. In the context of this study, TAM is relevant in assessing the second objective which is on perceptions and readiness of staff and management toward the adoption of port automation technologies. As automation involves significant shifts in workflows and skill requirements, understanding how port personnel perceive its usefulness and usability is critical to predicting successful adoption. Research has shown that when users perceive technology as beneficial and easy to operate, they are more likely to embrace it (Sarkar & Shankar, 2023). TAM thus supports the second specific objective of the study.

2.2 Empirical Review

2.2.1 Cargo Handling Operations

Cargo handling operations involve the systematic management of receiving, loading, unloading, storing, and dispatching cargo, supported by specialized equipment and safety protocols (Luna et al., 2018). In advanced economies, these processes are increasingly automated. Terminals in Rotterdam and Singapore, for instance, use automated cranes and guided vehicles controlled centrally, achieving productivity gains of 25 to 35% (Bottalico, 2022). In contrast, ports in developing countries often rely on manual processes and outdated infrastructure (Olapoju, 2023) Kenya's Mombasa Port performs better in East Africa, with average ship wait times of 36 hours (Nganda, 2021; Mwamutsi, 2022). Tanzania's Dar es Salaam Port has improved significantly through modernization under the Maritime Gateway Project

and a concession with DP World, reducing turnaround time to 36 to 48 hours by late 2024 (Yussuf, 2023; Mabinga & Mwalukasa, 2024). However, Zanzibar's Malindi Port continues to face challenges related to limited berth capacity and inefficient operations with average ship wait times of 14 days during peak periods (Bakari & Subriadi, 2020; Juma & Jin, 2021).

2.2.2 Perceptions and Readiness Towards Automation

The effective implementation of port automation depends not only on technological capacity but also on the attitudes and readiness of staff and management (De Alwis & Nam, 2025). Positive staff perceptions facilitate adoption, while fears of job loss, inadequate training, and skill mismatches can hinder progress (Flory, 2025). In U.S. ports such as Los Angeles and Long Beach, semi-automation efforts have faced union resistance over job security, slowing adoption despite potential efficiency gains (Jobran & Kara, 2022). By contrast, ports in Rotterdam and Brisbane have achieved smoother transitions through structured labor-management dialogue and retraining programs, though actual productivity gains have been mixed (Knatz et al., 2024).

In African ports, staff perceptions are often cautious. At Ghana's Tema Port, management supports digitization, but limited digital literacy and staff engagement remain barriers (Kuteyi & Winkler, 2022). Similar issues are evident in Durban and Mombasa, where modernization faces skepticism due to insufficient training (Nganda, 2021). In Tanzania, Dar es Salaam Port has introduced ICT-based reforms, yet concerns persist among staff about shifting roles and limited training (Kajuna, 2024). At the Zanzibar Multipurpose Terminal, proactive leadership and investment in automation continue to face mixed staff perceptions (Hamisi & Kileo, 2024).

2.2.3 Barriers to Automation Adoption

In high-income countries, automation adoption in ports is primarily constrained by high capital costs and complex integration demands. Khan, et al. (2022) highlight that technologies like automated stacking cranes and terminal operating systems require significant investment, often yielding modest returns. Wang et al. (2024) report average returns on investment of only 6–8% in most automated ports. Labor resistance also poses a significant barrier. In U.S. ports such as Los Angeles and Long Beach, union opposition has delayed or reshaped automation efforts due to job security concerns and inadequate retraining (Nikolaieva, et al., 2024). Additionally, fragmented IT systems hinder data sharing and real-time coordination (Nguyen & Kim, 2024), while shortages in skilled labor, particularly in cybersecurity and mechatronics, impede implementation (Rodrigue & Notteboom, 2021).

In contrast, developing countries face foundational challenges. Many ports lack reliable infrastructure, including power supply, equipment, and digital connectivity (Olapoju, 2023). In Cameroon and Ghana, poor road access and weak ICT systems obstruct progress despite managerial interest (Oyewole & Olufemi, 2020). Financial constraints further limit automation feasibility, with many projects reliant on donor funding or public-private partnerships (World Bank, 2021). Human capital limitations are also critical (Bakari & Subriadi, 2020). While Kenya's Mombasa Port shows progress, gaps in training and mid-level resistance remain (Mwamutsi, 2022). In Tanzania, training institutions such as Bandari College and the National Institute of Transport provide support, yet shortages in automation engineering expertise persist (TPA, 2023). Structural challenges, such as shallow berths at Malindi Port (Juma & Jin, 2022) and weak institutional coordination in Zanzibar (Kombo, 2015), further hinder automation. Moreover, many employees lack digital proficiency and confidence (Issa & Masanja, 2022).

III. METHODOLOGY

This study utilized a cross-sectional research design to collect data at a single point in time. A convergent parallel mixed-methods approach was adopted, allowing for the simultaneous collection of quantitative and qualitative data. The study was conducted in Zanzibar, a semi-autonomous region of the United Republic of Tanzania. There are several ports located in Zanzibar, including Malindi passengers and RoRo ports, Fumba port, Maruhubi inland port, Mwangapwani port, Mkokotoni port, Mkoani port, Wete port and Weshu port. Nonetheless, specifically, the study was conducted at the main Zanzibar Port, Multipurpose Terminal located in Malindi, Unguja Island. The port is managed and operated by the Zanzibar Ports Corporation and regulated by the Zanzibar Maritime Authority. The port was purposefully selected due to its strategic role in handling the majority of the archipelago's import, export, passenger, and fishing operations, making it an ideal site for assessing cargo handling practices and automation readiness.

The target population comprised 152 individuals directly involved in port operations and governance, including port staff, customs declaration officers, shipping agency personnel, authorized clearing and forwarding and shipping lines agencies based in Zanzibar, including; Emirates Shipping Line, UAFL, CMA CGM, MAERSK Line, MSC, Pacific International Line, Mediterranean Shipping Company and Coastal International Shipping Zanzibar. These participants represent a diverse cross-section of both operational and managerial stakeholders, ensuring a comprehensive perspective on institutional processes and logistical challenges. The study employed a purposive sampling method to select

individuals involved in cargo and port management. While a simple random on the other hand, was used to select port and shipping agency staff. The sample size for this study was 108 determined using the sampling table developed by (Krejcie & Morgan, 1970; as cited by Adam, 2020).

Quantitative data were obtained through structured questionnaires with closed-ended items. Qualitative data were collected through semi-structured interviews with 9 key informants. The integration of both data strands occurred during the interpretation phase, facilitating a holistic analysis by identifying convergences, divergences, and complementary findings. The questionnaires were distributed to 108 respondents. However, only 90 questionnaires were returned. Therefore, the total number of all respondents was 90 with an overall response rate of 85.7%.

3.1 Data Measurement and Control

In this study, port automation served as the independent variable and was measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The independent variables were categorized into control variables and key explanatory variables: *Control Variables*: Age was coded into five age groups (1= under 25 to 5= 55 and above). Sex was measured as a binary variable (1= Male, 0= Female). *Education level* was coded based on the highest qualification attained (1= No formal education to 5= Bachelor's Degree). *Years of experience* were classified from less than 1 year (1) to more than 6 years (4). *Familiarity with port automation* was measured using a four-point scale from (1= Not familiar at all to 4 Very familiar). *Key variables*: *Perceptions and Readiness for Automation* included measures of perceived efficiency, digital confidence, willingness to adopt, training adequacy, job security concerns, and staff support. Items were rated on a five-point Likert scale, and a readiness index was created, with higher values denoting greater readiness. *Barriers to Automation Adoption* were evaluated based on infrastructure, system integration, costs, financial support, policy frameworks, institutional coordination, and regulation. These were also measured on a five-point Likert scale and aggregated into an index, where higher scores indicated greater barriers.

Dependent Variables: *Cargo Handling Operations* were assessed through multiple indicators (e.g., berthing frequency, tracking, ICT infrastructure) using a five-point Likert scale. A composite index was created by summing the item scores, with higher scores indicating better cargo handling performance.

3.2 Data Analysis

The study used both quantitative and qualitative data analysis techniques, consistent with the mixed methods convergent parallel design, where both types of data are analyzed separately and then integrated during interpretation to provide a comprehensive understanding of the research problem. Quantitative data was coded and analyzed using descriptive statistical methods with the aid of statistical software *Jamovi* version 2.6. Qualitative data from interviews was transcribed and analyzed using thematic analysis. Following independent analysis, findings from the quantitative and qualitative strands were merged during interpretation to identify areas of convergence, divergence, or complementarity.

IV. FINDINGS & DISCUSSION

4.1 Social Demographic Characteristics of Respondents

As summarized in Table 1, the demographic profile of the respondents was assessed through variables such as gender, age, staff role, education level, and years of experience in the port sector. These characteristics are critical for understanding how demographic dynamics may influence the adoption of port automation technologies. The results indicate a significant gender imbalance among respondents, with male participants accounting for 68 individuals (75.6%), while female participants comprised only 22 individuals (24.4%). The predominance of male staff suggests that port operations in Zanzibar remain a male-dominated sector. This aligns with findings by Issa and Masanja (2022) who reported a similar trend in Tanzanian ports, noting that socio-cultural perceptions and physical demands of port-related tasks often contribute to the gender disparity. The majority of respondents were within the 20 to 30 years age, accounting for 40 individuals (44.4%). This was followed by those aged 31 to 40 years (24.4%). The dominance of younger respondents, particularly those under 40, indicates a workforce that may be more adaptable to technological changes, including automation (Nguyen et al., 2022). Younger personnel often demonstrate greater digital literacy, which may enhance the readiness and effectiveness of automation implementation. Port operations staff constituted the largest group, representing 60% of respondents. Customs officers (14.4%), shipping line staff (13.3%), and shipping agency staff (12.2%) comprised smaller proportions. The predominance of port operations personnel aligns with the operational focus of automation technologies, which are primarily designed to improve efficiency in cargo movement and terminal operations (Knatz et al., 2024). Their high representation enhances the validity of insights regarding automation from the perspective of those most directly engaged in cargo handling processes.

In terms of educational qualifications, the largest proportion held diplomas (37.8%), followed by those with secondary education (28.8%), and undergraduate degrees (15.6%). The predominance of diploma holders suggests that



the workforce has foundational technical training but limited higher academic exposure. This could imply a potential need for upskilling initiatives to ensure successful adoption and management of automated systems, as higher education levels have been linked to improved technology acceptance (Khan et al., 2022). Regarding the working experience, 40% of respondents had over 11 years in the sector, while 38.9% had between 1 to 5 years, and 16.7% had 6 to 10 years. This implies that substantial representation of experienced personnel suggests a workforce with significant institutional knowledge, which may either facilitate or hinder automation depending on attitudes toward change. Similarly, Issa and Masanja (2022) highlighted that while experience brings operational expertise, it can also correlate with resistance to change, particularly if automation is perceived as a threat to job security.

Table 1
Demographic Characteristics of Respondents

Gender	Categories	Counts	Percent
	Male	68	75.60%
	Female	22	24.40%
Frequencies of Age			
	20-30	40	44.40%
	31-40	22	24.40%
	41-50	16	17.80%
	51 and above	12	13.30%
Frequencies of Education levels			
	Secondary	26	28.88%
	Certificate	11	12.20%
	Diploma	34	37.80%
	Undergraduate	14	15.60%
	Postgraduate	5	5.55%
Years of experience in the port sector			
	Less than 1 year	4	4.40%
	1-4 years	35	38.90%
	5-8 years	15	16.70%
	9 years and above	36	40.00%

4.1.1 Awareness of Port Automation among Respondents

The study sought to examine the level of awareness of port automation among respondents. The findings were presented in Table 2.

Table 2
Level of Awareness about Port Automation

Level of awareness about port automation	Counts	Percent
Not aware at all	25	27.8%
Less than average	19	21.1%
Average	40	44.4%
Excellent	6	6.7%

The results show that a substantial proportion of respondents demonstrated limited awareness of port automation. Specifically, 25 (27.8%) individuals reported being not aware at all, while 19 (21.1%) indicated less than average awareness. These findings suggest that nearly half of the respondents (44.4%) possess below-average knowledge of automation systems, which may pose a barrier to effective adoption and implementation. A lack of awareness is a commonly cited inhibitor in technology diffusion literature, particularly in the port sector, where understanding the purpose and function of automation is crucial for its successful integration (Knatz et al., 2024; Kishore et al., 2024). These awareness levels also reflect the broader state of digital literacy and exposure within Zanzibar’s port workforce. With automation technologies becoming increasingly complex, the lack of foundational knowledge may hinder both user acceptance and the full realization of automation's benefits.



4.1.2 Current State of Cargo Handling and Port Operations

The study sought to examine the State of Cargo Handling and Port Operations. The findings were presented in Table 3.

Table 3
Frequencies of Cargo Handling Processes

Statements	SD		D		N		A		SA	
	N	%	N	%	N	%	N	%	N	%
Cargo handling processes are manual	4	4.40%	1	1.10%	28	31.10%	31	34.40%	26	28.90%
Berthing delays and congestion					6	6.70%	54	60.00%	30	33.30%
Cargo turnaround time due to inefficient processes	5	5.60%	0	0.00%	29	32.20%	30	33.30%	26	28.90%
The port lacks modern cargo tracking			11	12.20%	34	37.80%	42	46.70%	3	3.30%
The existing ICT infrastructure supports port operations	1	1.10%	14	15.60%	34	37.80%	20	22.20%	21	23.30%
There are clear procedures for cargo handling			7	7.80%	23	25.60%	59	65.60%	1	1.10%

The findings as summarized in Table 3 show that a significant proportion of respondents affirmed the semi-automated nature of cargo handling processes, with 34.4% agreeing and 28.9% strongly agreeing with the statement. These results indicate that over 63% of the respondents recognize that cargo handling is still reliant on manual labor. This hybrid orientation is often linked with low productivity, human error, and time inefficiencies, as reported in related studies on African port logistics (Kuteyi & Winkler, 2022; Olapoju, 2023). Delays in berthing and port congestion were widely acknowledged, with 60.0% agreeing and 33.3% strongly agreeing to the issue. This near-unanimous agreement (93.3%) points to systemic inefficiencies that significantly slow down port operations. Jobran and Kara (2022) found that congestion and berth delays are common symptoms of outdated infrastructure and inadequate coordination, factors that automation technologies are specifically designed to address.

Responses also show that inefficient processes contribute to long cargo turnaround times, with 33.3% agreeing and 28.9% strongly agreeing. This aligns with previous studies such as Heikkilä et al. (2022), indicating that non-automated cargo handling often results in unnecessary delays, higher costs, and reduced port throughput. A lack of modern cargo tracking technologies was another major issue, with 46.7% strongly agreeing and 37.8% agreeing that the port lacks such systems. This finding suggests a critical technological gap in cargo visibility and traceability. According to Boadu et al. (2025), the absence of tracking systems undermines the reliability and transparency of cargo movement, which automation could significantly enhance. Perceptions of ICT infrastructure were more mixed. While 23.3% strongly agreed and 22.2% agreed that ICT supports port operations, a considerable 15.6% disagreed, and 37.8% remained neutral. These results suggest that while some systems are in place, their effectiveness or reach may be limited. Limited integration, system fragmentation, or insufficient training may contribute to this ambivalence. Finally, on the clarity of cargo handling procedures, 65.6% agreed. This implies that while procedural guidelines exist, there may be inconsistencies in implementation or gaps in communication that affect understanding among staff.

4.1.3 Staff Perception and Adoption of Port Automation

This section presents findings related to staff attitudes toward the adoption of port automation, including perceived efficiency gains, digital system confidence, training adequacy, and job security concerns. Understanding these perceptions is essential, as employee buy-in is a critical factor in the successful implementation of automation technologies in port environments. As summarized in Table 4, a substantial majority of respondents (51.1%) agreed that port automation would improve efficiency and reduce delays, while a further 26.7% strongly agreed. This strong consensus (77.8%) reflects an overall positive perception of the benefits of automation in enhancing operational performance. These results mirror findings by Kaburu (2022), who noted that in emerging economies, automation is broadly perceived as a remedy for operational inefficiencies and congestion.

Respondents' confidence in using digital systems varied widely. While 33.3% strongly agreed and 22.2% agreed, indicating some degree of self-assuredness, a significant 38.8% either disagreed or strongly disagreed. This suggests a divided workforce, with nearly 40% expressing low digital confidence. According to Daniel et al. (2025), low perceived ease of use can be a major barrier to technology adoption, even when usefulness is acknowledged. Despite varying confidence levels, a majority (68.8%) of respondents expressed willingness to adopt automation systems, with 35.6% agreeing and 33.3% strongly agreeing. Only 26.7% expressed any form of resistance. This result indicates a latent readiness for change among port staff, provided the transition is supported by appropriate training and change management strategies (Notteboom, et al., 2022). A large share of respondents, 60% in total, indicated that they had not



received adequate training in ICT or port technologies. This training deficit represents a critical barrier to automation adoption. Boadu et al., (2025) noted that inadequate skills can lead to resistance, errors, and underutilization of automated systems. A significant majority of respondents 52.2% strongly agreeing and 26.7% agreeing, expressed anxiety that automation could result in job losses. This finding highlights a deep-seated concern about job displacement, consistent with global literature on labor responses to automation. On this concern, Ogola et al. (2025) opined that unless addressed through proactive employment policies, such fears may hinder adoption despite technical readiness.

Table 1
Staff Perception and Adoption of Port Automation

Statements	SD		D		N		A		SA	
	N	%	N	%	N	%	N	%	N	%
Port automation would improve efficiency and reduce delays			2	2.20%	46	51.10%	18	20.00%	24	26.70%
Confidence in using digital systems	22	24.40%	13	14.40%	5	5.60%	20	22.20%	30	33.30%
I am willing to adopt automation systems	14	15.60%	10	11.11%	4	4.40%	32	35.55%	30	33.30%
Adequate training in ICT or port technology systems	24	26.70%	30	33.30%	11	12.20%	25	27.80%		
Anxious that automation could lead to job loss	47	52.20%	24	26.70%	10	11.10%	5	5.60%	4	4.40%

4.1.4 Challenges to the Adoption of Port Automation

This section presents empirical findings related to the key structural, financial, institutional, and regulatory barriers that hinder the adoption of port automation in Zanzibar. Considerate these challenges is vital for designing policy interventions and technology integration strategies that support the modernization of port operations. The findings were presented in Table 5.

Table 5
Challenges of Adoption of Port Automation

Statements	SD		D		N		A		SA	
	N	%	N	%	N	%	N	%	N	%
There is a lack of integration between the port and customs IT systems	4	4.40%	2	2.20%	29	32.20%	32	35.60%	23	25.60%
There is a lack of integration between the port and other IT systems	4	4.40%	2	2.20%	29	32.20%	32	35.60%	23	25.60%
The cost of automation technology is too high for current budgets			10	11.10%	42	46.70%	14	15.60%	24	26.70%
There is inadequate financial support from government or donors for automation projects			30	33.30%	36	40.00%	18	20.00%	6	6.70%
The port suffers from weak policy frameworks guiding automation					17	18.90%	26	28.90%	47	52.20%
There is limited coordination among port institutions regarding technology upgrades			20	22.22%	9	10.00%	28	31.11%	33	36.70%
The regulatory environment does not sufficiently support digital transformation in maritime operations	9	10.00%	6	6.70%	43	47.80%	28	31.10%	4	4.40%

The findings as presented in Table 5 reveal a significant challenge in system interoperability and a lack of integration between the port and customs IT systems. 35.6% agreed and 25.6% strongly agreed. This means that over 61% of respondents recognize weak IT system integration as a barrier. Similarly, Olapaju (2023) opined that the fragmentation of port, customs, and other institutional systems limits the effectiveness of automation. A considerable 72.3% of respondents either agreed or strongly agreed that automation technology costs exceed current budget capabilities, with only 11.1% remaining neutral. Similarly, 60% agreed or strongly agreed that financial support from the government or donors is inadequate, suggesting that both internal budgetary limitations and external financing gaps are substantial barriers to progress. These financial constraints are consistent with observations made by Bottalico (2022), who highlighted that limited funding remains a core impediment to digital transformation in ports within developing countries.



A substantial 81.1% of respondents either agreed (28.9%) or strongly agreed (52.2%) that policy frameworks guiding automation are weak. This indicates a critical institutional void that may hinder coordination, investment prioritization, and regulatory clarity around automation implementation. Additionally, regarding the regulatory environment, 35.5% of respondents agreed or strongly agreed that it is inadequate, while 47.8% remained neutral. The high level of neutrality may point to limited awareness or uncertainty among staff regarding the legal and institutional environment governing digital transformation in the maritime sector. Juma and Jin, (2021) argue that without strong, adaptive regulatory frameworks, digital infrastructure is unlikely to be fully adopted or scaled. The data also show limited coordination among port institutions, with 31.1% agreeing and 36.7% strongly agreeing that coordination is lacking. This reveals a substantial gap in inter-agency collaboration, which is a known barrier to unified technology rollout in port ecosystems. This result is in line with the study by Rusinov et al., (2021) who stated that poor coordination can result in duplication of efforts, uneven system adoption, and failure to align automation strategies across stakeholders.

4.2 Discussion

The study confirms that there is an ongoing development of e-port system which incorporate terminal operating system, including, staff management information system. Despite the acquisition of two 75-ton modern mobile cranes in 2023, interview data reveal a growing consensus among port officials that the current manual and paper-based systems are unsustainable amid increasing cargo volumes and regional competition. One official noted that reliance on human labor contributes to inefficiencies and delays, an issue common to ports in many developing economies (Bakari, & Subriadi, 2020; Nguyen et al., 2022). Other respondents cited issues such as poor system integration and limited access to system among port stakeholders. Severe congestion at the container terminal, compounded by inadequate infrastructure and the lack of space for physical expansion, further challenges port operations. However, recent administrative reforms and investments by Africa Global Logistics have marked a turning point. A respondent elaborated: The development of an inland container depot at Maruhubi, along with the strategic removal of empty containers, has alleviated congestion, a trend consistent with findings in the Digital Logistics Capacity Assessments Report of 2025. However, surprisingly, one shipping line representative noted that the promised improvements by the port investor have not yet attained.

Availability of container monitoring system controlled by Shipping Agency was reported as one step forward facilitating cargo handling. However, complicated formalities and procedures in cargo clearing were noted as key challenges by both shipping lines and clearing and forwarding agencies. Encouragingly, the port's management expressed intentions to adopt advanced containers tracking technologies in line with recent strategic plans emphasizing ICT investment and reviewing the current procedures (The Citizen, 2024). Furthermore, employee readiness, attitudes, and concerns play a pivotal role in the successful adoption of new technologies. However, the study indicates a widespread digital competency gap. Many staff report low confidence in using digital tools and cite insufficient training. As a senior manager noted, *"While we are eager to implement new systems, our workforce needs the right skills and training to fully utilize these tools"* (July 4, 2025). Encouragingly, most respondents expressed a willingness to embrace automation, provided appropriate training and support are available. This highlights a key opportunity that the challenge lies not in resistance but in creating an enabling environment that supports learning and role clarity.

Nonetheless, about 79% of staff voiced fears of job losses, concerns common in automation transitions globally (Śledziowska, et al., 2025). If unaddressed, such fears may fuel resistance. Kotter's (1996) change management model emphasizes the importance of transparent communication and addressing staff concerns to foster commitment. Encouragingly, port management has committed to structured training programs aimed at equipping all staff levels to navigate the shift toward automation. One manager insisted: *"We are in the process of designing training programs tailored to different staff levels, ensuring that everyone, from operations to administration, is confident in using digital platforms,"* (July 5, 2025). While automation is increasingly recognized as a pathway to improving port efficiency and reducing delays, its adoption in Zanzibar remains hindered by a combination of systemic, financial, institutional, and regulatory barriers. Key obstacles identified by most respondents is the lack of integration between port IT systems and those of customs and logistics partners and financial constraint. These reflect broader structural challenges common in developing country ports, where modernization is often constrained by policy gaps, institutional inertia, and limited resources (Kishore, et al., 2024; De Alwis & Nam, 2024). This fragmentation, also noted by Kuteyi and Winkler (2022), hampers efficient cargo processing and disrupts port community systems. One senior manager remarked, *"When systems don't communicate, it slows everything down"* (July 6, 2025), resounding Yese's (2020) assertion that interoperability is crucial for real-time decision-making and streamlined logistics. Moreover, Olapoju (2023) and Sarkar et al. (2023), highlighted financial constraints as a pervasive barrier to port innovation in Africa.

Policy-related findings were more complex. While 80% of survey respondents viewed the regulatory framework as weak, interview data presented a contrasting view. Port management emphasized that policies supporting digital transformation do exist and are being refined within strategic plans. One official explained, *"We have foundational ICT*



policy in place and are actively engaging stakeholders to ensure alignment” (July 8, 2025). This discrepancy suggests the problem lies more in policy communication and implementation than in their actual absence. Tsagkaris and Moschovou (2025) argue, clear regulatory frameworks are essential for guiding investments and aligning roles in automation. Similarly, Nguyen and Kim (2024) emphasized that effective digital transformation requires enforceable, operational policy mechanisms.

V. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the study findings, it can be concluded that the Zanzibar's port operations highlight significant systemic and operational inefficiencies, driven largely by semi-automated to manual processes, fragmented ICT infrastructure, and lack of system integration. While there is encouraging consensus among staff on the potential benefits of automation, concerns around digital competency and job security remain prominent. Importantly, staff willingness to embrace automation, coupled with management's commitment to training and capacity building, presents a strategic opportunity for a successful transition. Key barriers to the Zanzibar port automation implementation, include poor system interoperability, limited financial resources, and fragmented communication around existing policy frameworks.

5.2 Recommendations

Based on the study findings, several actionable recommendations are proposed to enhance the successful implementation of port automation in Zanzibar. The port authority should prioritize the development and deployment of an integrated port management system that consolidates currently fragmented platforms into a unified digital architecture. Rather than a full-scale immediate transformation, the authority should implement a phased automation approach to manage the transition from semi-automated and manual processes. The process may start with high-impact areas such as cargo tracking, documentation processing, and gate operations, to allow for system testing, user adaptation, and risk mitigation.

The port authority should introduce structured and ongoing training initiatives to equip employees with the necessary technical and operational skills. The training should be tailored to different staff roles and should include both basic digital literacy and advanced system-specific competencies. The port authority should strengthen policy coordination and communication frameworks by ensuring that all stakeholders are well-informed about relevant policies, regulations, and the port strategic plans.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding Declaration

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

- Adam, A. M. (2020). Sample size determination in survey research. *Journal of Scientific Research and Reports*, 26(5), 90–97.
- Ali, A., Buana, I. G. N. S., & Suastika, I. K. (2022). A study of efficiency of container terminals: A case study of ports in Tanzania. *Revolution*, 4, 53–62.
- Bakari, B. O., & Subriadi, A. P. (2020). Information systems usage on enhancing port performance: Perceived service quality as a mediating role: The case study of container terminals in Tanzania. In *2020 IEEE International Conference on Sustainable Engineering and Creative Computing (ICSECC)* (pp. 309–316). IEEE.
- Boadu, S., Thompson, E. A., Godavarthy, R., Boateng, A., & Penneigh, R. (2025). A decade of smart port concept: A comprehensive review of past, present, and future implications. *Australian Journal of Maritime & Ocean Affairs*, 1–27. <https://doi.org/10.1080/18366503.2025.2546729>
- Bottalico, A. (2022). Automation processes in the port industry and union strategies: The case of Antwerp. *New Global Studies*, 16(1), 31–47.
- Chen, R., Meng, Q., & Jia, P. (2022). Container port drayage operations and management: Past and future. *Transportation Research Part E: Logistics and Transportation Review*, 159, 102633.
- Daniel, E. I., Makokha, A., Ren, X., & Olatunji, E. (2025). Digital transitions of critical energy infrastructure in maritime ports: A scoping review. *Journal of Marine Science and Engineering*, 13(7), 1264.



- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
- De Alwis, N., & Nam, H. S. (2025). A way towards port automation: Challenges and implications. *WMU Journal of Maritime Affairs*, 24(2), 225–247.
- Flory, O. O. (2025). The future of logistics in Tanzania: Innovations and developments. *African Journal of Entrepreneurship and Innovations*, 1(2), 62–74.
- Hamisi, S. R., & Kileo, W. J. (2024). The effect of automated customs clearance systems on enhancing trade efficiency in Tanzania. *International Journal of Social Sciences and Management Research*, 10(8), 408–422.
- Heikkilä, M., Saarni, J., & Saurama, A. (2022). Innovation in smart ports: Future directions of digitalization in container ports. *Journal of Marine Science and Engineering*, 10(12), 1925.
- 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*, 18(4), 337–354.
- Jobran, Y., & Kara, G. (2022). Examining the efficiency of automation in container terminals. *Journal of Transportation and Logistics*, 7(1), 137–155.
- Juma, M., & Jin, Z. (2021). Seaport governance framework in Tanzania: Challenges and strategies. In *Proceedings of the 2021 12th International Conference on E-business, Management and Economics* (pp. 695–700).
- Kaburu, J. W. (2022). *The impact of the digital maturity level on port operations in Africa* (Master's thesis, World Maritime University). https://commons.wmu.se/cgi/viewcontent.cgi?article=3106&context=all_dissertations
- Kajuna, E. G. (2024). Assessment on the efficiency of the adopted emerging technologies for optimizing container terminal operations at the Dar es Salaam Port. *International Journal of Education and Evaluation*, 10(3), 457–471.
- Khan, R. U., Yin, J., Mustafa, F. S., & Wang, S. (2022). Analyzing human factor involvement in sustainable hazardous cargo port operations. *Ocean Engineering*, 250, 111028.
- Kishore, L., Pai, Y. P., Ghosh, B. K., & Pakkan, S. (2024). Maritime shipping ports performance: A systematic literature review. *Discover Sustainability*, 5(1), 108.
- Knatz, G., Notteboom, T., & Pallis, A. A. (2024). Container terminal automation: Assessment of drivers and benefits. *Maritime Policy & Management*, 51(6), 1252–1276.
- Kombo, A. H. (2015). *Analysing the impact of increasing maritime transport costs on price of imported goods: Case for Zanzibar* (Doctoral dissertation, The Open University of Tanzania).
- Kotter, J. P. (1996). *Leading change*. Harvard Business School Press.
- Kuteyi, D., & Winkler, H. (2022). Logistics challenges in sub-Saharan Africa and opportunities for digitalization. *Sustainability*, 14(4), 2399.
- Luna, J. H., Mar-Ortiz, J., Gracia, M. D., & Morales-Ramírez, D. (2018). An efficiency analysis of cargo-handling operations at container terminals. *Maritime Economics & Logistics*, 20(2), 190–210.
- Mabinga, E. V., & Mwalukasa, B. (2024). The effect of port operations on port performance: A case study of Dar es Salaam Port. *Asian Journal of Management, Entrepreneurship and Social Science*, 4(4), 1435–1447.
- Mwamutsi, D. M. (2022). *Factors affecting cargo clearance efficiency at the Port of Lamu Kenya* (Doctoral dissertation, KESRA/JKUAT).
- Nganda, E. L. (2021). *Effect of system automation on customs performance at the Port of Mombasa in Kenya* (Postgraduate diploma research project, Jomo Kenyatta University of Agriculture and Technology).
- Nguyen, P. N., & Kim, H. (2024). Analysis of effectiveness for cargo operation productivity considering environmental efficiency on container ports in the Northeast Asian region. *Transport Policy*, 157, 111–123.
- Nguyen, P. N., Woo, S. H., & Kim, H. (2022). Ship emissions in hotelling phase and loading/unloading in Southeast Asia ports. *Transportation Research Part D: Transport and Environment*, 105, 103223.
- Nikolaieva, L. L., Omelchenko, T. Y., & Haichenia, O. V. (2024). Hierarchical management system for container vessels automated cargo handling. *Journal of ETA Maritime Science*, 12(1), 25–35.
- Notteboom, T., Pallis, A., & Rodrigue, J. P. (2022). *Port economics, management and policy*. Routledge.
- Ogola, D. B., Okpara, R. A., Ombe, T. M., Faghawari, N. D., Yerin, E. Y., & Sile, A. A. (2025). Port automation on yard operation in Calabar Seaport of Nigeria: Implications for Africa's regional development. *International Journal of Maritime and Interdisciplinary Research*, 7(3), 17–33.
- Olapoju, O. M. (2023). Autonomous ships, port operations, and the challenges of African ports. *Maritime Technology and Research*, 5(1), 260194.
- Oyewole, & Olufemi, F. (2020). Influence of work automation on the performance of Nigerian ports. *Journal of Management and Science*, 10(3), 12–24. <https://doi.org/10.26524/jms.10.3>
- Rodrigue, J. P., & Notteboom, T. (2021). Automation in container port systems and management. *TR News*, 334, 20–25.



- Rusinov, I., Besedina, E., & Shcherbinin, N. (2021). Global trends of the cargo handling operations automatization at container terminals. In *International Scientific Siberian Transport Forum* (pp. 1492–1508). Springer International Publishing.
- Sarkar, B. D., Shankar, R., & Kar, A. K. (2023). Port logistic issues and challenges in the Industry 4.0 era for emerging economies: An India perspective. *Benchmarking: An International Journal*, 30(1), 50–74.
- Śledziewska, K., Włoch, R., & Wilamowski, M. (2025). Adapting to digital transformation: Determinants of training motivation in response to digital automation among workers in six EU countries. *Oeconomia Copernicana*, 16(2), 523–555.
- Tanzania Ports Authority. (2023). *Annual report: Modernization and automation update*.
- The Citizen. (2024, May 31). Zanzibar Port Authority's new strategies in the fiscal year 2024/25. *The Citizen*.
- Tsagkaris, P., & Moschovou, T. P. (2025). The impact of automation on the efficiency of port container terminals. *Future Transportation*, 5(4), 155.
- Wang, N., Yuen, K. F., Chang, D., & Gao, Y. (2024). Analysis of the key factors influencing automation transformation in container terminals based on the Dempster–Shafer evidence interval method. *Transportation Research Record*, 2678(6), 891–910.
- World Bank. (2021). *Customs modernization handbook*. World Bank Publications.
- Yese, M. (2020). *Impacts of containerised cargo handling system in logistics performances: A case of Tanzania Port Authority* (Doctoral dissertation, The Open University of Tanzania).
- Yussuf, I. (2023, September 28). Malindi Port handles over 300 containers of ZMT. *Daily News*. <https://dailynews.co.tz/malindi-port-handles-over-300-containers-of-zmt/>