

Proposal for Adaptation of Sustainable Operational Plan Within Seaport System to Approach Climate Change

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The dynamic relationship between climate change and seaports underscores the intricate balance between human activity and environmental impact. Some substantial issues from seaport activities including land reclamation, ship emissions, extensive energy usage while berthing, and heavy fossil fuel dependency have contributed to climate change. However, many seaports have understood their role in protecting the environment. The mitigation procedure is complex due to the geospatial policies and financial constraints. Therefore, a standardised adaptation procedure needs to be introduced at seaports to ease these nodes to adopt and adapt the procedure to address climate change. The sustainable adaptation plan needs to be developed and introduced to the seaports to enhance their capability to understand and adapt the proposed plan without being hindered by internal and external constraints in seaports. Conversely, global trade has experienced substantial growth and is projected to continue expanding in the near future and eventually exacerbate climate change. By employing a qualitative approach grounded in theory, fourteen respondents were interviewed to explore why sustainable operating procedures need to be introduced in current Malaysian seaports and the impact on seaport competitiveness after the implementation of this procedure. The findings indicate that the sustainable procedure needs to be implemented for substantial climate change resilience in the seaport, bridging with international targets and regulations, strengthening environmental sustainability and conservation, encouraging the green approach, enhancing efficient collaboration, harnessing economic benefits and resilience, as well as refining social benefits and responsibility. After the implementation, the attractiveness of the seaport might develop the operational efficiency, refined transition management, transparency, synergy, and environmental responsibility, as well as improve the operational excellence, risk mitigation, regulatory alignment and boosting dynamic and structured investment in the seaport. Within the given context, the adaptation procedure through the sustainable operating procedure at the seaport offers a provisional resolution due to the escalating frequency and intensity of climate change in all its manifestations.

KEYWORDS

Climate change;
Seaport;
Sustainability


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1. INTRODUCTION

Climate change and seaport are correlated in exacerbating and inducing weather-related disasters. In recent years, climate change has excessively debated globally due to the high number of disasters and damages caused by weather events. Conversely, climate change has been observed and identified as constant changes of climate pattern that has potential in inducing extreme weather events (Loo et al., 2015; Jebbad et al., 2022; Shariful et al., 2020). This constant alteration evidently seen in the form of increasing trend of global temperature, decrease in ice-sheet extend and sea level rise that associated with anthropogenic emission (Pörtner et al., 2022; Masson-Delmotte et al., 2021; Nerem et al., 2018). Furthermore, coastal regions are observed to receive more threat due to increasing sea level rise that resulted in inundation and flooding (Durand et al., 2022; Magnan et al., 2022). This event is noticed to be extreme and associated with king tide, surge and others causing severe damages to coastal entities (Vitousek et al., 2017; Kouakou et al., 2023). Nevertheless, seaports are part of coastal entities that act as bridge and boundary connecting between countries that are regularly disrupted by extreme weather events (UNCTAD, 2020; Chapapria et al., 2021). Preserving the seaport function and operating sustainably will preserve its functionality in generating economic benefits (UNCTAD, 2018).

Nevertheless, climate change has significantly contributed in causing disruptions on seaport that has resulted in millions of losses due to damages in return, seaport and related activities has eventually become contributing factor whether is directly or indirectly which had intensified the climate change (Cruz-Perez et al., 2022; Christodoulou et al., 2019; Yan et al., 2022; Golnar et al., 2022). In context, the concentration of greenhouse gases (GHG) released in seaport mainly from 2 major source which are from stationary (port tenants, nearby industries and generating plant) and mobile source (ships, crane, conveyors, trolleys, forklifts, haulage and others) (Song, 2021). This source has continuously become promoting agents for climate change due heavy reliance on fossil fuels.

On the other hand, seaport evolution and growth are important for continuity contribution to the nation's economy. This growth is evidently portrayed in UNCTAD (2022), which showed an increase in trade from 30000 billion (2002) to 60000 billion (2022). Positive increase in trade proportionally increases the emission rate as indicated in the International Maritime Organisations report (IMO, 2020; Cai et al., 2021). In addition, UNCTAD (2022) reported that 4.7 per cent of global GHG contributed directly by shipping and this value might be extensive in 2050 (Boekhoff, 2022). Based on the sustainable development goal, seaport should prevent the use of greenhouse gases and achieve zero emission target by 2050, which urges the necessity in transiting to green energy or port.

Moreover, developing countries are actively involved in higher emissions compared to developed countries. Asia, known as a developing continent, has been indicated as an active zone of emission, especially its seaport, which contributes about 55 per cent of total global emission (Lu et al., 2023). According to Liu (2023) & Nguyen et al (2022), Malaysia, Singapore, Thailand and Indonesia known for its massive seaport that actively gained high volume of ship calls and number of containers that had induced higher emission during berthing and hoteling. Furthermore, UNCTAD (2022) reported that Asia holds the highest number of loading (42 per cent world tonnage) and discharge cargo (64 per cent world tonnage) in 2021. In accordance, seaport activities have resulted in a high number of wastes, air pollution, water pollution and oil spills incidents (Jeevan et al., 2022). Thus, this research emphasises on finding the necessity of having sustainable operating procedure in the current Malaysia seaport system and its impact on seaport competitiveness after the implementation of sustainable operating procedure.

2. AN OVERALL VIEW ON CLIMATE CHANGE

Intergovernmental Panel on Climate change (IPCC), (2013) categorised climate change as a result from anthropogenic emission that alters the earth atmosphere causing alteration to the climate system. Eventually this term is proven by evidence of continuous increase in global temperature, sea level rise and extreme weather resulting from anthropogenic activities such as industries, infrastructure development, energy usage, transportation and many others (UN, 2021). Nevertheless, the increase of surface temperature (1.1 degree Celsius) observed since 2011 to 2022 prove that human activities have exacerbated climate change (Pörtner et al., 2022). Additionally, human activities involving such usage of energy, land utilisation, shifting way of life, industrialisation and others from regional, national and individual level become a responsible factor in increasing the impact of climate change.

Furthermore, 79 per cent of GHG in 2019 are sourced from sectors involving constructions, power industries, and commerce industries and logistic whereas 21 per cent related to forestry, farming and others (IPCC, 2023). This context proves that climate change is happening and solely responsible by human activities. Somehow, these activities are important to generate nation economies but over usage of resources in unsustainable ways resulted in strengthening of climate change. This is true when comparing the increase rate of global temperature whereby 0.08 degree Celsius to 0.18 degree

Celsius since 1981 (Lindsey et al., 2023). Notably, climate change and climate variability correspond to these changes through elongation of certain climate periods such as the El-Nino Southern Oscillation (ENSO) which categorised by dry and wet period (L'heureux, 2014). In 2022, ENSO is categorised as wet period (La-Nina) which supposedly act as cooling properties eventually failed as the year 2022 is categorised as warmest consecutive year (Bardan, 2023).

Nevertheless, sea surface temperature records showing an increasing trend because of the continuous increase of greenhouse gases (GHG) as the ocean acted as the largest absorbance of GHG (Cai et al., 2018). This impact has eventually become a strengthening property between ocean and atmosphere intensifying the impact of ENSO particularly during Southeast Asia, East Asian Monsoon (Power et al., 2020). Correlation between ENSO and humans is showcased in the 2016 year of El-Nino, a dry condition that resulted in increase of power usage due to discomfort caused by the weather (Thirumalai et al., 2017). Moreover, ENSO has severely affected China causing devastating heatwaves and been affected by extreme rainfall due to remnants of Typhoon Doksuri (Gayle, 2023). GHG overall is an important composition that keeps the earth warm during night hours (Yoro et al., 2020) but abundance of the composition will increase extreme in the weather system (Eckstein et al., 2020).

In summary, the ongoing global warming is evident from the rising trend in global temperatures and the heightened frequency and intensity of extreme weather events, which are largely attributed to human activities. Within the context of seaport industries, which heavily depend on fossil fuels and contribute significantly to national economies, they are undeniably part of the equation driving climate change. The ambitious goal of achieving zero carbon emissions by 2050, as part of sustainable development efforts, presents a formidable challenge for certain seaports, particularly those in developing nations. Ensuring the sustainability of these crucial industries is imperative to uphold their functionality and economic viability amidst the imperative to address climate change.

2.1 The interconnectedness of climate change and seaport

Seaport has been serving as moderator to almost 80 per cent of world trading (Shi et al., 2017; UNCTAD, 2022; Ayesu et al., 2024) that motivate the economic and infrastructure growth. Seaport is important asset that drive the community activities through trading and guarantees the economic benefits (Xu, 2022). The escalating threats posed by climate change, including tropical storms, sea level rise, and flooding, are poised to profoundly disrupt seaport operations, with far-reaching implications for socio-economic dynamics (Wei et al., 2022). Moreover, according to Asariotis et al., (2018), combination of climate change and climate variability has disastrous impact such as directly (Infrastructure damage, service and operation disruptions) and indirectly (seaport demand, trade and investment choices). Each impact has a multifaceted impact on individual to nation, which urges the importance of having a resilience plan through sustainable operating procedure combating climate change.

Seaport activities have the highest potential to act as emitters due to the activities since its commencement to operation that involve deforestation, land use change, and fossil fuel usage that is listed as significant contributor (Masson-Delmotte et al., 2019). Subsequently, the emission of GHG has extended life span in the atmosphere that results in an increasing trend of global temperature (Tuckett, 2018). Furthermore, fluctuation in climate variability leading to flooding and impact of climate change leading to sea level rise has endangered the seaport environment (Abdelhafez et al., 2021; Asariotis et al., 2024). Thus, looking back on the threat and damages possessed by climate change and involved cost of repair gives an importance in developing the sustainable operating procedure that governs the seaport operations.

Nevertheless, seaport is highly correlated with hinterland transportation on distribution, a role in the supply chain that is mostly affected by climate change, which has the biggest impact on the economy (UNCTAD, 2020). Apart from these, seaport disruption will severely affect trade, energy, food supply as well as tourism (Sirimane, 2022). This proves that in 2017, 45 seaports were severely affected from hurricane Harvey, Irma and Maria in the lower continent of United States and Caribbean territories (Chambers, 2021). In accordance, in 2012 Hurricane Sandy had resulted in damages amounting in total to USD 60 billion whereby 8.1 billion damages related to sea level rise (Strauss et al., 2021). Additionally, coastal located seaports will be severely exposed to threats such as sea level rise, extreme weather events and flooding (Hafez, 2019; Izaguirre et al, 2021; Ng et al., 2018). If this severity is prolonged, relocation of seaport becomes a necessity in order to prevent the impact of climate change. Thus, a strategy is required to prevent cost of relocation through developing the sustainable operating procedure, which is emphasised in this research

2.2 Seaport sustainability from the perspective of climate change

Achieving positive economic growth while navigating the social needs, sustainability offers resilience to climate change impact by protecting human and natural resources through reducing harming factors (Cheon, 2016; Laxe et al., 2017). Sustainability in seaport achievable when considering both internal involving seaport activities and external involving transportation (marine & land transport) (Alamoush et al., 2021). Additionally, seaport has been a significant contributor in exacerbating the climate change impact that requires mitigation from continuity in global warming further protecting the function of seaport and its mutual benefits.

Sustainable development in seaports often sparks debate, primarily due to the significant investments required. In the case of privately-owned ports, profit typically takes precedence over environmental mitigation efforts (Gong et al., 2020). This profit-driven approach can have disastrous consequences, particularly in the context of climate change, which frequently leads to operational disruptions and economic losses (Verschuur et al., 2020). As noted by Asariotis et al. (2024), current industry-wide port adaptation strategies remain fragmented, hindered by critical knowledge gaps and delays in implementation. Moreover, between 2017 and 2022, awareness of climate change and its economic ramifications has grown significantly, underscoring the urgent need for sustainable operational practices (Puig et al., 2022). Given these challenges, this research aims to emphasize the importance of adaptation and mitigation strategies in seaport operations, raising awareness among stakeholders about the need for proactive climate resilience.

Seaport had continuously adapted to climate change impact through implementation of Grey structure such as breakwater, groyne, and others as part of sustainability but this action was considered temporary due to continuity in intensity and frequency of extremes in climate change (Rashidi et al., 2021). In addition, most prominent sustainability through mitigation, which offers a long-term solution such as adaptation to green energy and proper waste management (Osman et al., 2022; Abubakar et al., 2022). Mitigation and adaptation should be side-by-side action as these both features offer better seaport functionality while reducing environmental harm (Jiang et al., 2020). Thus, sustainability should involve a wide range of factors considering their economic benefits and finding the connection of seaport and climate change, which offered by this research.

Moreover, the need to identify the factor in seaport that contributes to climate change is important and mitigating through adoption of green technologies, transition to alternate fuels and environmentally friendly operations will govern the seaport operations. In addition, dry port offers better mitigation in reducing seaport congestion and enhancing the seaport operation (Tsao et al., 2018). According to Heinold et al., (2018), dry port linkage with rail systems offers reduced GHG emission compared to land transport. The disadvantage of the rail system compared to land transport is the limitation on schedule offered which resulted in delayed shipments (Tsao et al., 2018). Apart from these, seaport activities such as dredging, fuel bunkering, cargo loading/unloading resulted in higher GHG emission, which raises the importance of having a sustainability approach (Walker et al., 2019). Furthermore, action such as incentives and carbon taxes will provide better resolution in achieving zero carbon emission in accordance with sustainable development goals (Tao et al., 2021). This research thus helps to understand the importance of developing sustainable operating procedures especially in the current Malaysia seaport system. In addition, with better sustainability, seaports in Malaysia will have a higher chance to become more competitive in offering its services.

2.3 Climate change and seaport competitiveness

Globally, seaports compete with each other by offering safe and multifaceted services in accommodating the global trade. Climate change normally has a severe impact on seaport competitiveness causing severe damages to cargo and infrastructure (Brunila et al., 2021; Luo et al., 2022). The wide range of impact such as flooding, failure in operation and many others will severely affect the investment choice that delays the plan such as port extension to offer more cargo space that directly influences the seaport competitiveness (Hanson et al., 2020). Substantially, the seaport needs to adapt a sustainable approach to hinder climate change impact and enhance its climate resilience approach to become positively competitive.

Therefore, a potential answer to these issues is the adoption of cutting-edge technology, such as low-carbon LNG supply, energy storage systems, energy-efficient improvements, and ecologically friendly solutions (Szymanowska et al., 2023). This approach indirectly promotes mitigation of climate change impacts while fostering competitiveness. Besides that, research and development to foster green technologies offer positive reaction and growth to macroeconomics, which become beneficial to society (Khyareh et al., 2021; Gries et al., 2017). Since innovation and technology can benefit both parties, it is essential to include them into long-term, strategic planning. In line with sustainability and competitiveness goals, this kind of integration minimises environmental effects while simultaneously promoting economic growth.

In addition, the geographic location of seaport constantly offers threats due to weather conditions such as sea level rise, storm surge and many others (Yang et al., 2020). This threat often causes damages and jeopardises the safety of seaport causing severe delays and litigation that resulted in lack of attractiveness to stakeholder to invest resulting in poor competitiveness state (Hossain et al., 2019). Moreover, this impact will escalate causing severe congestion, blockage, delays and many others that affect the seaport competitiveness (NCFRP, 2014). Seaports need to employ both mitigation and adaptation measures to address all climate change-related challenges in order to remain competitive. This all-encompassing strategy not only improves seaport safety but also boosts seaport competitiveness in a constantly shifting global environment.

Additionally, the Northern Sea Route that resulted from climate change has become an alternate route, which offers shorter travel distance and fuel saving (Pruyn et al., 2022). This choice offers more investors the opportunity to invest in developing the Northern Sea route. This route has evidently gained in popularity whereby in 2021 compared to 2019 the deadweight tonnage indicates a steady increase from 18,846 to 23,736 tonnes (Tsai et al., 2023). The consequences of using this route had caused a mixed reaction whereby the by-product from burning the fossil fuel will further exacerbate sea level rise and negative impact to existing seaport through loss of clients. Apart from these, climate change has severely caused disruption on Southeast Asia seaport, which resulted in economic loss and long-term losses of ship calls (Lam et al., 2015; Friedt, 2018). Given that climate change has detrimental economic effects on already-existing seaports, mitigation and adaptation strategies should be top priority by seaports in order to improve competitiveness. Thus, through sustainable operating procedure, seaport may be able to improvise the entire safety factor and be resilient to weather extremes that in-turn improvise the competitiveness of seaport, which is emphasised through this research.

3.0 RESEARCH METHODOLOGY

A qualitative approach has been utilised for the procedures of data gathering and analysis, which entails conducting in-depth interviews to investigate a standardised adaptation procedure at seaports to ease these nodes to adopt and adapt the procedure to address the climate change. In this research, the sustainable adaptation plan needs to be developed and introduced to enhance their capability to understand and adapt the proposed plan without being hindered by internal and external constraints in seaports. To answer these questions, a grounded theory approach will be utilised to analyse all of the information gathered from the interview sessions in order to determine which themes are most pertinent to each research topic (Jeevan et al. 2021) non-probability sampling is utilised during the qualitative phase. The sample sizes used in this phase vary depending on the unit of analysis and the research issue being investigated. A sampling approach known as convenience sampling is utilised for the purpose of this investigation. According to Golzar, Noor, and Tajik (2022), convenience sampling picks participants from the target population based on accessibility. This approach typically results in cost savings and faster data collection.

To begin, the grounded theory begins with conducting in-depth interviews to explore the procedure to address climate change and a plan that needs to be introduced to seaport to strengthen their capabilities. Following that, it investigates the significance of implementing a sustainable strategy and assesses the outcome of the framework with regard to the competitiveness of Malaysian seaports. The information that was acquired from the interview sessions will be analysed to discover which themes are most relevant to each research topic. This will be done in order to determine which themes are most relevant. This methodological approach ensures that the research objectives are extensively studied by first delving into qualitative insights with a thorough investigation.

This research is particularly well suited to the application of grounded theory since it enables the speedy collection of the essential material and provides important contributions from the managerial point of view. Complex phenomena, such as the elements that influence the development of a climate change framework and the significance of sustainable practices within the Malaysian seaport system, can be investigated and comprehended with the assistance of this tool. When it comes to resolving problems that occur in the real world and drawing generalisations from comparisons that occur across a variety of social situations, the flexibility of grounded theory in taking into consideration a wide range of data and analytical perspectives is vital. This trait guarantees that data from a variety of stakeholders are incorporated in a complete manner, which makes it easier to establish a methodical approach to answering the problems raised by secondary research.

4.0 RESPONDENTS' PROFILES

This survey was conducted through a combination of face-to-face and online interviews involving 14 individuals carefully selected from various organisations, including both government and private sectors. The government representatives comprised personnel from Kuantan Port (3 representative), Labuan Port (1 representative), Johor Port (1 representative), Bintulu Port (1 representative), the Malaysia Marine Department (2 representative), the Malaysia Meteorological Department (3 representative), the National Hydraulic Research Institute of Malaysia (NAHRIM) (1 representative), and the Royal Malaysian Navy (1 representative). Additionally, one representative from the private sector, specifically PKT Logistic Group Sdn Bhd, participated in the survey. These participants were chosen based on their expertise and relevance to the fields of climate change and seaport operations. The survey achieved a 100% response rate, indicating full cooperation from all respondents in providing feedback for the research. In total, the survey process consumed approximately 1,110 minutes (equivalent to 18.5 hours), with an average duration of 79.3 minutes (or 1.32 hours) per person. The survey duration ranged from a minimum of 60 minutes to a maximum of 120 minutes per participant.

According to table 1, nearly 58% of the respondents have accumulated around 16 years of working experience, while 21% have between 11 to 15 years of experience. The remaining 21% have approximately 5 years of experience. This distribution indicates that the majority of participants in this survey are seasoned professionals, suggesting that their insights hold significant value for this research. The selection of organisations for this survey was deliberate, with a focus on their involvement in pertinent areas related to climate change. For instance, NAHRIM, renowned for its expertise in climate change, modelling, and coastal engineering, brings invaluable insights to the table. Similarly, the Malaysia Meteorological Department, specialising in atmospheric data analysis, plays a crucial role in understanding climate trends and patterns. Their participation underscores the gravity of the current climate situation, especially concerning Malaysia's coastal regions

No	Respondent Id	Organisation	Working Experience	Date of Interview	Time of Interview	Duration of Interview
1	R1	Kuantan Port	5	06 Feb2024	10.00 - 11.30	90 minutes
2	R2	Kuantan Port	5			
3	R3	Kuantan Port	5			
4	R4	Labuan Port	16	08 Feb 2024	14.00 – 16.00	120 minutes
5	R5	Lembaga Pelabuhan Johor	16	08 Feb 2024	10.00 - 12.00	120 minutes
6	R6	Malaysia Marine Department	16	07 Feb 2024	09.00 - 10.30	90 minutes
7	R7	Malaysia Marine Department	12	07 Feb 2024	11.00 – 12.00	60 minutes
8	R8	Malaysia Meteorological Department	16	29 Jan 2024	13.00 - 14.00	60 minutes
9	R9	Malaysia Meteorological Department	16	30 Jan 2024	13.00 - 14.00	60 minutes
10	R10	Malaysia Meteorological Department	16	31 Jan 2024	13.00 - 14.00	60 minutes
11	R11	National Hydraulic Research Institute of Malaysia (NAHRIM)	16	15 Feb 2024	10.00 - 12.00	120 minutes
12	R12	Royal Malaysian Navy	14	01 Feb 2024	10.00 - 11.30	90 minutes
13	R13	Pkt Logistic Group Sdn Bhd	12	01 Feb 2024	14.00 - 16.00	120 minutes
14	R14	Bintulu Port Authority	16	15 Feb 2024	14.00 - 16.00	120 minutes

Table 1. Summary of total respondent and interview details

Furthermore, the respondents from seaport backgrounds offer first-hand accounts of climate change's impact on port operations, providing crucial insights into the state of maritime infrastructure and the urgent need for sustainable operating practices. Additionally, the perspective offered by logistic companies like PKT Logistic Group Sdn Bhd sheds light on supply chain challenges and disruptions stemming from climate change. Lastly, respondents from organisations involved in law and legislation, such as the Marine Department and the Royal Malaysian Navy, contribute essential perspectives on regulatory frameworks and enforcement mechanisms related to climate change adaptation in maritime contexts. Together, their diverse contributions form a comprehensive understanding of the pressing need for sustainable operating procedures in the face of climate change challenges.

4.1 Procedure of data analysis

This research commenced with two primary questions, which are:

1. How is the seaport competitiveness affected by implementation of sustainable operating procedure?
2. Why does sustainable operating procedure need to be introduced in current Malaysia seaport?

Based on a qualitative method, this research is governed by grounded theory that requires continuous contrasting evaluation involving adjustment according to field of research (Cohen et al., 2006; Parveen, 2018). This qualitative analysis stands in two phases, i.e. familiarisation, and reflection, which is known as informal data analysis (Strauss et al., 1997; 1998). Familiarisation phase involves the research to be acquainted with respondent response. For example, the question, "How is the seaport competitiveness affected by implementation of sustainable operating procedure". The response to this question can be transliterated into the following as indicated in Table 2:

Familiarisation	
Question one	<i>How is the seaport competitiveness affected by implementation of sustainable operating procedure?</i>
Respondent	R13
Code	<ol style="list-style-type: none"> 1. Ports that can maintain reliable operations in the face of climate challenges may gain a competitive advantage by ensuring uninterrupted services to shipping lines and cargo owners. 2. Ports with lower operational costs may offer more competitive pricing and services to shipping lines and cargo owners 3. Ports adhering to global standards and regulations may find it easier to engage in international trade and partnerships, as many countries and organisations increasingly prioritise sustainable practices.

Table 2: Familiarisation process based on response from respondent R13

Referring to the process in 4.1, the entire interview responses were processed through familiarisation phase. The next steps involve reflection that involve steps on identifying the similarity between past literature and the new findings that display the position of current findings (Strauss et al., 1997; 1998). Through familiarisation and reflection on question one, 12 key codes were identified individually from 14 respondents on ways that seaport may get affected after the implementation of sustainable operating procedure. The findings are grouped and analysed according to previous literature. The findings are listed below in Table 3.

Key codes of familiarisation	Reflection through scrutinising
<ol style="list-style-type: none"> 1. Increase the investment on green technologies (R1) 2. Increase the initiative to use environmentally friendly material such as high-quality coal by TNB (R2) 3. Renewable energy adoption or waste reduction (R4) 4. Unlock additional resources and support for innovation and infrastructure upgrades (R4) 5. Streamlining operations and optimising resource use (R4) 6. Enhanced the seaport resilience, making them less susceptible to extreme weather events, rising sea levels, and another climate-related risks (R11) 7. Enhance the resilience of seaport infrastructure against extreme weather events like storms and sea-level rise (R12) 8. Improve the seaport's operational efficiency, reducing downtime and potential damage to equipment and facilities (R12) 9. Modernising infrastructure or implementing new technologies (R12) 10. Increasingly prioritise sustainable practices (R13) 11. Resilience and reliability (R14) 12. Sustainable infrastructure and adaptation measures minimise impact from extreme weather events (R14) 	<p>Green Technologies and Sustainability (Castellano et al., 2020; Sifakas & Tsoutsos, 2021; Pruyn and Van Hassel, 2022) and Digitalization and Smart Technologies (Salleh et al., 2021; Yau et al., 2020; Li et al., 2023 (Salleh et al., 2021; Yau et al., 2020; Li et al., 2023)</p>

Table 3: Procedure for familiarisation and reflection for Question 1: *“How is the seaport competitiveness affected by implementation of sustainable operating procedure”*

The next steps involve formal data processing involving the development of coding through 3 categories, which are open coding, axial coding, and selective coding (Parveen, 2018; Strauss et al., 1998). Based on Question 1, open coding involves categorisation of key codes from familiarisation into segments groups (Cohen et al., 2006). Then, the axial coding involves a decision in choosing a proper theme based on the open coding. Furthering this process involves selective coding, which encourages grouping and combining themes and categories to find new themes that represent proposed study as showcase by Table 4.

QUALITATIVE DATA ANALYSIS					
Respondents	Familiarisation	Reflection	Open Coding	Axial coding	Selective Coding
R4, R5, R6, R9, R12, R14	1. Regularly reviewing and updating the framework based on new developments of technologies (R4) 2. Green policies should be a joint effort from industries, government, communities and university (R5) 3. Regulatory harmonisation (R6) 4. Enable the legislation to be framed and practise apart from being just a matter of enforcement (R9) 5. Involve complying with local and international regulations aimed at reducing greenhouse gas emissions (R12) 6. Demonstrating leadership in sustainability prepares the port for stricter regulations and consumer preferences (R14)	Global Cooperation and Policy Harmonization (Lam & Notteboom, 2014; Pasetto and Giacomello, 2023)	1. Framework review and technological updates 2. Collaborative approach to green policies 3. Regulatory harmonisation 4. Legislation enablement 5. Compliance with emission reduction regulations 6. Leadership in sustainability	1. Adaptation and collaboration 2. Regulatory alignment and compliance 3. Leadership in sustainability	Enhanced adaptive collaboration and regulatory alignment

Table 4: Sample of informal and formal data analysis for Question 1:
“How is the seaport competitiveness affected by implementation of sustainable operating procedure”

5.0 DISCUSSION

5.1 Sustainable operating procedure in Malaysian seaport

The survey began by querying the importance of implementing sustainable operating procedures in Malaysian seaports. Fourteen respondents provided their insights to this initial inquiry. Employing qualitative data analysis techniques, seven distinct themes emerged from their responses, as outlined in Table 5.

Respondent	Generated themes for question: “Why does sustainable operating procedure need to be introduced in current Malaysia seaport?”	Percentage of response (%)
R1, R5, R8, R9, R10	Better resilience and adaptation	35.7
R2, R3, R6, R7, R11	Bridging with international targets and regulations	35.7
R4, R6, R9, R12, R13, R14	Strengthening environmental sustainability and conservation	42.9
R4, R12, R13	Encouraging green approach	21.4
R4, R5, R7, R8, R10, R12, R13	Enhancing efficient collaboration	50.0
R4, R6, R11, R12, R13, R14	Economy benefits	42.9
R4, R6, R14	Refine social benefit and responsibility.	21.4

Table 5: Generated themes based on respondent respond

The data presented in Table 5 indicate that 50 percent of the respondents recognize the importance of implementing sustainable operating procedures to enhance efficient collaboration. This recognition holds particular significance for developing countries like Malaysia, where financial support is essential for climate change actions due to the substantial investment required for both adaptation and mitigation efforts. Collaborative efforts among nations become indispensable in achieving favourable outcomes in this regard. Enhanced collaboration has the potential to improve seaport operations, aligning them with sustainable development goals, especially those aimed at achieving zero emissions. Initiating such actions necessitates active engagement of stakeholders and communities to advocate for sustainable practices, utilising their collective expertise and resources. Through collaboration, seaports can develop comprehensive guidelines that ensure operational integrity while also adhering to relevant laws and regulations. These measures not only attract investors but also ensure returns on investment, thereby fostering long-term sustainability and resilience in seaport operations.

Additionally, a significant number of respondents, accounting for 42.9 percent, concurred that sustainable procedure would not only yield economic benefits but also enhance environmental sustainability and conservation efforts. This finding holds relevance, as sustainable procedures are known to facilitate improved resource management, cost-effectiveness, and waste reduction. The current emphasis on sustainable environmental practices underscores their importance in providing positive responses to climate change challenges. Furthermore, sustainable environmental practices are instrumental in reducing greenhouse gas (GHG) emissions through the adoption of alternative fuel options, cleaner energy sources like renewable energy, and other eco-friendly measures. By prioritising conservation efforts, activities such as seaport extension or dredging, which entail land use changes, are monitored further to safeguard biodiversity. Moreover, sustainability and conservation initiatives can stimulate economic growth by promoting the adoption of green solutions, thereby reducing overall costs associated with climate change adaptation. Additionally, seaports stand to benefit from opportunities such as green financing, which is offered by financial institutions and investors prioritising sustainable projects and businesses.

Moreover, a significant number of respondents, i.e. 35.7 percent, expressed agreement that sustainable operating procedures could enhance the resilience and adaptation of seaports. The profound impact of climate change on seaports, notably through sea-level rise and extreme weather events, often results in service disruptions and substantial losses. Consequently, investments in weather-resilient infrastructure, including grey structures and mitigation measures, are crucial for governing seaport operations. Resilience, defined as the capacity of seaports to recover from severe weather impacts, bears multifaceted effects throughout the entire sector. Additionally, adaptation efforts entail adjusting policies, practices, and systems to reduce vulnerability and capitalise on opportunities presented by evolving environmental conditions. This thematic perspective underscores the imperative for seaports to incorporate resilience and adaptation considerations into their long-term planning and governance strategies. Similarly, 35.7 percent of respondents concur that sustainable operating procedures align with international targets and regulations. The Paris Agreement's initial goals aimed to limit temperature increases to 2 degrees Celsius and, ideally, to 1.5 degrees Celsius; however, given the current temperature and greenhouse gas trends, achieving these targets appears increasingly challenging. Consequently, sustainable development goals necessitate most industries, including seaports, to transition towards zero carbon emissions by 2050, underscoring the importance of aligning seaport operations with sustainable practices through a green approach.

Additionally, sustainable operational practices encourage environmentally friendly approaches and social accountability, a stance supported by 21.4 percent of the respondents. This eco-conscious approach advocates for a pristine environment, not only aiding in mitigating the broad impacts of climate change, but also aligning with sustainability objectives. Measures such as utilising renewable energy sources, enhancing energy efficiency, and advocating for eco-sensitive transportation further propel endeavours to reduce emissions and realize sustainable goals. Moreover, sustainable operational practices offer societal advantages by bolstering the quality of water and air, thereby leading to enhanced well-being for neighbouring communities. In summary, the adoption of sustainable operational practices is pivotal in tackling environmental challenges, meeting global targets, and fostering economic and social prosperity. Achieving these aims demands dedication, cooperation, and ingenuity from all involved stakeholders.

5.2 Impact of sustainable operating procedure on seaport competitiveness

Based on the question that investigates the impact on seaport competitiveness due to commencement of sustainable operating procedure, fourteen respondents provided their insights on seaport competitiveness. The corresponding data are analysed using qualitative methods that are related to eight themes, as shown in Table 6.

Respondent	Generated themes for question: “How is the seaport competitiveness affected by implementation of sustainable operating procedure?”	Percentage of response (%)
R1, R2, R4, R11, R12, R13, R14	Improved Sustainable Resilience and Operational Efficiency	50.0
R1, R2, R4, R6, R11	Refined Transition Management	35.7
R2, R3, R4, R12, R13, R14	Perfected Transparency, Synergy, and Environmental Responsibility	42.9
R2, R4, R5, R8, R10, R11, R12, R13, R14	Enhanced Reputation and Operational Excellence	64.3
R4, R8, R12, R14	Advanced Risk Mitigation and Reliability	28.6
R4, R5, R7, R8, R12, R13, R14	Elevated Competitiveness through Sustainability and Resilience	50.0
R4, R5, R6, R9, R12, R14	Bettered Adaptive Collaboration and Regulatory Alignment	42.9
R4, R7, R10, R13, R14	Augmented Competitiveness through Structured Investment	35.7

Table 6: Generated themes based on respondent respond

According to Table 6, a significant majority of respondents (64.3 per cent) believe that the implementation of sustainable operating procedures can improve both the reputation and operational effectiveness of seaports, ultimately giving them a competitive edge. The reputation of a seaport is crucial for attracting business and investors, providing vital support for service enhancement and mitigating negative operational impacts. Moreover, the smooth flow of loading and unloading processes is indicative of a seaport's operational excellence. This can result in an increase in ship calls and a reduction in congestion, which is linked to higher emissions. Furthermore, seaport's reputation is gained based on its management and recovery during weather disasters. In addition, safety in seaport and green strategies approach, enabling the seaport to prevent environment damage while being resilient to weather, will attract more business and generate economic benefits.

Moreover, half of the surveyed respondents (50 per cent) believe that implementing sustainable operational methods can improve both the resilience of sustainability and operational effectiveness, consequently enhancing competitiveness. Embracing these practices offers various benefits, including strengthening climate resilience and operational efficiency, while also enabling seaports to excel in challenging conditions and reduce resource usage and waste. Through the adoption of sustainable approaches, seaports position themselves for assessment and comparison with other industry players, thereby attracting interest and investment. Additionally, the incorporation of technologies like IoT (Internet of Things), traffic monitoring and emission tracking will further advance seaports towards the efficient identification and management of their operations.

Similarly, 42.9% of respondents believe that the competitiveness of seaports can be influenced by improved adaptive collaboration and regulatory alignment. Seaports that prioritise sustainability place a strong emphasis on working closely with stakeholders and ensuring adherence to regulations and industry standards. Ports that can effectively adapt and collaborate with regulators, customers, and other stakeholders, are positioned to navigate regulatory changes and market dynamics, thereby enhancing their competitiveness. Moreover, seaport competitiveness is also positively affected by transparency, cooperation, and environmental protection. By building trust with stakeholders and demonstrating a commitment to sustainability, seaports can attract investment, customers, and partners, ultimately strengthening their competitiveness.

In the context provided, the themes of increased competitiveness through structured investment and refined transition management received a response rate of 35.7 percent. The implementation of sustainable operating procedures typically involves initial investments in infrastructure, technology, and workforce development. Seaports that strategically invest in sustainability initiatives can expect to reduce long-term costs, attract investment, and gain a competitive advantage over peers who are slower to adopt sustainable practices. In summary, the adoption of sustainable operating procedures has the potential to enhance the competitiveness of seaports by improving resilience, efficiency, reputation, risk management, and collaboration. Sustainable ports are better equipped to attract business, investment, and skilled personnel, thus strengthening their position in the global market. Managing the transition towards environmentally friendly and resilient practices is a key aspect of sustainable operating procedures. Seaports that navigate this transition successfully can distinguish themselves in the market and appeal to environmentally conscious customers and stakeholders, increasing their competitiveness.

Finally, the competitiveness of seaports is influenced by advanced risk mitigation and reliability, as agreed upon by 28.6 percent of respondents. Sustainable operating procedures involve measures aimed at mitigating risks associated with climate change, regulatory changes, and other uncertainties. Seaports that take proactive measures to manage these risks and ensure consistent operations are more attractive to shipping lines, cargo owners, and other stakeholders, thereby improving their competitiveness. In conclusion, sustainable operating procedures have a positive impact on seaport competitiveness. Considering Malaysia's status as a developing country and a primary fossil-fuel producer, generating income while minimising environmental harm would be advantageous. A sudden transition to green energy could have significant economic implications, so this research underscores the importance of adopting green solutions while aligning with sustainable development goals.

5.3 Enhancing seaport competitiveness

Seaport competitiveness should be harnessed in order to gain attention from stakeholder and customer by offering better accommodation, infrastructure and others (Wahyuni et al., 2020). The key component of competitiveness relies on strategies by enhancing the infrastructures, facilities and services that are able to provide cost-saving options, safety of goods, faster clearance and others (Kammoun et al., 2022). Moreover, the top priority is to offer better management that involves handling fees, improvised hinterland connection and enhanced reliability (Jeevan et al., 2018). Additionally, green technologies offer better solutions and strategy, and in accordance with sustainable goals to reduce the GHG emission will further boost the seaport competitiveness (Castellano et al., 2020). This strategy increases maritime productivity while also reducing the environmental variables that greatly contribute to climate change. This technique is mutually beneficial for sustainability and competitiveness in the marine sector since it not only manages environmental concerns that greatly contribute to climate change but also increases seaport productivity.

Furthermore, the resilience of seaport to recover from natural disasters, and offering profitability to companies and supporting economic growth and reducing environmental harm are the key strategies to improve the seaport competitiveness (Becker et al., 2018; Jeevan et al. 2020). Seaport resilience requires careful consideration of climate dangers, planning for adaptation, and identifying barriers to adaptation. Climate change-related seaport disruptions have a substantial influence on human welfare and the resilience of the global economy (Becker et al., 2018). Better-resilient seaports typically handle higher cargo volumes and draw investment interest from stakeholders. In conclusion, seaports that are more resilient typically manage bigger cargo volumes and draw more interest and funding from stakeholders, thus becoming further competitive globally.

Globally, seaports compete to offer better services; in order to achieve the goal, seaport should be ready in term of receiving higher throughput, seaport extensions and quality of service (Munim et al., 2022). The important factor in competitiveness always involves time of clearance from congestion and, according to Zain et al. (2022) and Jeevan et al., (2023), dry port interventions offer better solutions through reduced cost, fast cargo clearance, increased berthing efficiency and increased ship calls. These enhancements help to lessen environmental problems in addition to increasing seaport production. Apart from these, with current technologies, smart applications, such as customs clearance, will further decrease the seaport congestion fostering faster clearance timing to improve the seaport competitiveness. These smart technologies, which help to improvise the management such as monitoring of traffic, energy consumption and container management, will hence increase the ship calls and improve the seaport competitiveness.

6.0 CONCLUSION

In conclusion, it is crucial to implement sustainable operating procedures in Malaysian seaports. These measures are essential for promoting effective collaboration, enhancing environmental sustainability, fostering economic growth, increasing resilience and adaptation, and adhering to international standards and regulations. The key findings and conclusions of this research highlight the urgent need for immediate action to address the impacts of climate change, which pose significant risks to seaport operations and could lead to their failure. The primary focus should be on aligning seaports with international goals and regulations, such as the Sustainable Development Goals, which prioritise reducing greenhouse gas emissions. Additionally, seaports should prioritise collaboration and partnerships to achieve cost savings and investments in mitigating climate change impacts. Emphasising resilience planning through collaboration will provide guidance and set common targets for seaports globally, encouraging others to join in combating emissions. These measures will not only contribute to economic growth by generating revenue but also ensure the long-term sustainability and resilience of seaport operations.

Moreover, upon reviewing the impact of implementing sustainable operating procedures on seaport competitiveness, it becomes evident from respondents' feedback that there exists a positive relationship between sustainability efforts and heightened competitiveness. The highlighted themes, such as sustainable resilience and operational efficiency, transparency, synergy, environmental responsibility, improved reputation and operational excellence, and increased competitiveness through sustainability and resilience, emphasise the importance of sustainable practices in strengthening seaport competitiveness. The point lies in the fact that sustainability initiatives empower seaports to achieve smoother traffic flow, utilise renewable energy sources, improve safety and weather resilience, all of which attract business and investment opportunities. Therefore, the implementation of sustainable practices in Malaysian seaports is expected to be well-received and to contribute to long-term economic benefits.

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CONFLICT OF INTEREST

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