MRT
ISSN 2812-5622

http://dx.doi.org/10.21622/MRT.2025.04.2.1346

The Impact of Implementing Digital Transformation Requirements on the Performance of Ports in Accordance with Sustainable Development Requirements

Nabil Abdullah Bin Aifan [1], Mahmoud Al Sayed AlBawab [2], and Alaa Mahmoud Morsi [3]

[1] Deputy General Manager of the Maritime Affairs Authority, Hadhramaut, Yemen.
[2] Arab Academy for Science, Technology & Maritime Transport, Maritime Education and Training, Egypt.
[3] Arab Academy for Science, Technology & Maritime Transport, The Port Training Institute and Research Center, Egypt.

Emails: nnn5582@gmail.com, elbawab@gmail.com, alaamorsy@aast.edu

Received: 13 May 2025 Accepted: 26 June 2025 Published: 11 September 2025

Abstract

The maritime transport industry is vital to global trade, accounting for approximately 90% of cargo movement, with container transport representing 35% of volume and over 60% of cargo value. Seaports play a crucial role in national economic Development by attracting investment, generating foreign exchange, and fostering competitive economic activities. Port development efforts increasingly emphasize the adoption of new technologies, economic diversification, innovation, and alignment with global best practices, in accordance with the Sustainable Development Goals (SDGs).

Digital transformation is becoming prevalent in port development, with many ports undergoing partial or full digitalization. Advanced technologies enhance productivity and operational efficiency, enabling port authorities to function as digital service providers through tailored solutions for strategic planning and real-time monitoring.

This study addresses the research problem of poor performance and low productivity at the Aden container terminal, compounded by inadequate implementation of digital transformation and sustainable development requirements. Employing a descriptive analytical methodology, data were collected and analyzed through an electronic questionnaire. The findings highlight the urgent need to enhance terminal performance by drawing on the experiences of successful regional ports and fully integrating sustainable development principles, particularly digital transformation initiatives.

Keywords:

Sustainable Development, Digital transformation, Aden container terminal.

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2025.04.2.1346

1. Introduction

The maritime transport sector constitutes the foundation of international commerce, providing the most cost-effective means of conveyance (World Bank, 2023). This industry is responsible for transporting approximately 90% of global trade (IMO.2024), with containerized shipping comprising 35% of total cargo volume and exceeding 60% of its monetary value (World Bank. 2023). Seaports play a crucial role in facilitating national economic growth and serve as essential hubs for fostering competitive business activities (Gurumurthy. 2019).

Port development has experienced significant acceleration over the past three decades, primarily driven by population growth, economic expansion, foreign trade, and containerized transport (Jolly, 2016). Ports have demonstrated resilience, even during severe disruptions. Throughout the COVID-19 pandemic, ports have fulfilled a pivotal role in global transport by ensuring the continuous delivery of medical supplies, food, energy, raw materials, and manufactured goods and components (Alamoush, 2021).

Aden container terminals faces challenges related to reduced operational capacity and urgently require investment packages to maintain their current operational levels (UNDP. 2021). Despite its strategic location near international maritime routes and proximity to the Bab al Mandab Strait, which is only 110 nautical miles away (Qardash. 2021), the port performance remains suboptimal.

This weakness necessitates a thorough study of ports to identify the pathways for their Development, making them key drivers of national economic growth. The implementation of sustainable development requirements as a modern approach enhances the economic performance of ports (Lim, 2019), improving efficiency and contributing to economic prosperity, environmental quality, and social responsibility (ESCAP., 2020). Additionally, integrating digital transformation requirements into port operations, along with investments in sustainable technologies, can improve maritime transport efficiency and help address the challenges associated with port operations (Christodoulou, 2021).

The importance of this research lies in addressing the limitations and deficiencies in the performance and productivity of the Aden container terminal and its limited focus on digital transformation and sustainable Development. This study leverages specialized reports, comparative analyses of successful ports in the region, and survey-based evaluations of Yemeni port specialists and workers. This research aims to assess the current situation, propose actionable solutions, and develop strategies for improvement.

2. Significance and objectives

This study addresses the underperformance and low productivity of the Aden container terminal by exploring sustainable development and digital transformation as a means of enhancing its operations. It also aims to raise awareness of the terminal's strategic importance and contribute to Arabic maritime research.

The research aims to evaluate the current status and challenges of the Aden terminal, assess digital transformation implementation, analyze its impact on performance, and propose recommendations based on regional best practices.

3. Research problem

The Development and continuous improvement of seaports are critical steps toward enhancing their performance, positioning them as drivers of national economic Development, and enabling them to compete with neighboring ports. Achieving this would secure their place among successful ports regionally and globally. However, the research problem lies in the fact that the Aden container terminal suffers from poor performance, low productivity, and limited adoption of mechanisms for container terminal development in alignment with sustainable development requirements. This has led to significant inefficiencies and reduced productivity.

In 2021, the Aden container terminal handled 418,711 containers. This number decreased to 365,470 containers in 2022 and further declined to 282,652 containers in 2023. Similarly, the berth occupancy rate at the terminal also decreased, reaching 42% in 2021, 35% in 2022, and dropping further to 29% in 2023. The yard utilization rate followed the same trend, declining from 62% to 43% during the same period.

These statistics indicate a significant operational deficiency and a clear weakness that poses a substantial future challenge. This underperformance directly affects the future of Yemen's maritime transport sector and national economy as a whole. Furthermore, it raises concerns regarding the ability of the state and its maritime sector to meet the current and future requirements of the global maritime transport industry. Therefore, this situation requires thorough attention and studies to identify and implement appropriate solutions.

4. Literature review

Sustainable development requirements hold significant importance for seaports, as aligning port functions with sustainable development goals is essential (ESCAP., 2020). Progress toward sustainable development goals can be

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2025.04.2.1346

achieved by improving resource efficiency, adopting cleaner and more environmentally friendly industrial technologies and processes, and ensuring countries take action according to their capacities (ESCAP., 2020). According to the World Ports Sustainability Program (WPSP), implementing sustainability focuses on six essential elements, including digitalization applications and capacity building (WPSP, 2020).

Implementing port digitalization contributes to providing better services, generating added value, improving operational efficiency, reducing costs, facilitating trade, increasing transparency, and attracting new business entities (Gurning. 2019); (Mudronja. 2020) Digital transformation in ports is currently the most widely adopted strategy for port development (ESCAP. 2020) The digitalization of ports is also expected to attract global digital operators, such as Amazon and Alibaba, into port operations, while traditional operators, such as Maersk, will incorporate AI-based components into their operations to maintain competitive advantages (Gurumurthy et al. 2019).

Port digitalization is also linked to workforce restructuring (ESCAP., 2020). Contemporary port digitalization requires fewer workers but allows flexibility in performing diverse tasks (Vaggelas, 2020). Therefore, consultations with workers are critical because transitioning from manual labor to skill-based roles requires new capabilities, specific training plans, and certifications, as well as a highly skilled workforce to ensure port efficiency (Vaggelas, 2020). However, port clients have expressed concerns about certain digital port services, citing negative effects such as reduced employment opportunities, risks of power disruptions, unstable Internet connectivity, cybercrimes, difficulties in repairing semi-automated equipment, and increased investments. These concerns necessitate the implementation of digitalization requirements at the highest possible standards (Gurning, 2019).

Explored the effectiveness of digital transformation in port operations and trade by gathering the opinions of 600 port users. The study concludes that digitalization enhances service performance, creates added value, improves efficiency, and provides better operational control. However, port users have raised concerns about employment, costs, and digital transactions.

Similarly, Gurumurthy et al. 2019) emphasized the necessity of automation for Indian ports. The study surveyed 700 users across 14 ports and revealed dissatisfaction due to insufficient digital infrastructure. This study predicts that the sector will witness the involvement of global digital operators and the use of AI-driven services by shipping companies.

5. Methodology

The research adopts a descriptive analytical approach, which focuses on describing the characteristics of the research sample, collecting relevant data, and analyzing the variables and dimensions of the study. This method is employed to achieve the research objectives, provide data and facts regarding the research problem, interpret the findings, answer the research questions, and test the hypothesis.

The study relies on data collected through a questionnaire, which will be analyzed to derive the necessary conclusions. This approach was chosen because it is the most suitable methodology for studying social science research and addressing the complexities of the research problem.

6. The role of Sustainable Development requirements in enhancing port performance

The 2030 Agenda for Sustainable Development, adopted by all United Nations member states in 2015, provides a shared blueprint for peace and prosperity for people and the planet, both now and in the future, through its 17 Sustainable Development Goals (SDGs) (UN, 2023). These goals address a broad range of global challenges, including sustainable economic growth and environmental preservation (UNDP., 2018). Sustainable Development is defined as meeting the needs of the present without compromising the ability of future generations to meet their needs. It has emerged as a guiding principle for global progress, aiming to achieve economic Development, social Development, and environmental protection in a balanced manner (UN, 2023).

In the maritime transport and port industries, sustainable Development refers to business strategies and activities that meet current and future port needs. Sustainable practices in port operations involve strategic and operational approaches. This involves the simultaneous pursuit of economic prosperity, environmental quality, social responsibility, and operational feasibility (Kim, 2014).

Sustainable port development enhances maritime transport efficiency and competitiveness by fostering stakeholder collaboration, aligning operations, and supporting informed decision-making. It improves port performance through cooperative strategies that boost both efficiency and competitive advantage (Christodoulou et al., 2021).

6.1. The World Ports Sustainability Program (WPSP)

The World Ports Sustainability Program (WPSP) was established on May 12, 2017, and it is managed by the International Association of Ports and Harbors (IAPH), guided by the United Nations' 17 Sustainable Development Goals (SDGs) (IAPH, 2024). The program enhances and coordinates the future sustainability efforts of ports worldwide, while promoting international cooperation with supply chain partners (IAPH. 2024).

The establishment of the WPSP fulfills multiple roles, including acting as a knowledge hub for consultation among participants in supply chain operations. The program also serves as a research center, where innovative ideas and philosophies surrounding sustainable ports, including the economic factors influencing sustainability, are translated into practical methods for designing, managing, and operating ports effectively.

The WPSP identifies six essential elements for sustainable port development: infrastructure, digitalization, health, safety, security, environmental care, community engagement, and climate and energy. Digitalization is central to improving operational efficiency through innovative applications, stakeholder data sharing, streamlined processes, enhanced communication, and smart-port systems such as port community systems and single maritime windows (WPSP, 2024).

7. Digital transformation requirements in ports

The term "digital transformation" or "Digitalization" refers to the adoption or increased use of digital or computational technologies by an organization, industry, or country as a primary operational trend. Digitalization is a dynamic process that reshapes the factors of production and productivity during the fourth industrial revolution. This is driven by the rapid Development of big data, cloud computing, artificial intelligence, and other next-generation information technologies (Sun., 2021).

The application of digital transformation requirements to port development has become increasingly popular. New port projects will be partially or fully digitalized, and fully digital ports have already become a reality (Gurumurthy et al.2019). The COVID-19 pandemic has accelerated this digitalization trend, enabling ports to continue operations while minimizing physical interaction and contact. It has also spurred the rise of new technologies and online trade, which has changed consumer shopping habits and spending patterns. As a result, investing in digital infrastructure has become crucial for effective information exchange and resource planning, helping to solve many challenges faced by the maritime transport and port industries (UNCTAD, 2021). According to the World Ports Sustainability Program, digital transformation in ports is linked to several Sustainable Development Goals (SDGs), specifically, Goals 17, 11, 9, 8, and 4 (WPSP, 2024).

Several cutting-edge technologies have driven the maritime industry beyond its traditional limits and have created new opportunities to enhance productivity and efficiency. (UNCTAD. 2021).

Several systems play a crucial role in modern ports, including Port Community Systems (PCS), maritime single windows (MSW), Terminal Operating Systems (TOS), Vessel Traffic Services (VTS), and Port Management Information Systems (PMIS) (IMO, 2023). These systems streamline operations and enhance port management efficiency. Figure 1 below illustrates the systems currently in use in maritime ports.

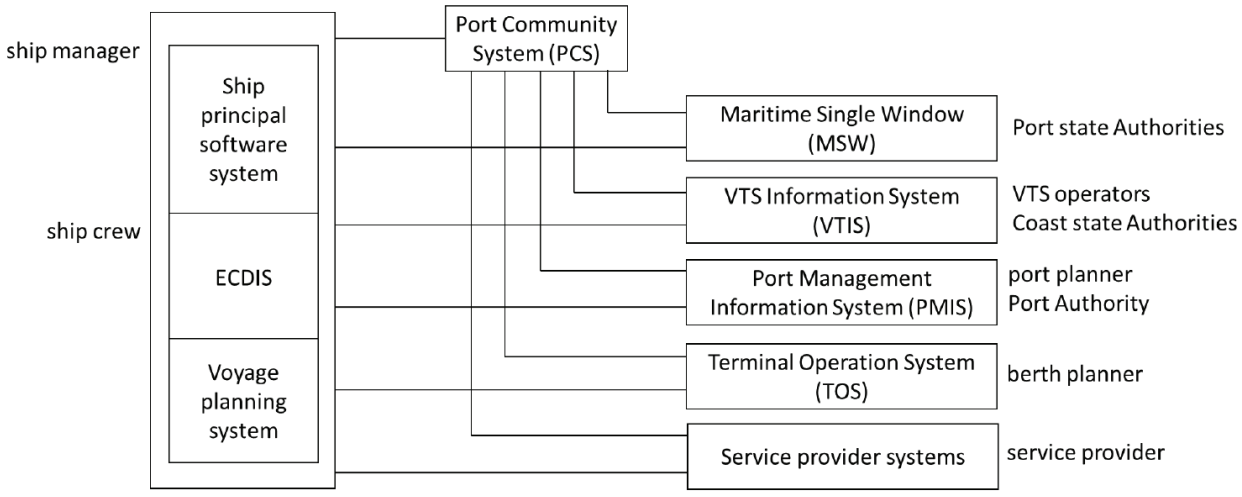

Figure 1: Diagram of Systems in Use in Ships and Seaports.
Source: (IMO 2023)

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2025.04.2.1346

7.1. Challenges facing ports in implementing digital transformation requirements

Cybersecurity:

Cybersecurity is considered the most critical factor hindering digital transformation operations. Cyber risk management can be defined as the process of identifying, analyzing, evaluating, and communicating internet-related risks, and either avoiding, transferring, or mitigating them to an acceptable level, considering the costs and benefits of the measures taken. This involves necessary steps to protect devices and systems from unauthorized access or attacks. (Aboul Dahab. 2020).

High capital expenditure for digital transformation implementation:

Although ports have adopted technology and digitization more slowly than similar sectors, the pace of adoption has begun to accelerate. Automated ports are safer than traditional ports (Chu et al.2018). However, digitization is not without difficulties, particularly in the early stages of adoption. (Brunila et al. 2021) Initial capital expenditures are exceedingly high (Chu et al.2018), but the impact of digitization on competitiveness is a matter of maturity, especially in the early stages. Economic gains are expected to be significantly higher for early adopters than for latecomers; however, over time, these differences will decrease as technologies mature and become more affordable. Digitization in ports is applied in phases within the context of port operations. (Brunila et al.2021).

Staff capability shortage and fear of job loss:

Advances in port digitization have allowed operations to be conducted with fewer workers possessing skills suitable for digital transformation applications. (Prism. 2019) A report from the World Maritime University (WMU) highlights the impact of technological change on maritime workers' future employment prospects. According to the report, port workers and crane operators will no longer have jobs in their current form by 2040. (Schröder et al.2019) Some ports using digitization applications have shown that workforce reduction can be limited but requires a set of skills different from those of traditional terminals. Lack of capabilities is one of the main barriers hindering successful port automation. (Schröder et al.2019).

Multiple stakeholders involved in port digital transformation:

One of the challenges that some ports still face in using digital systems or find difficult to implement is the large volume of information and the numerous parties involved in port digitization efforts. (Bourish 2017).

8. Developing container terminal performance

The pursuit of performance measurement is critical for ports to organize their operations efficiently and effectively. Performance refers to the execution of port activities in a way that meets the goals and fulfills the expectations of port customers while operating within an economic context and broader port structures. (Notteboom et al.2022) Performance measurement has gained strong ground in contemporary port management, as intense competition and involvement in supply chains have made port performance measurement crucial. It is essential for a port to compare its performance with that of its competitors. (Vaggelas.2019) Performance measurement organizes the use of available resources and planning for their expansion, as well as the interactions between ports and their users, to improve the services provided. Performance measurement results help ports achieve their defined objectives. (Notteboom et al.2022).

Evaluating port performance presents a significant challenge, as it encompasses various dimensions, ranging from service quality and value for money to return on investment and economic efficiency, with a vast array of performance evaluation criteria. (UNCTAD 2023).

Performance evaluation generally involves considering multiple inputs and outputs to assess efficiency. This requires data analysis that aligns well with the strategic goal and the context of each region. This requires ports with a wide range of data to allow for various types of analysis across multiple dimensions. (Nong 2023).

According to the United Nations Conference on Trade and Development (UNCTAD), port performance indicators comprise seven categories: financial, human resources, vessel operations, cargo operations, governance, resilience, and environmental sustainability. The inclusion of sustainability indicators in performance evaluation is vital for their importance. (UNCTAD 2023).

9. Discussion and findings

Yemen Gulf of Aden Ports Corporation (YGAPC) was established under presidential decree No. (61) in 2007, replacing the Yemen Ports Authority in Aden. The corporation includes several key components, such as the Aden container terminal, as well as the quay for ship handling in Ma'alla Port, Small Aden Areas, Khur Makser, Tawahi, and the internal basin of Aden Port (Decree of the Corporation Establishment.2007).

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2025.04.2.1346

The Aden container terminal (ACT) was officially inaugurated in 1999, and it represents 70% of the port's activity. The Port is located on the northern shore of Aden Port, handling transit cargo and import/export containers for the local market. It has been operated by various global container terminal operators, and since September 20, 2012, it has been managed by Yemen Ports Development Company, a national Yemeni company. (YGAPC 2023)

The terminal is located in a vast area that will be used as backup support for the port's activities. It is also close to international navigation routes, with only four nautical miles away and 110 nautical miles from the Bab al Mandab Strait, which is the southern gateway to the Red Sea. It is a strategic location for all ships passing through Southeast Asia and Europe, via the Middle East. (YGAPC 2023)

Table 1: Aden Container Terminal Statistics (2020 -2022).

Details	2020	2021	2022
Number of Container Ships	123	152	163
Loaded Containers	210,387	213,523	181,182
Unloaded Containers	213,006	205,188	187,316
Total Containers Handled	423,393	418,711	368,498

Source: (YGAPC 2023)

Aden Container Terminal requires an update of the technology used within it by assessing technological needs and replacing outdated equipment and systems with advanced modern technologies. In addition, it is essential to improve information systems, automation, and necessary devices and equipment for container operations (Hafez et al., 2023). There is a significant technological gap between Aden Container Terminal and neighboring competitive ports. The terminal lacks several systems implemented in competing ports, such as remote sensing devices, electronic gates, and renewable energy sources. It also does not apply the ISO energy management requirements.

The terminal uses the Zodiac system, which is outdated compared with the advanced Zodiac programs used in container terminals. This system lacks the features present in other systems, such as electronic customer integration, which allows them to perform transactions, issue invoices, make electronic payments, and more (Amzarbah.2023).

10. Study population and field sample

In light of the main objective of the field study, which aims to identify the impact of implementing sustainable development requirements on the performance of seaports, with application to the Aden container terminal, the study population included officials at the Aden container terminal, employees of the Yemen Ports Authority at the level of section head and above, maritime experts, captains, and marine engineers.

The questionnaire's reliability was measured using Cronbach's alpha, yielding a coefficient of 0.82, which exceeds the acceptable threshold of 0.70, indicating high internal consistency. Reliability analysis of each dimension, through item deletion and Corrected Item-Total Correlation, showed that removing any item reduced reliability, confirming the importance of all items. All item correlations were above 0.30, demonstrating satisfactory consistency.

The questionnaire was electronically distributed to the targeted study population in August 2024, considering the characteristics and variables of the original population. The researcher obtained 219 complete responses. The study sample can be described based on primary characteristics (job rank, years of experience, and qualifications), as presented in Table 1.

Table 2: Description of the Study Sample Based on Primary Data.

Variable	Count	Percentage
Job Rank:		
Employees	57	26.03%
Captain or Marine Engineer	45	20.55%
Section Head	35	15.98%
Department Manager	42	19.18%
General Manager	40	18.26%
Years of Experience:		
Less than 10 years	60	27.40%
10 to 20 years	70	31.96%
More than 20 years	89	40.64%
Educational Qualification:		
High School	13	5.94%
Bachelor's Degree	110	50.23%
Diploma	17	7.76%
Master's Degree	61	27.85%
Doctorate	18	8.22%
Total Study Sample	219	100.00%

10.1. The study sample description, as detailed in Table 1, reveals the following:

- **Job Rank Variable:** The study sample includes 57 employees (26.03%), 45 captains or marine engineers (20.55%), 35 section heads (15.98%), 42 department managers (19.18%), and 40 general managers (18.26%).

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2025.04.2.1346

- **Years of Experience Variable:** The study sample includes 60 participants with less than 10 years of experience (27.4%), 70 participants with 10–20 years of experience (31.96%), and 89 participants with more than 20 years of experience (40.64%).
- **Educational Qualification Variable:** The study sample includes 13 participants with high school qualifications (5.94%), 110 with a bachelor's degree (50.23%), 17 with a diploma (7.76%), 61 with a master's degree (27.85%), and 18 with a doctorate (8.22%).

10.2. Questionnaire design

The questionnaire was designed electronically using Google Forms, a tool from Google and one of the most popular platforms for creating questionnaires. The questionnaire items were developed using the five-point Likert Scale, a widely used tool for surveys, data collection, and scientific studies.

The Likert Scale was introduced by Rensis Likert in 1935. This scale requires the items to be interrelated and targeted toward measuring the intended attribute (Al Lami, 2021).

10.3. Results related to sustainable development requirements

The degree of fulfillment for sustainable development requirements achieved a "very high" level with a mean score of 4.31. The confidence interval for the mean score at a 95% confidence level ranged between 4.27 and 4.36, confirming that sustainable development requirements fall within the "very high" level.

10.4. Results related to the digital transformation requirements

According to the study sample, the degree of fulfillment for applying the digital transformation requirements achieved a "very high" level, with a mean score of 4.28. The mean scores for the individual items ranged from 3.88 to 4.53, indicating that all items were achieved at a "high" or "very high" level. The items were ranked in descending order by mean scores as follows:

1. The availability of qualified human resources in technology contributes to implementing digital transformation at the terminal, with a mean score of 4.53 and a standard deviation of 0.60.
2. The availability of digital infrastructure at the terminal contributes to service efficiency and performance improvement, with a mean score of 4.45 and a standard deviation of 0.58.
3. Implementing the single window system at the terminal contributes to improving service efficiency and performance, with a mean score of 4.34 and a standard deviation of 0.61.
4. Implementing the Port Community System at the terminal contributed to improving service efficiency and performance, with a mean score of 4.32 and a standard deviation of 0.61.
5. Employee encouragement contributes to implementing digital transformation requirements at the terminal, with a mean score of 4.27 and a standard deviation of 0.56.
6. Encouraging stakeholders—governmental and private institutions—to contribute to implementing digital transformation requirements at the terminal, with a mean score of 4.15 and a standard deviation of 0.61.
7. The terminal has sufficient financial resources to implement digital transformation requirements, with a mean score of 3.88 and a standard deviation of 0.77.

The results regarding the implementation of digital transformation requirements indicate that qualified human resources are ranked first, followed by digital infrastructure. The implementation of the Single Window System and the Port Community System comes next in importance, highlighting the participants' belief in the critical role of these systems for achieving digital transformation in port operations. This emphasizes the need to prioritize human resources and digital infrastructure while ensuring the effective adoption of key systems to enhance operational efficiency and competitiveness.

Employee and stakeholder encouragement ranked fifth and sixth, respectively, in supporting digital transformation requirements. Lastly, financial resources ranked the lowest, which is unexpected because financial support is typically among the most critical factors. However, this result suggests that when qualified personnel and digital infrastructure are in place, the foundational pillars for digital transformation have already been established.

11. CONCLUSIONS

1. The Aden container terminal (ACT) has a strategic geographical location, situated only four nautical miles from international maritime shipping lanes connecting East and West and 110 nautical miles from the Bab el Mandeb Strait.

2. The terminal's current management combines private and public sector models. The company is operated by a national company, the Aden Ports Development Company, and functions under private sector principles while being supervised by the Yemeni Gulf of Aden Ports Corporation.

3. Aden container terminals suffer a significant technological gap compared to competing ports in neighboring countries. This requires the urgent modernization of its equipment and systems, replacing outdated technologies with advanced solutions.

4. The terminal operates using the ZODIAC system, which lags behind the advanced ZODIAC systems used in competing container terminals. This system lacks features such as electronic customer connectivity, billing, and online payment capabilities.

5. The terminal does not have key systems such as the Port Management Information System (PMIS), the Terminal Operating System (TOS), the Port Community System (PCS), and the Maritime Single Window (MSW). Existing MSW system requires further Development.

6. Yemen's port sector has been negatively affected by the country's political instability since 2011. The situation further deteriorated following the Yemeni crisis and the conflict that began in 2015.

12. Recommendations

1. Utilize the terminal's geographical location to improve its performance, boost productivity, enhance current services, and offer value-added services.

2. Assess the current technological status of the terminal and conduct a study to strengthen digital transformation efforts, starting with an urgent phase for current operations and scheduling future phases with defined funding mechanisms.

3. Upgrade the existing ZODIAC operating system or replace it with a modern system that aligns with the terminal's current and future operational requirements.

4. This study focuses on the implementation of Port Management Information Systems (PMIS), Terminal Operating Systems (TOS), and Port Community Systems (PCS). The findings were applied to select the most suitable system for terminal operation.

5. Implementation of a maritime single window (MSW) system in accordance with international standards.

6. Explore the establishment of effective partnerships with regular shipping lines and logistics companies or pursue management and operation agreements for the terminal.

7. Benefit from programs aimed at supporting maritime institutions in developing countries, such as those implemented by the International Maritime Organization (IMO), including support for establishing a Single Window System.

8. Utilize artificial intelligence applications to assist with data analysis, forecasting, and decision-making processes.

References

Aboul-Dahab, karim. (2021), "DEMONSTRATING THE CYBER VULNERABILITIES OF SIGNIFICANT MARITIME TECHNOLOGIES TO THE PORT FACILITIES AND ON BOARD OF VESSELS", *SSRN Electronic Journal*, doi: 10.2139/ssrn.3816734.

Alamoush, A.S., Ballini, F. and 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*, Vol. 6 No. 1, p. 19, doi: 10.1186/s41072-021-00101-6.

Al-Yazidi, M. (2021), *The Role of Electronic Marketing Tools in Improving Services at Yemeni Ports*, Master's Thesis, Hadhramout University.

Amzarba, M. (2023), *The Impact of Implementing Smart Port Requirements on the Competitive Capabilities of Aden Container Terminal*, Master's Thesis, Arab Academy for Science, Technology and Maritime Transport.

"Areas of Interest - World Port Sustainability Program". (2024), .

Barasti, D., Troscia, M., Lattuca, D., Tardo, A., Barsanti, I. and Pagano, P. (2021), "An ICT Prototyping Framework for the 'Port of the Future'", *Sensors*, Vol. 22, p. 246, doi: 10.3390/s22010246.

Bouriche, H. (2017), "Electronic Management of Maritime Ports: Arab Models. Center for Research and Development of Human Resources (Ramah) and Laboratory for Organizational Development and Human Resource Management, Ali Lounici University of Blida".

Brunila, O.-P., Kunnaala-Hyrkki, V. and Inkinen, T. (2021), "Hindrances in port digitalization? Identifying problems in adoption and implementation", *European Transport Research Review*, Vol. 13 No. 1, p. 62, doi: 10.1186/s12544-021-00523-0.

Christodoulou, A., Dalaklis, D., Ölcer, A. and Ballini, F. (2021), "Linking Digitalization to Sustainable Development: the Case of the Port of Gothenburg In Proceedings of the International Maritime Transport and Logistics Conference, Arab Academy for Science, Technology and Maritime Transport", July, doi: 10.13140/RG.2.2.33917.08168.

ESCAP. (2020), "SUSTAINABLE PORT DEVELOPMENT AND IMPROVING PORT PRODUCTIVITY IN ESCAP MEMBER COUNTRIES".

Sen Gupta, M. (2020), "What is Digitization, Digitalization, and Digital Transformation | ARC Advisory", July.

Gurning, R.O.S. (2019), "Determining The Important Factors of Port Digitalization: The Empirical Cases of Indonesian Ports.", *9th International Conference on Operations and Supply Chain Management, Vietnam, 2019*.

Gurumurthy, A. and Bharthur, D. (2019), "Impact of Digitalisation in the Ports Sector", *SSRN Electronic Journal*, doi: 10.2139/ssrn.3873179.

Hafez, A., Amzarba, M. and Qardash, A. (2023), "The Role of Technological Restructuring in Improving the Operational Performance of Aden container terminal", *Scientific Journal of Commercial and Environmental Studies*.

"IAPH World Ports Sustainability Program". (2024), .

"International Maritime Organization IMO. Guidelines for Harmonized Communication and Electronic Exchange of Operational Data for Port Calls". (2023), .

"International Maritime Organization IMO. Guidelines on Port Community Systems". (2024), .

Jolly, C. (2016), "The ocean economy in 2030", *Workshop on Maritime Cluster and Global Challenges 50th Anniversary of the WP6 (Vol. 1)*.

Kim, S. (2014), "Megaport competitiveness and sustainability practice in container Shipping Logistics in Northeast Asia".

Lim, S., Pettit, S., Abouarghoub, W. and Beresford, A. (2019), "Port sustainability and performance: A systematic literature review", *Transportation Research Part D: Transport and Environment*, Vol. 72, pp. 47–64, doi: 10.1016/j.trd.2019.04.009.

Mudronja, G., Jugović, A. and Škalamera-Alilović, D. (2020), "Seaports and economic growth: Panel data analysis of eu port regions", *Journal of Marine Science and Engineering*, Vol. 8 No. 12, doi: 10.3390/jmse8121017.

Nations, U. (2023), "The 17 Sustainable Development Goals".

Nong, T.N.M. (2023), "Performance efficiency assessment of Vietnamese ports: An application of Delphi with Kamet principles and DEA model", *Asian Journal of Shipping and Logistics*, Vol. 39 No. 1, doi: 10.1016/j.ajsl.2022.10.002.

Notteboom, T., Pallis, A. and Rodrigue, J.-P. (2021), *Port Economics, Management and Policy*, *Port Economics, Management and Policy*, doi: 10.4324/9780429318184.

Oloan, R. and Gurning, S. (2019), "DETERMINING THE IMPORTANT FACTORS OF PORT DIGITALIZATION: THE EMPIRICAL CASES OF INDONESIAN PORTS".

Prism, E. and Analysis. (2019), "Economic Impact Study of Digitization and Automation of Marine Port Terminal Operations in British Columbia".

Qardash, A.Ali. (2021), *Analysis of the Competitive Situation of Aden Container Terminal in Light of Regional Competition*, Master's Thesis, Arab Academy for Science, Technology, and Maritime Transport.

Roh, S., Thai, V. V., Jang, H. and Yeo, G.T. (2023), "The best practices of port sustainable development: a case study in Korea", *Maritime Policy and Management*, Vol. 50 No. 2, doi: 10.1080/03088839.2021.1979266.

Schröder-Hinrichs, J.-U., Song, D.-W., Fonseca, T., Lagdami, K., Shi, X. and Loer, K. (2019), *Transport 2040: Automation, Technology, Employment - The Future of Work*, Malmö, doi: 10.21677/itf.20190104.

Sun, X. (2021), "Digitalization in the port industry from the perspectives of bibliometric analysis".

Sunitiyoso, Y., Nuraeni, S., Pambudi, N.F., Inayati, T., Nurdayat, I.F., Hadiansyah, F. and Tiara, A.R. (2022), "Port performance factors and their interactions: A systems thinking approach", *Asian Journal of Shipping and Logistics*, Vol. 38 No. 2, doi: 10.1016/j.ajsl.2022.04.001.

"The World Ports Sustainability Program WPSP. World Ports Sustainability Report 2020, International Association of Ports and Harbours (IAPH). ". (2020), .

UNCTAD, Parry, I., Kizzier, K., Smith, T. and Heine, D. (2018), "Sustainable freight transport in support of the 2030 Agenda for Sustainable Development", *United Nations Conference on Trade and Development Commission Sixth Session; 21-23 November*, Vol. 15150 No. September.

"United Nations Conference on Trade and Development UNCTAT. PORT MANAGEMENT2023 Volume 11 Port Performance Indicators." (2023), .

"United Nations Conference on Trade and Development UNCTAT. Review of maritime transport 2021". (2021), .

"United Nations Development Programme UNDP. What are the Sustainable Development Goals?. ". (2018),.

United, N.D.P.U. (2021), "Damage and Capacity Assessment: Port of Aden and Port of Mukalla".

United, N.U.N. (2024), "World Ports Sustainability Program | Department of Economic and Social Affairs".

Vaggelas, G.K. and Leotta, C. (2019), "Port labour in the era of automation and digitalization. What's next?", *Impresa Progetto-Electronic Journal of Management*, Vol. 3 No. September 2019.

World, B.G. (2023), "The Container Port Performance Index 2023 A Comparable Assessment of Performance Based on Vessel Time in Port".

"Yemen Gulf Aden Ports Corporation (YGAPC). Establishment". (2023), .